Proceedings of the Symposium on Endangered Marine Animals and Marine Parks

COCHIN, INDIA * 12-16, JANUARY 1985

MARINE BIOLOGICAL ASSOCIATION OF INDIA
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Proceedings of the Symposium on Endangered Marine Animals and Marine Parks

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Edited by: E. G. SILAS

(*Issued in October* 1988)

MARINE BIOLOGICAL ASSOCIATION OF INDIA
POST BOX NO. 2673, COCHIN 682031, INDIA

This volume is dedicated to the memory of. Late Dr. Salim Ali as a token of our esteem for his immense contributions to the natural history, ornithology and conservation and management of the endangered living resources of this subcontinent. The Marine Biological Association of India had the privilege of having Dr. Salim Ali as the Chief Guest to inaugurate and fully participate in this Symposium.

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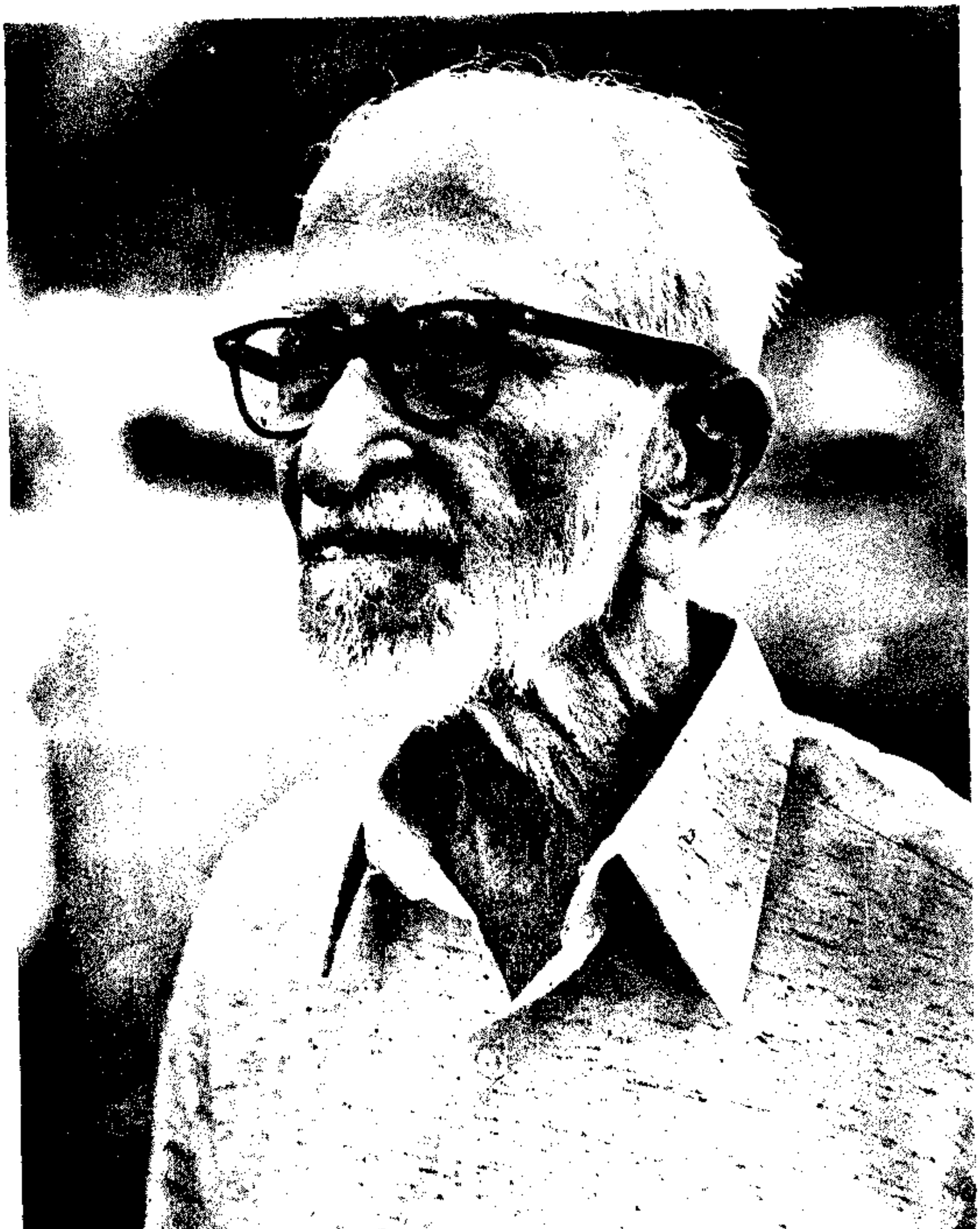


DR. A. SALIM ALI
12TH NOV. 1896 – 20TH JUNE 1987

PROCEEDINGS OF THE SYMPOSIUM ON ENDANGERED MARINE ANIMALS AND MARINE PARKS

CONTENTS

ESTUARINE AND MARINE REPTILES

MARINE PARKS, SANCTUARIES, RESERVES, ZOOS AND OCEANARIUMS

OTHER MARINE VERTEBRATES AND INVERTEBRATES

FOREWORD

One of the most valuable natural assets of India is her wildlife. In the aquatic eco-system of the country, these include the ever curious animals such as the fresh-water crocodile, the Gharial, the estuarine crocodile, marine turtles, dugong, porpoises, dolphins, and whales. In the seas around India, as many as 25 species of cetaceans, one species of sirenia and 5 species of turtles are known to occur. All these are considered as endangered animals. Besides these, the white bellied sea eagle of the Indian coastal areas and Bay Islands, the Nicobar Megapode, and invertebrates such as the coconut or the robber crab found along the coasts of Bay Islands have been affected by habitat destruction and exploitation. The Indian dugong, the only herbivorous marine mammal in the Indo-Pacific, due to the unscrupulous exploitation over the years, has reduced at present to a residual population. Similarly, the sea turtles occurring in our seas, although protected under the Indian Wild Life (Protection) Act, 1972, are illegally exploited. Further, destruction of eggs of these turtles through human and animal predation are adversely affecting the population. The major threat to the turtle population is caused when they aggregate close to the shore for mating or during their sojourns to shallower waters or when they visit the beaches for nesting. The destruction to these resources are causing great problems of management and conservation of the resource and it has now become an urgent necessity to restore the status of their population as these endangered animals play significant roles in maintaining the balance of nature, providing recreation, scientific advancement and in the religion and culture of the country.

Although adequate legislations are now available for protection and management of these endangered species, and steps are being taken to conserve the resources, several handicaps due to the difficulties of implementation of the legislation, lack of understanding among the public on the value of the resource and vested interest for the continued exploitation are encountered in the pragmatic management of the conservation efforts. In addition to these, the recent ecological imbalances occurring in the coastal zone due to pollution, agro-industrial development, denudation of the mangroves, beaches and mining from reef areas and degradation of the coastal flora are causing considerable deterioration of this fragile ecosystem. As the coastal zone is intimately linked up with the wellbeing of the several endangered and/or vulnerable resources which utilise this ecosystem during the part or whole of their life-cycle, protection and preservation of these habitats forms an essential prerequisite activity in the conservation and management of the endangered resources.

In the above context and the urgent need of creating an awareness among the public as well as the different agencies engaged in the planning, administration, research, development, management and conservation of these most precious resources, to take stock of the present status of the resource and to develop a functional action plan for the conservation of the resources, a Symposium entitled '**Endangered Marine Animals and Marine Parks**' was organised from 12-16 January, 1985 at Cochin under the auspices of the Marine Biological Association of India.

The Symposium was inaugurated by Dr. Salim Ali, President, Bombay Natural History Society and National Professor, and a world authority on birds, on 12th January, 1985. The Conference was attended by about 170 participants representing 16 countries. The symposium was organised under 6 Technical Sessions wherein a total of 60 experience and review papers were presented and discussed. The details of the Technical Sessions and the papers presented were as follows :

Technical Session I	..	MARINE MAMMALS : LESSER CETACEANS Papers presented 5
Technical Session II	..	MARINE MAMMALS : WHALES Papers presented 11
Technical Session III	..	MARINE MAMMALS : DUGONG Papers presented 4
Technical Session IV	..	ESTUARINE AND MARINE REPTILES Papers presented 14
Technical Session V	..	MARINE PARKS, SANCTUARIES AND RESERVES Papers presented 9
Technical Session VI	..	ENDANGERED AND/OR VULNERABLE MARINE INVERTEBRATES AND VERTEBRATES Papers presented 17

The technical sessions in the afternoon of 12th commenced with an introductory session under the Chairmanship of Dr. Salim Ali and the present status on wildlife conservation in India was presented by Mr. J. C. Daniel. The several papers presented on whales, dugong, dolphins and sea turtles elicited detailed discussions. Similarly, various problems and constraints in the habitat preservation was discussed vigorously in the session on 'Marine parks, Sanctuaries and Reserves'. In the Plenary Session, the discussions held in the previous sessions were reviewed and recommendations were formulated for immediate implementation by the concerned agencies. The salient points of observations and conclusions of the symposium and the recommendations made by the participants are given in the following pages.

The Association is aware that the main success of the symposium does not end with its organisation and conduct, but on the follow-up actions taken and the speedy implementation of the recommendations by all the concerned agencies and organisations. This requires cooperation, mission-oriented action and integrated approach by the different organisations and institutions. Realising the urgent need of management and conservation of the endangered and or vulnerable resources and preservation of their habitats, it is hoped that these recommendations would receive immediate attention and early action.

I am extremely grateful for the valuable help given to me in the preparation of the manuscripts for publication by Dr. P. Vedavyasa Rao, Dr. K. Rengarajan and Mr. P. T. Meenakshisundaram. I also wish to express my sincere thanks to the Chairmen and Rapporteaurs of the various Technical Sessions for ably conducting the concerned sessions and documenting the very useful discussions which facilitated the formulation of the recommendations.

The Indian Council of Agricultural Research, New Delhi has always evinced keen interest in the activities of the Association and I wish to record the support I have received from the Council towards conducting the Symposium.

I look forward to this Symposium creating a greater awareness on conservation and management problems relating to marine living resources and habitats among the researchers and decision makers-both at the Centre and State levels.

E. G. Silas
President
Marine Biological Association of India
and
Convenor
Symposium on Endangered Marine Animals and Marine Parks

Proc. Symp. Endangered Marine Animals and Marine Parks, 1985,

PRESIDENTIAL ADDRESS BY DR. E. G. SILAS

President, Marine Biological Association of India

Our Chief Guest Dr. Salim Ali, Founder President of the Marine Biological Association of India, Dr. S. Jones, Members of the Reception Committee, Distinguished participants to the Symposium from abroad, Members of the Association and Ladies and Gentlemen,

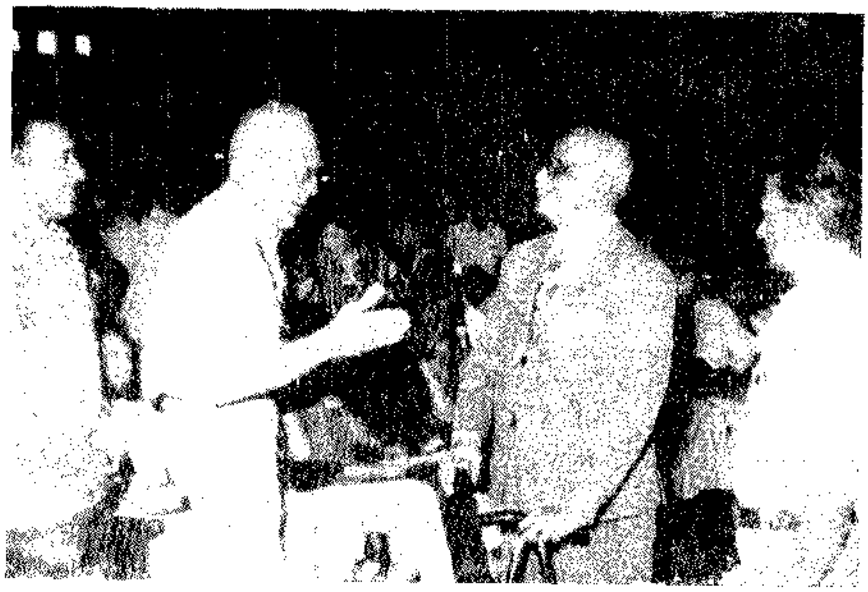
The Marine Biological Association of India was founded in October 1957 and Registered as an Association in 1958, thus completing twenty-five years of its existence in 1984. To mark the occasion it was decided early last year to organise a Symposium in January 1985 which will be topical, have a wide appeal and a message to give. We felt that the focal theme 'Endangered Marine Animals and Marine Parks' was fully in keeping with the objectives of the Association.

Despite the U.N. Conference on 'Human Environment' held at Stockholm in June 1972, the maladies of willful environmental degradation, depletion and dessimination of the living resources both in the developed and developing world continues unabated. The Bhopal Tragedy is fresh in our minds. Reverting to our focal theme, some of the marine animals and plants are highly endangered or vulnerable and need immediate attention to protect and manage them back to normalcy.

A number of marine animals, both vertebrates and invertebrates from our seas find a place in Schedule I of the Indian Wildlife (Protection) Act 1972. Unlike Wildlife sanctuaries and land animals, the management and implementation of conservation measures in the marine ecosystem poses several problems. Precise quantified data on the resource may not be available and locating them often underwater poses problems in monitoring. The Cetaceans, the sea turtles to name some are highly migratory, transgressing beyond the jurisdictional limits of our country. In the case of the dugong, we cannot separate the habitat, namely, the seagrass ecosystem from the animal, since they are herbivorous.

Whales are one of world's common property resource. The International Whaling Commission declared in 1980 the Indian Ocean as a Sanctuary for whales while proposing a moratorium on whaling from the 1985-86 season. The limits of the Sanctuary are 20°E to 130°E and 55°S Latitude. At the Indian Ocean Alliance Meeting held at Seychelles in 1981 the limits of the Indian Ocean Sanctuary was suggested to be extended further southward to the Antarctic coastline for the more effective protection of the male sperm whale. Today, but for two or three Nations, all Member countries of the IWC have supported a 10 year moratorium for whaling from 1986 onwards. India became a Member of the IWC in 1982 though the initiative taken by our Late Prime Minister Smt. Indira Gandhi and has played an important role in the conservation of the whale resources.

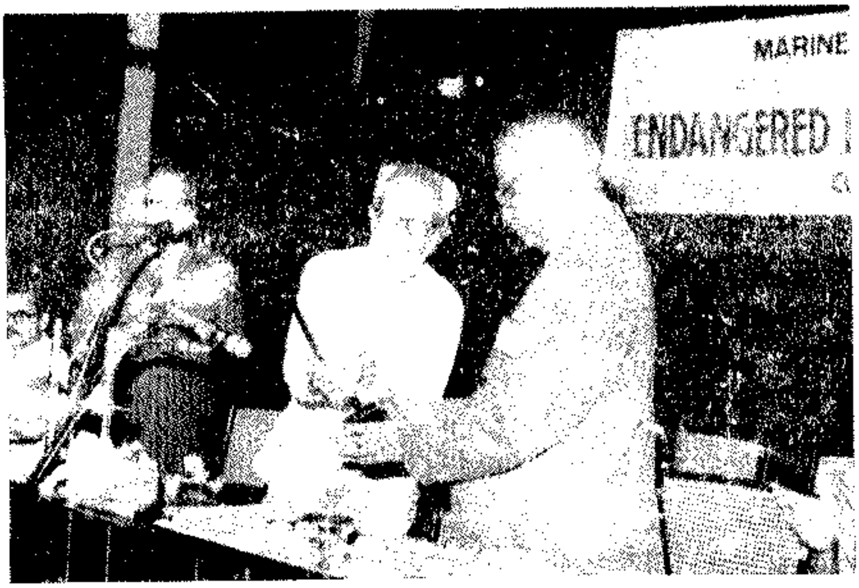
From one of exploitation, today the emphasis is shifting to the non-consumptive utilization of the cetaceans for educational, tourism and benign research. This shift initiated at a Conference in Boston in 1983 is very significant and should not merely be for whales alone, but for all endangered and vulnerable marine animals threatened to extinction. This Symposium should highlight this alternate option open to us.



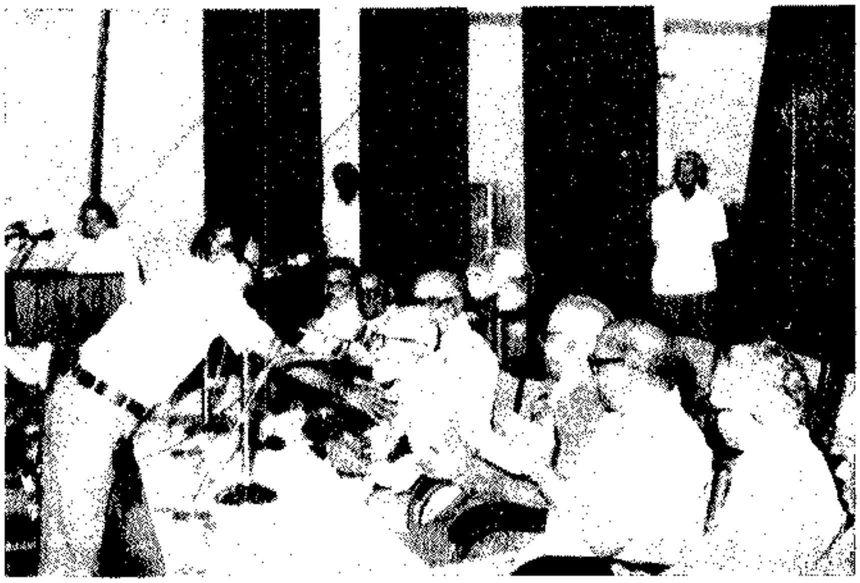
7. Dr. Paul K. Anderson with Dr. S. Jones and looking on are Dr. Rama N. De Silva (left) and Dr. P. V. Rao (right).

8. A section of the audience.

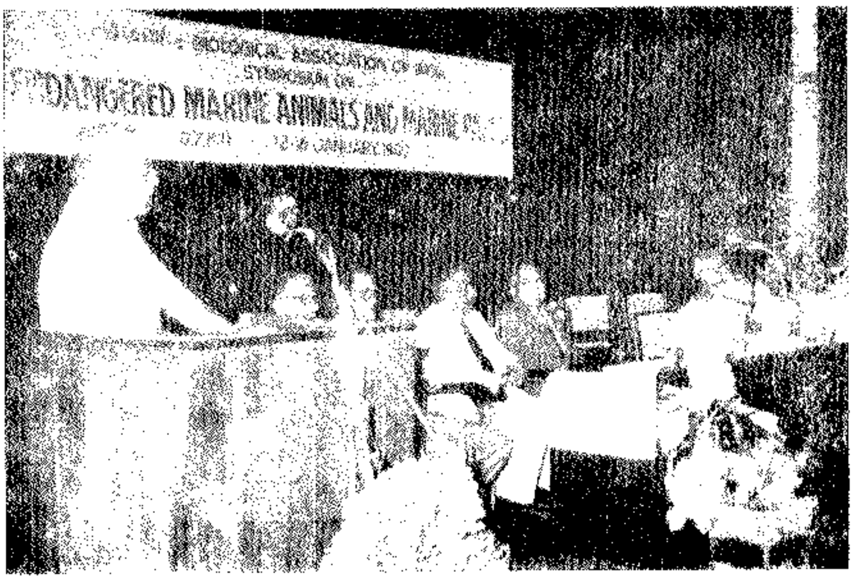
5. Inaugural address by Dr. Salim Ali



6. Dr. Salim Ali presents the Silver Jubilee memento of the Association to the Founder President, Dr. S. Jones



3. Dr. C. K. Gopalan garlands the Chief Guest.



4. Presidential address by Dr. E. G. Silas.

1. Receiving Dr. Salim Ali, the Chief Guest.

2. Dr. P. V. Rao welcomes: Left to right on dais Dr. K. Alagarswami, Justice K. Sukumaran, Dr. K. Gopalan, Dr. E. G. Silas, Dr. Salim Ali, Dr. S. Jones, Dr. P. S. B. R. James, Mr. M. R. Nair and Dr. C. T. Samuel.

The lesser Cetaceans, the dolphins and porpoises including the species confined to the riverine system, namely the Gangetic dolphin are highly vulnerable. With more sophistication in fishing gears, more numbers are today taken in incidental catch. How do we circumvent this ? In many places along the coast tradition and religious beliefs help the conservation cause, but with increased fishing effort in the coastal waters, an escalation in incidental or accidental capture is bound to occur. Preventive strategies of keeping dolphins off fishing gear have to be developed or if techniques are already available be adopted.

Multiplicity of implementing agencies often twart or retard conservation measures- For instance, under the Act, the Department of Forest and Wildlife may be responsible for what is happening even in the sea, but the extent of coordination with the Department of Fisheries needs strengthening. Thus there is a crying need for greater coordination in these matters between different Departments and Agencies.

The dugong is the most endangered of our marine mammals and the residual population in the Gulf of Mannar and Palk Bay is highly vulnerable today to illegal take. We are discussing this distressing phenomenon at this Symposium and if the present trend continues unchecked, the residual population of a few hundred animals may be wiped out in no time. What do we do about this ?

The mass breeding migration and nesting (arribada) of the olive ridley turtle along the Orissa Coast is now well documented. However, we know little about the recruitment to the population ; the migratory pathways of hatchlings to feeding grounds ; growth ; migration to the mating grounds ; reproductive physiology ; renesting of the animals during the same season and a myried of other problems. Recent researches have shown that temperature plays an important role in sex determination during embryonic development and turtle eggs incubated below the pivotal temperature turns out to be 100 per cent males while those that are incubated at higher temperature are females. One could guess the result if unimaginative management measures are adopted in incubating turtle eggs at only higher or lower temperatures in hatcheries. It is here that affording protection to the nesting grounds of sea turtles assumes great importance as nature should take care of proper recruitment and prevent imbalance in the sex ratio in the population.

Further, at the arribadas in Gahirmatha, off Orissa the destruction of virtually millions of eggs and hatchlings take place year after year resulting from various sequence of events. The question is could we utilize the 'doomed eggs'? Should emotion over-ride the development of sane management reasons ? We have to take management decisions on this.

The nesting *habitats* or rookeries of some of the sea birds have become highly vulnerable to human interference. This has to be stopped. Similarly, a large number of invertebrates are highly vulnerable to man-made changes, industrial pollution affecting inter tidal areas and other stresses in the environment. The need for protecting such resources is as important as that of conserving the whale stocks.

The concept of preserving the genetic resources in the marine environment has not caught up as in land based ecosystems. There is a need for an inventory of genetic resources most endangered by depletion or extinction, Recommendation 115 of the U.N. Conference on ' Human Environment ' dealing with animal germ plasm mentions in the operative clause that :

— specific methods for the maintenance of gene pools for aquatic species be developed.

It is in this context that for marine animals we think in terms of Marine Parks, reserves and sanctuaries where the endangered and vulnerable animals could be accorded full protection in both their feeding grounds as well as breeding grounds or nursery phases which often may be separated by several thousand kilometres. There has been an urgent need to protect some of the critical habitats along our coast and bay islands. The concept of marine parks and reserves will not only help in giving adequate protection and act as nursery areas for even commercial fisheries, but also help in bringing about greater awareness on the need for conservation and management of some of our eco-systems. Here we should be aware of the limitations such measures would have, if we do not take into confidence and involve the people of the coastal zone. Such an integration is vital in our country.

The concern of our Government to the maintenance of the quality of our environment is so great that today we have a fullfledged Ministry of Environment which has as its mandate Environment, Forest and Wildlife. This recent changes should augur well for the speedier implementation of the establishment of Marine Parks and Reserves including developing simultaneously the infrastructure in man-power and development of management practices for such areas. Ultimately this should help in the development of integrated biosphere reserves which may also facilitate demarcation of different categories of ecosystems such as coastal marshes, coastal lagoons, coastal mangroves, intertidal mud and sand flats, coral reefs, seagrass beds and so on.

It is for strengthening this understanding and for focusing attention on more specific problems at the national level and where international cooperation is needed that this Symposium has been organised with the following objectives :

— to facilitate an understanding of the present status of endangered fauna in the Exclusive Economic Zone of India and in the adjacent region ;
— to bring together the various agencies engaged in the survey, investigation, exploitation, development, management and conservation of the resources ;
— to consider ways and means for management and conservation of the endangered species through co-ordinated and practical measures and their recommendation to the policy and implementing agencies ;
— to promote public interest on wildlife/endangered species and their conservation ; and
— to consider setting up of biosphere reserves, marine parks, sanctuaries, and reserves.
— to draw strength and expertise from exprinces in other areas on management of marine living resources and threatened habitats.

The Meetingwhich are arranged under six Technical Sessions should help to focus attention on critical areas which need priority attention.

I hope the deliberations of the Symposium will enable us to develop a proper action programme for the future both for the conservation and management of endangered and vulnerable marine animals as well as threatened and critical marine and coastal habitats.

MARINE ENDANGERED SPECIES

DR. SALIM ALI
National Professor and President, Bombay Natural History Society, Bombay

Exploitation of marine resources other than fishes has been, and continues to be a traditional occupation. In the case of sea birds the exploitation has largely consisted of egg-gathering, but often of young and adults as well, as witness the extinction of the Great Auk and the Dodo, both flightless species, and island dwellers. Exploitation of island-nesting littoral species of birds continues along the Indian coasts. The utilisation of this valuable food resource may not be totally harmful if properly regulated, and practised within reasonable limits. But this does not often happen in the context of the increasing demands of the ever increasing human population.

Over-exploitation remains the major threat for all species of marine vertebrates, and this Seminar should examine how best this can be controlled, organised and limited.

It is often difficult to convince people that they are over-exploiting a natural resource. Especially when they see thousands of individuals of species like gulls and terns and the Riddley turtle nesting on a single island or stretch of sea beach, as happens in the case of the Lakshadweep islands or of the Gahirmatha beach in Orissa. However, the conservationist cannot overlook the fact that what we see nesting on such comparatively small stretches of land may be the entire concentrated population existing in a vast area of the oceans around, and over-exploitation of the resource may lead to the destruction of a population not only of our surrounding seas but of other areas of South East Asia, and far beyond.

The only protection that man can afford to sea turtles is protecting their nesting beaches on the Indian coast. This requires strict regulation of the use of these beaches for human needs.

The one species of marine mammal that, I think, requires immediate and urgent attention is the Dugong. Very little is known about this animals status along the Indian coasts and its ecological requirements apart from the information collected by the Central Marine Fisheries Research Institute. This species deserves a sustained and long term scientific study.

As I have often stressed to wildlife enthusiasts of the emotional and sentimental variety, meaningful conservation does not mean the complete denial of these very valuable natural resources which have helped to sustain man for thousands of years. It only means the scientifically managed and wisely controlled use of the resources so that in our short-sighted greed we do not, at one stroke, kill the proverbial goose that lays the golden eggs ! Let us hope that this seminar will help in devising means for reconciling human needs with the welfare of marine animal life and their habitats elsewhere in the world also.

12-1-1985. SALIM ALI

FELICITATION TO DR. SANTAPPAN JONES, FOUNDER PRESIDENT OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA, ON THE OCCASION OF THE SILVER JUBILEE OF THE ASSOCIATION

DR. E. G. SILAS

Respected Sir,

We, the members of the Marine Biological Association of India, and all those assembled here take pride to honour you and would like to express our deep-felt feelings on the occasion when the Association completes twenty-five years of its existence serving the causes of marine science in India. With a rare foresight and mission-oriented ideologies, you, founded, two and half decades ago, this Association which has since then grown into an organisation of International repute.

Sir, we admire your multifarious activities and multifaceted life. After a brilliant academic career at His Highness the Maharaja's College at Trivandrum and an early research fellowship under renowned Prof. R. Gopala Aiyer and a brief tenure as a teacher in the Department of Zoology, Madras Christian College, you joined the Department of Agriculture and Fisheries of the erstwhile Travancore State. Your earlier interest has been Agricultural entomology, but soon drawn in by the Government of India to lead the R & D programmes in fisheries at the Central Inland Fisheries Research Institute in 1947, when the fisheries of India was in an infant stage of development. From here, as destiny willed it, it was the gain of the marine science, particularly the fisheries science which enjoyed your dedicated service, dynamic leadership and outstanding contributions.

Sir, you are a born naturalist and a scientist. This is evidenced by your precocious interest right from school and college days when two milipedes and a gryllid collected by you and were described as new to science. This keen interest in the collection and description of curious, rare and new species sustains in you even today. With about 150 scientific publications on different aspects of fish and fisheries, entomology, carcinology, animal associations and behaviour, mammology and marine biology your contributions to science is a remarkable odessy. To mention a few, the studies on breeding and development of brackishwater fishes, investigations on the Indian shad, comprehensive report on fish and fisheries of Chilka Lake, researches on eggs and larvae of several marine fishes, contributions on oceanic fishes, specially tunas and on fish and fisheries of Laccadive seas are outstanding and pointed out the extent of potential fishery resources available in the seas around India for exploitation and formed the basis for the rapid development of the fisheries witnessed during the post-Independent years.

We record here with great appreciation your administrative and organisational capabilities. As Director of the Central Marine Fisheries Research Institute for about 13 years and as a member of several national and international committees, Councils and Boards your direction and advice have been path-finding and inspiring. Showing an upsurge of interest in the development of marine sciences in the country, realising the urgent need for an organisation free from bureaucratic complexities to foster marine science and in the background of rich experience you conceived the establishment of the Marine Biological Association of India in the fall of 1958. Guiding it through over a decade, you nurtured the organisation, brought it up on a sound foundation both organisationally and financially by your tireless and energetic drive into an international organisation second to none in this part of the world. To accomplish the objectives of the Association and to encourage dissemination of research results an official organ of the Association entitled 'Journal of Marine Biological Association of India' was started, which today has acquired International reputation and the papers published in the journal are widely referred to. Realising the importance of a common forum for facilitating exchange of views among research workers, experts, planners, administrators and endusers on the advances made, constraints encountered, in subjects of basic and applied utility and, to formulate strategies for future development, you first started a series of symposia under the auspices of the Association and organised them in an exemplary manner. These symposia, as opined unanimously, formed the mile-stones in the marine science research and development in the country. You have been the guiding spirit in the various activities of the Association. It is gratifying to note that the Estimates Committee of the Indian Parliament appreciated your yeoman service in the field. We take this opportunity to assure you Sir, that we earnestly wish to continue these efforts and activities of the Association in the guidelines showed by you.

Besides your academic and scientific achievements, we appreciate and admire your keen interest in the ancient and traditional culture, phenomenal memory, enlightened and dynamic nature, untiring capacity to work, stirling humane qualities, being kind, considerate, sympathetic and helpful to all, above all, your present-day philanthropic activities in the service of the handicapped and disabled persons, despite your own physical handicap. Yours is a life of inspiration and dedication, and you are what we call a true 'Karma Yogi'. The great activities of yours shall be remembered for long both by the scientific and human world.

We wish you Sir, and your family members, long life, happiness ana prosperity. While we are aware that this momento to be presented now is insignificant in the light of your greatness, we express our gratitude, appreciation and respect through this.

Dr. S. Jones thanked the Marine Biological Association of India and its President for the momento presented to him commemorating the Silver Jubilee of the Association. While recalling the humble beginning of the Association, he expressed appreciation at the growth of the Association through the dedicated ana selfless efforts of the members. He felt that the Symposium on Endangered Marine Animals and Marine Parks was of considerable topical interest and would go a long way in creating an awareness within the country on the conservation and management of endangered and vulnerable animals and plants and marine habitats. He wished the Association and its activities, sustained growth to serve efficiently the cause of marine sciences in the country.

Dr. K. Alagarswami proposed a vote of thanks.

SYMPOSIUM ON ENDANGERED MARINE ANIMALS AND MARINE PARKS, COCHIN 12-16, JANUARY, 1985

RECOMMENDATIONS

Background

About 200,000 species of plants and animals, it has been estimated, inhabit the world oceans. Being more uniformly distributed than the terrestrial species, the threat of extinction, it has been believed, is relatively less in these marine species. However, unscientific commercial exploitation and increasing damage to the marine ecosystem from human activities and other economic interests since the turn of this century are posing great threats to certain marine living resources. This is particularly evident in the less fecund animals such as marine turtles and mammals. Ever since the modern whaling started in 1868, too much exploitation with too little knowledge on the resource has led to the alarming decline of whale populations in the World oceans. Similarly, the resources of dugong in several regions of the seas have been reduced to meagre residual populations. Certain species of marine turtles, their eggs and hatchlings are unscrupulously exploited and quite frequently destroyed or subjected to heavy predation. The nesting beaches of sea turtles are subjected to greater human perturbations. Many of the coral reefs and mangrove communities have been degraded or destroyed along the coasts of America, Africa, India, Thailand, Malaysia, Vietnam, Indonesia, Philippines and east and south Australia. Rapid changes occurring in the coastal zones due to technological developments, conflicts within the sectoral use and agencies, denudation of coastal flora and pollution of coastal zone are also causing hazards to the marine species that use this ecosystem during certain phases of their life activities.

In the seas around India too, the marine animals such as the dugong in the Gulf of Mannar and Palk Bay and the marine turtles along the coast, particularly along the Orissa coast, where they congregate in enormous numbers for nesting and egg laying during certain seasons are exploited. Increasing human and non-human interference in these nesting areas, predation and destruction of turtle eggs and hatchlings adversely affect the population and its replenishment. Besides, the increasing coastal environmental degradation, fragile nature of the near shore seas and coastal zone ecosystem, its multiple use resources strategies, social and economic complications are also posing problems to the pragmatic coastal zone management in respect of the conservation *vis-a-vis* the resources that utilise the ecosystem.

The Symposium

In the light of the above situation and concern, the Marine Biological Association of India organised a five-day long Symposium on Endangered Marine Animals and Marine Parks from 12 to 16th January, 1985 at Cochin. Although there have been conferences on the subject prior to this in other parts of the world, this is the first time that a symposium is organised and held in India on endangered marine animals and marine parks. The main objectives of the symposium, briefly, are to bring together the persons and organisations concerned with the subject to discuss the present state of affairs, *modus operandi* of the activities taken up to collect information and for implementation, data collected, constraints encountered, and to formulate future strategies and proposals to achieve the main theme of the symposium—management and conservation of the endangered marine species, their protection and preservation of their habitats.

Representatives from 16 countries, namely, Austria, Bangladesh, Canada, Egypt, France, Federal Republic of Germany, India, Iran, Maldives, Sultanate of Oman, Pakistan, Panama, Sri Lanka, Thailand, United Kingdom and United States of America, besides the delegate from the UNESCO participated in the Symposium. The deliberations were held on whales, lesser cetaceans, dugong, estuarine and marine reptiles, endangered marine invertebrates and other vertebrates and on marine parks, sanctuaries and reserves.

Salient Observations/Conclusions

The enhanced exploitation of endangered marine animals in the seas around India and in the adjacent regions, and their management and conservation face a series of problems and necessitate urgently an evolution of an explicit frame work. These problems and the salient observations made in the symposium can be summarised as follows :

1. Although the recent advances in the aerial surveys and other investigations on the population structure, biology, reproductive characteristics and behaviour of whales, lesser cetaceans and dugong have gathered valuable information, the scientists placed great emphasis on the need for intense data collection from different regions to understand the overall resource status and its dynamics.

2. The data on capture of or stranded endangered and (or vulnerable) marine species in the Indian and adjacent seas be collected and made available presently to an organisation such as the Central Marine Fisheries Research Institute which may develop a system to collate these data and disseminate the same.

3. It was noted that, at the 31st annual meeting of the International Whaling Commission (IWC) held in London in 1979, the IWC created the 'Indian Ocean Sanctuary' comprising the waters of the Northern Hemisphere from the coast of Africa to 100°E, including the Red Sea, the Arabian Sea and the Gulf of Oman, and the waters of the Southern Hemisphere in the sector from 20°E to 130°E as far as 55°S, thus setting aside 50 million sq. km of ocean as a conservation and study area in which no commercial whaling be permitted for at least the next 10 years.

4. It was further observed that at the preliminary meeting of the Indian Ocean Alliance and Seminar on the conservation in the Indian Ocean Area held at Mahe Seychelles in April 1980, the establishment of the 'Indian Ocean Sanctuary' created great interest throughout the world and had been welcomed by several Indian Ocean coastal states, who were not members of the IWC, but had expressed their interest in joining the Commission and that the participants in the meeting had recommended that the Governments of the Indian Ocean Coastal States may request the IWC to amend its schedule so as to extend the 'Indian Ocean Sanctuary' southwards to the Antarctic coastline, and that the Governments of all Indian Ocean States be invited to offer their support in the matter. The

'Indian Ocean Sanctuary' was further discussed at the 1983 Boston Conference on the non-consumptive uses of marine mammals and also in the recently held Colombo Conference.

5. The Zoos and Oceanaria play significant role in the conservation of marine animals, promotion of research and public education. However, inappropriately designed systems or exhibits and poor husbandry practices would often cause diseases and mortalities of captive animals. It is, therefore, essential to upgrade and improve the maintenance of the existing zoos and oceanaria and to afford congenial habitat, utilising the knowledge and expertise available. As the establishment of properly designed zoos and oceanaria providing clear environment, water quality, health care, feeds and other facilities and their proper maintenance are expensive, caution must be exercised on their multiplication.

6. The lesser cetaceans often form incidental catches in the different fishing gears operated in the marine region. A close monitoring system of the sea catches may be evolved and endeavours made to release them back to the sea wherever and whenever possible.

7. The most threatened marine mammal in the Indian Ocean region is the dugong. Although protected under the Indian Wildlife (Protection) Act, 1972, the residual population in the Gulf of Mannar and Palk Bay is, however, subjected to illegal exploitation and utilisation. The fishing for dugong and the use of dynamite and explosives and special nets to kill the animals and the covered marketing practices should be immediately condemned and stopped. A comprehensive project for the management and conservation of the dugong resource and efforts to create a public awareness to save the dugong population were discussed in detail.

8. The sea grass bed which forms the feeding ground of dugong, is in a critical state of degradation in several areas. It is of paramount importance to protect and improve this ecosystem, as it is significantly linked with the dugong resource conservation.

9. The brackishwater turtles of India, *Batagur baska* and *Pelochelys bibroni* are heavily exploited and have become quite rare. Very little information is available on the distribution pattern, population characteristics, biology, reproduction and nesting sites of these species. It is, therefore, essential to undertake comprehensive surveys of the resources in the estuarine regions of the major rivers and adjoining coastal areas to assess the population, locate the nesting sites and to study their biology and behaviour.

10. Supplementing the information already available and presented at the Work-shop on 'Sea turtle Conservation' held in Madras on 27-29 February, 1984, on the marine turtles of India, and noting the status of sea turtle in the neighbouring countries and in the United States of America, the participants reiterated the major areas such as habitat preservation, particularly of the present critical areas ; species preservation through recovery programmes, translocation of nests and

setting up of hatcheries ; enforcement of prevailing laws and regulations ; intensive research on the biology, ecology, reproduction and behaviour and strengthening of education, training and extension to create an awareness of the importance of the marine turtle resources , identified for evolving effective strategies for their conservation and management.

11. The Conference noted the heavy exploitation and destruction of coral reefs in several areas along the coast and the status of the endangered and vulnerable invertebrates, and observed that such exploitation was weighted in favour of short-term economic gains. Beach sand mining has led to large scale siltation and other problems in coral reef areas. It is essential to create an awareness of the role of these magnificent organisms in the marine ecosystem and the need for sound ecological guidelines for sustainable resource development of the area.

12. The participants of the Symposium noted the rapid changes occurring in the near shore seas and the adjacent land in the coastal zone due to biological, physical, ecological and agro-industrial influences, and human activities. It observed that pressures for coastal resource development are increasing and would continue in the foreseeable future. The conflicts among the different sectoral agencies on the allocation and use of resources often lead to destruction of coastal resource opportunities. Nevertheless, taking into consideration the various adverse activities causing considerable destruction or impairment of ecological chain in the coastal zone ; in consideration of a long-term objective of establishing a sustainable resource development ; in consideration of promotion of natural science and education ; recreation, sport and tourism and in consideration of significant role of the coastal ecosystem in the management and conservation of the endangered marine species, the establishment of marine parks and reserves in certain areas are found to be essential and imperative.

13. Mangroves from an unique and dynamic ecosystem for a variety of reasons, large areas of mangrove vegetation and its environment are being lost or threatened with disruption. In view of the significant input to the fisheries they support, the role they play in the ecology of the coastal system and for the purpose of management of the resources on a sustained yield basis, the symposium noted their importance and the need for immediate protection.

14. The Conference noted the substantial changes and the complex interaction occurring at certain transitional areas between the hinterland, intertidal zone and open sea due to clearing off or deforestation of vegetation in the coastal zone, scouring and siltation of estuarine distributaries and river mouths, increasing pollution, frequent floodings and geomorphological changes causing erosion of shore line by wave and current action, and stressed the need for detailed investigations on the natural and man-induced changes so as to evolve most effective programmes of coastal zone management.

15. Besides the scientific investigation on the endangered marine species and the practical measures to be taken up for the management and conservation of their

resources, the symposium laid considerable emphasis on education, training and extension on the value of the resources in maintaining the balance of nature, their role in the marine ecosystem and the need and responsibilities towards the management and conservation of these resources to the benefit of mankind.

16. It also noted that the public at large is not aware of the status of endangered and vulnerable marine animals and that public opinion in favour of conservation of these organisms can arise only from awareness of their present status. This necessitates well organised public awareness programmes.

17. Investigations on endangered marine animals and their habitat would often transcend regional and national boundaries. Exchange of data would also help to better appreciation and understanding of the resources and problems encountered. This would require international cooperation to share the knowledge and expertise to develop mutually beneficial programmes and to ensure better management and implementation of these programmes.

RECOMMENDATIONS

On the premises of the foregoing observations and on the basis of the general consensus the Symposium identifies the following priority areas and recommends that :

1. The Indian Ocean Sanctuary be included as a subject matter for discussion in the Agenda of the forthcoming Working Group meeting to be held in Cambridge, United Kingdom in February, 1985 if already not done so to discuss the future of the International Whaling Commission and that some of the Indian Ocean coastal states be included in the Working Group formed to discuss the future of the International Whaling Commission so as to enable them to express their concern and interest in the Indian Ocean Sanctuary.

2. The Indian Ocean coastal states themselves may come forward in an appropriate manner to look after the interests of the Indian Ocean Sanctuary for non-consumptive utilisation of the marine mammals at least for the next ten years.

3. A comprehensive project entitled 'Project Dugong', involving population assessment, investigations on the biology, ecology and behaviour of the dugong and practical measures for management and conservation be formulated and implemented immediately with adequate financial and manpower allocations and infrastructural facilities. Simultaneously, vigorous and massive efforts be launched in cooperation with the local village organisations to create a public awareness on the need for the conservation of the residual population in the gulf of Mannar and Palk Bay and to cease further exploitation and utilisation of the resource. International Co-operation between India and Sri Lanka will also be necessary to make "Project Dugong" a success.

4. In view of the dwindling resource of dugong and its illegal exploitation, the concerned authorities and the Indian Wildlife (Protection) Act 1972 enforcing agencies be informed of the urgency of strict enforcement of regulations to protect the dugong, and be requested to act immediately and forcefully to prevent the loss of the remaining stock.

5. Data on capture of endangered marine animals, their strandings and on the incidental catches in fishing and other activities be collected and made available to a National Data Centre for consolidation and dissemination.

6. Strategies for conservation and management of the sea turtle resources of India through habitat preservation, species preservation, enforcement of prevalent laws and regulations, researches on the resource and through education, training and extension identified and recommended in the Workshop on 'Sea Turtle Conservation' held in Madras in February, 1984 be implemented immediately.

7. The massive Arribada nesting of the olive ridley turtles along the Bhitarkanika and Konark coasts in Orissa is an unique phenomenon and is one of the most interesting features in the animal and biological realm. To provide protection and proper management and conservation measures to this breeding population, the Conference urges to elevate the status of Bhitarkanika and Konark Sanctuaries to that of National Parks and to extend the seaward boundary of these areas to 10 nautical miles all along the Gahirmatha-Konark coast so as to afford seasonal protection to the mating and nesting olive ridley.

8. The brackishwater turtles, namely, *Batagur baska* and *Pelochelys bibroni* which are heavily exploited and highly vulnerable be included in the Schedule I of the Indian Wildlife (Protection) Act, 1972. A scientifically planned survey be immediately launched in the major estuarine systems of India and in the adjacent coastal systems to assess their population and distribution pattern and to locate the nesting sites of the endangered brackishwater turtles. Similarly, hatcheries or protected nesting sites be established in appropriate localities to replenish the resources through recovery programmes.

9. The National Marine Park proposed at Gulf of Mannar be established immediately, providing adequate finance, manpower and infrastructural facilities.

10. While establishing the Gulf of Mannar National Marine Park, attention should be paid to the human resource base within the area. For ensuring stability of the establishment, pragmatic programmes be evolved to utilise traditional skills of local communities in alternate avocations or in sectoral development programmes.

11. Further, the National Marine Park thus established be modelled to demonstrate the multiple use and utilisation of the system for research, education, propagation of awareness on the need for management and conservation of the resources and the ecosystem among the public and to show the advantages of rational exploitation of the sectoral resources available in the area.

12. A Marine Park Authority be established for administration and management of the National Marine Parks so as to ensure integrated approach to the development of the area and for better coordination of the different sectoral programmes envisaged in the National Marine Park Project.

13. Programmes be drawn up and implemented to survey the seagrass beds along the Indian Coasts as well as in the Bay islands and in Lakshadweep islands. Investigations may also be initiated to study the biology, ecology and dynamics of the seagrass ecosystem.
14. Adequate measures be developed to protect and propagate the mangrove ecosystem which plays significant role in providing food and shelter to several organisms and is recognised as an important resource which, with proper management can provide a base for conservation and integration to economic development schemes including fisheries and aquaculture.
15. Similarly, appropriate measures be initiated to preserve the coral reefs which are quarried and destroyed in favour of short-term economic gains.

In addition to the above important recommendations, the Symposium made the following general recommendations.

16. The multiplication of zoos and oceanaria for marine mammals be generally discouraged and the resources available for such programmes be utilised for improving the conditions of those existing and for establishing very limited number or additional oceanaria in regions/countries where such facility is considered absolutely essential in order to improve quality of research and aid building up of public awareness.
17. Well planned public awareness programmes be taken up to inform the public on the status of endangered and vulnerable marine animals through all available media of mass communication and appropriate displays and exhibitions.
18. Aerial surveys and remote sensing and other tested methods be employed for the assessment of endangered marine resources and to study the population characteristics and the ecosystem.
19. The mark-recovery programme on turtles to study their migration, age and growth, breeding habits and feeding grounds, be intensified and the cooperation of different Departments of the maritime states and the agencies involved in maritime activities be requested to gather reliable information for the success of the project.
20. Appropriate facilities be provided at Andaman and Nicobar islands where several endangered and/or vulnerable marine animals breed and propagate, for research and observation on their natural life and habitat.
21. Investigations be strengthened and intensified providing adequate facilities to study the pattern of natural and man-induced changes which considerably affect the coastal areas between the hinterland—intertidal zone—open sea, so as to evolve most effective and functional coastal zone management and resources management programmes.
22. As the resource of several of the endangered marine animals are distributed beyond the regional and national boundaries, international cooperation to exchange scientific knowledge and expertise be promoted for mutual benefit and advantage. Such cooperation could also help to consider international management problems of the endangered marine animals.

SYMPOSIUM ON ENDANGERED MARINE ANIMALS AND MARINE PARKS

COCHIN, INDIA* 12-16 JANUARY 1985

PROGRAMME

11 January 1985, Friday

Hours

1000—1600 **Registration**

Venue : Central Marine Fisheries Research Institute's Annex, M/s. S. T. Reddiar Press Building, M. G. Road, Cochin-682 035 (Opposite to International Hotel).

12 January 1985, Saturday

0800—1030 **Registration**

Venue : International Hotel, M. G. Road, Ernakulam, Cochin-682 035

1100—1230 **Inauguration of the Symposium**

Venue : Kerala Fine Arts Theatre,
Foreshore Road, Cochin-682 016

TECHNICAL SESSIONS

Venue : **Banquet Hall,** International Hotel

12 January 1985, Saturday

1330—1400 Meeting of Chairmen and Rapporteurs

1400—1445 INTRODUCTORY SESSION

Chairman	..	Dr. Salim Ali
Opening Statement	..	Dr. B. G. Silas
Keynote Address	..	J. C. Daniel

1445—1700 SESSION I : MARINE MAMMALS—LESSER CETACEANS

Chairman	..	Dr. S. Jones
Rapporteurs	..	Mr. S. Mahadevan
		Mr. M. M. Meiyappan

13 January 1985, Sunday

0990—1300 SESSION II : MARINE MAMMALS—WHALES

Chairman	..	Dr. Roger Payne
Rapporteurs	..	Dr. K. Alagarswami
		Dr. R. S. Lal Mohan

1400—1700 SESSION III : MARINE MAMMALS—DUGONGS

Chairman .. Dr. P. S. B. R. James
Rapporteurs .. Dr. D. B. James
Dr. P. Nammalwar

14 January 1985, Monday

0930—1300 SESSION IV : ESTUARINE AND MARINE REPTILES

Chairman .. Mr. J. C. Daniel
Rapporteurs .. Mr. P. Kannan
Mr. M. Rajagopalan

15 January 1985, Tuesday

0930—1300 SESSION V : MARINE PARKS, SANCTUARIES AND RESERVES

Chairman .. Dr. E. G. Silas
Rapporteurs .. Mr. K. Nagappan Nayar
Dr. P. P. Pillai

16 January 1985, Wednesday

0930—1300 SESSION VI : ENDANGERED AND/OR VULNERABLE MARINE INVERTEBRATES AND VERTEBRATES

Chairman .. Dr. Rudolf Altevogt
Rapporteurs .. Mr. M. S. Muthu
Mr. A. Bastian Fernando

1500—1630 PLENARY SESSION : RESUME AND RECOMMENDATIONS

Chairman .. Dr. E. G. Silas
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SYMPOSIUM ON ENDANGERED MARINE ANIMALS AND MARINE PARKS

COCHIN, INDIA 12-16 JANUARY 1985

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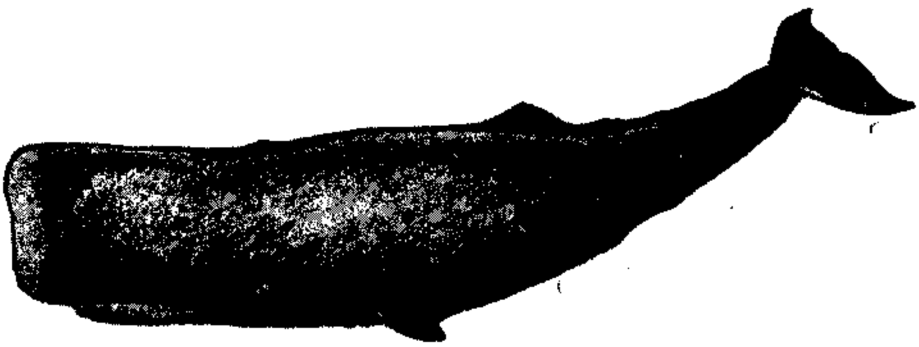
Marine Mammals



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WHAT IS 'ENDANGERED'?

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INTRODUCTION

IN ADDRESSING biological and management problems, one of the first points that must be established is the status of the population or species in question. When the future of a population or species is thought to be insecure, special attention is warranted ; special programs and protection are needed to insure its continued survival. The term 'endangered' is often applied to populations in this condition in order to draw attention to a serious problem in wildlife or fisheries management. The purpose of this paper is to examine : the concept 'endangered', how we define and recognize this condition objectively, and how we best use the term to attain long range management goals.

ABUNDANCE AS A MEASURE OF 'ENDANGEREDNESS'

As a general rule, what is rare is endangered. When populations exist in great numbers their futures are usually relatively secure ; when they exist in small numbers—are regarded as 'rare' —their futures are commonly insecure. However, there are exceptions, and abundance is only one of several indicators of the future status of a population.

ORGANISMS THAT ARE ABUNDANT

The generalization—'What is abundant is secure' has numerous exceptions in natural history. Bison (*Bison bison*) once occurred in North America in such numbers that they were the dominant species and the greatest concentration of vertebrate biomass over a vast area. There was no large vertebrate as abundant as Bison ('Buffalo') in the Great Plains, yet within a few decades of western colonization their numbers were so reduced that they were in danger of disappearing completely. Only a concerted last minute effort kept the Bison from certain extinction. Another example from North America is the Passenger Pigeon (*Ectopistes migratorious*), famous for blackening the sky with its enormous migratory flocks. Yet, abundance did not save this species, for after decades of slaughter the last one died in the confines of a zoo in 1914. There are many other examples, from other continents where merely being abundant or numerous did not secure the future of the species (*e.g.* caimans in Amazonia, Vicuñas in the Andean plateau, and the Quagga of Africa) (Dorst, 1972).

Species that are abundant or numerous on islands seem even less secure ; the histories of the Dodo (*Raphus cucullatus*), Giant Auk (*Alca impennis*) and several giant land tortoises (*Geochelone* spp.) illustrate this point. The fragility of island biotas is well known, as a great many island species have been exterminated or so decimated that there is less hope every year that they will be able to survive (Dorst, 1972).

Because, in general, there is better understanding of terrestrial than marine ecosystems more examples are available for land animals.

Perhaps the most dramatic example of an abundant marine animal that experienced a massive population decline is the Peruvian anchovey (*Engraulis ringens*). One of the world's largest fisheries was based on this small fish, but in 1972 the population crashed and it has never recovered (Barber & Chavez, 1983). The California sardine (*Sardinops caerulea*) had a similar fate, only earlier. Around the world, whale and seal populations that were once immense have been reduced to mere vestiges of their former numbers (Dorst, 1972). The same has happened to the formerly abundant sea otter (Ralls *et al.*, 1983).

Marine turtles, once incredibly abundant in many areas of the world, today often exist in small populations. In Bermuda, Cayman and other Caribbean islands enormous populations of Green Turtles, *Chelonia mydas*, were exterminated soon after the arrival of Europeans (King, 1982). Pacific Mexico once had 4 beaches, each with hundreds of thousands of Olive Ridleys, *Lepidochelys olivacea*, massing to nest; now three of these populations have been depleted to the point of economical extinction, i.e., the population is so diminished that it is no longer an economic resource (Frazier, 1980). In fact, among marine species it is common that populations that exist in large numbers are exterminated economically, not biologically.

Organisms that are Rare

In contrast to populations that occur in large numbers—are 'abundant', there are populations in which the individuals are highly dispersed or rare, and our evaluation of these species is often clouded by their rareness. According to several ecological and ethological principals we expect there to be a great difference in the relative abundance of different species. The Eltonian Piramid explains why large predators are much less common than their prey, or hervivores (Elton, 1927). Batesian mimics, that are edible or not dangerous yet resemble toxic or harmful species, are much less common than are their models (Wickler, 1968).

Some species, for reasons that are not always understood, are simply uncommon. The Coelecanth (*Latimeria chalumnae*) is regarded as rare, yet it seems to have survived for millennia (Smith, 1957). There are any number of marine gastropods that command extraordinary prices among collectors—simply because they are difficult to find, or rare. Existing at low density—being rare—is frequently characteristic, or part of the biology, of many species.

Fluctuations in Relative Abundance

When assigning a category of 'abundant' or 'rare', one is characterizing the status of a population at a particular point in time. It has been known for centuries that the sizes of populations may fluctuate tremendously (Elton, 1927). Man is not the only agent in causing changes in populations, although he has become a major factor during the last century. The Niño phenomenon of 1982-83 resulted in massive alterations to marine and terrestrial environments and populations dependent upon them (Halpern, 1982-84). Indeed, the relative abundance of animal populations, and the fluctuations that occur, has concerned biologists for centuries (Darwin, 1859). Hence, a category of relative abundance for a particular population may be valid for only a short time, and changes in abundance may or may not be related to Man's activities.

Are Rare Species more Endangered than Abundant Species?

Among some conservationists it is often taken as a truism that the rarer a species is the more endangered it is. However, the future of certain abundant species may not be secure, while the future of some rare species may be secure. The assumption that what is abundant is safe and what is rare is endangered is not always valid, and at times these are dangerously misleading assumption.

Relatively abundant species may experience massive population declines in response to a variety of factors such as climatic changes, habitat change, or disease. Density-dependent factors are of particular importance to relatively abundant species which have relatively greater impacts on their environments.

An abundant species is likely to attract attention and then an interest in exploitation. If, as is usually the case, it is a common resource, it is most likely that exploitation will be intense in an attempt to accrue the maximum gain with the minimum of time, effort and expense (Harden, 1938). Hence, certain abundant species may be more liable than uncommon species to suffer declines at the hand of Man.

The effects of a decline are more likely to be felt in a previously abundant species, which is likely to suffer a change of relatively greater magnitude. A species that normally exists at high density may lack physiological, ethological or ecological adaptations to survive at low densities. On the other hand, a decline may have little effect on a species that normally exists and successfully reproduces at low densities.

CONCEPTS INVOLVED IN THE TERM 'ENDANGERED'

A simple census of a particular population at a point in time is not adequate to determine whether or not the population is endangered. 'Endangered' is not a synonym for 'population size', or even 'population density', although it is commonly used in this way. The term embodies concepts such as rate of recruitment, and population dynamics, so that it is an estimate of the population size or density over some considerable *future* span of time. Simply, an endangered population is one that is unlikely to be able to replace itself given present conditions, and at some future point mortality will far outpace recruitment and it will disappear.

There is another semantic problem that is also serious. Sometimes 'endangered' is simply applied to populations that have experienced declines (with or without the help of Man) but are now stable or increasing. 'Endangered' incorporates elements of prediction, it is complementary—but not synonymous—with terms such as 'depleted', 'decimated', or 'reduced', which merely describe the past. This is not to deny that the past and the future are related, but instead to argue that they are not the same.

The study of population dynamics is almost as much Art as Science, and in very few cases is it possible to make predictions accruate enough to use the term 'endangered' with exactitude. Hence, in addition to semantic problems there are technical problems in the use of the term 'endangered'.

IS 'ENDANGERED' A USEFUL TERM FOR CONSERVATION?

With a history of semantic misuse (mistakenly using 'endangered' as an index of population size or population density or a description of past population declines) and grave technological limitations (inability to make accurate predictions of population dynamics and, hence inability to use the term 'endangered' precisely), it might be concluded that 'endangered' is not a useful term. There are strong arguments that 'To say that a species is endangered may suggest urgency but is not very informative' (Mrosovsky, 1983-84). However, the term appropriately emphasizes that a population or species is in peril or danger. It is indeed a useful term, but only if applied as an estimator of the future status of a population—not as simple indicator of past or present population levels.

Recommendations

In marine studies we are in many ways far behind terrestrial studies. The biology of marine turtles illustrates this: major populations are still being found, and there are reliable population estimates for almost none; despite the fact that the group is distinctive and small (about 7 species), there is taxonomic confusion with three species; basic points in the life history are unknown (*e.g.*, time to mature, longevity, sex ratios); and basic, obvious questions about their biology are unanswered (Frazier, 1984). The shortcomings seem all the greater when it is realized that detailed studies have been carried out for half a century (*e.g.*, Deraniyagala, 1939), and today there are hundreds of sea turtle biologists in over 80 countries (Frazer, 1984).

Efforts to conserve marine resources, such as marine turtles, are thus handicaped for many reasons, and it is imperative that efforts be concentrated on the most important issues. Appropriate use of the category 'endangered' will insure that the truly important problems will receive attention; overusing the term will detract attention from the critical issues and dilute efforts that already suffer from a lack of resources and support.

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ECONOMICS, NATURAL JUSTICE AND THE CONSERVATION OF MARINE MAMMALS

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ABSTRACT

The particularly emotive appeal of marine mammals should not override objective enquiry into their value. Economic techniques of evaluation refer to the judgements of value made by individuals, and a modern philosophy of justice requires us to give greatest attention to value accruing to least-favoured individuals. Inclusion of future generations only through the normal economic discounting process violates the ground rules of justice, and the value of long-term conservation is generally higher than credited by conventional cost-benefit analysis. The meaning and interpretation of conservation as an end in itself is debatable, but economic enquiry helps at least to clarify the issues.

INTRODUCTION

BIOLOGICAL scientists, who on the whole covet a reputation for objective enquiry, are apt to become a little less than objective when emotive policy issues which defy ready quantification are involved. The conservation of marine mammals is one such issue. Creatures like the dolphin enlist our sympathy as human beings through behavioural patterns which are easy to interpret anthropomorphically and through an apparent mutuality in enjoying the company of man. The whales engage our awe with their size and, more recently, by what some have interpreted as sensitivity and even creativity, while the dugong's popularity as a curio is well attested by its regular appearances in the literature of conservation. And when man, feeling lonely in the universe, poses metaphysical questions at the creation, perhaps the marine mammals seem to provide the closest thing to an unexpected answering voice from the animal kingdom.

Thus, more than with most creatures, it is tempting to respond to the question 'why, conserve marine mammals?' by asserting that they have a RIGHT to continued existence, much as we would claim that right for man, both as a species and as an individual. And that right is an absolute one, rather than a desideratum to be weighed relative to the right to existence of other creatures, or of human populations partially dependent on exploitation of that species.

Nevertheless, restricted budgets and competition for land and for access to marine resources have in recent years forced scientists to begin a more conscious search for priorities and relative values in nature conservation (Helliwell, 1973 ; Ratcliffe, 1977). And, as it becomes difficult to compare the intrinsic merit of very disparate habitats and organisms, some high-order criterion of value is required : Margules and Usher have studied criteria used for assessing conservation value of habitats and conclude that diversity, rarity and naturalness are the more widely applied. In relation to individual species, Moore (1969) and Helliwell (1973) go so far as to list material, recreational and scientific 'products' emanating from the existence of species. The view of conservation takes the first steps towards that of the economist.

ECONOMICS, UTILITY AND CONSERVATION

Economists too, among their own kind, cherish the reputation of objectivity. They also, in their way, are behavioural scientists, with a predilection for quantification as they study the patterns of choice made by humanity. They equally are testing hypotheses which may underlie humanity's attempt to satisfy apparently limitless wants in the face of limited resources. They, as much as biologists, are wary of perpetrating overt value judgements within their field of technical expertise. But for more than a century there has been a branch of the subject, welfare economics, which has grappled with the problem of evaluating alternative course of action and which has its present-day apotheosis in the widespread application of cost-benefit analysis (Winch, 1972). Stated simply, the philosophy of welfare economics is this: if at least one human individual prefers condition A to condition B, and no individual prefers condition B to condition A, then condition A is more valuable than condition B. This is not a very exciting proposition and one whose practical usefulness is restrictive in the extreme, since it may be assumed that changes which are agreeable to all individuals will be made without the facilitating services of welfare economists. However, the philosophy underlying cost-benefit analysis goes further: it can easily be shown that an individual acting to maximise his own satisfaction will arrange his discretionary purchases so that, for the last unit purchased of each commodity, the value or UTILITY per pound, dollar or rupee expended is equal. If, then, some individual is willing to pay P for admission to view a marine park, and Q for a kilogram of some material product based on exploitation of marine mammals, then P and Q are cardinal measures of the value to that individual of the recreational and material attributes of the marine mammal.

The evaluation of conservation is complicated by the time dimension, since exploitation or conservation NOW has implications for the stream of products to be expected in the future. The welfare economist, however, is able to adduce evidence for the value ascribed to future products by individuals, through examining choices made in financial and physical investments. Of the two approaches commonly adopted, that invoking the opportunity cost of capital is ignored here; its implications for marine mammals are reviewed in Price (1981). The alternative, time preference approach is as follows: if investment stops at the point where \$X of potential purchasing power sacrificed now will yield \$X+x of purchasing power in one year, then the implication is that \$X+x in a year is worth no more than \$X now: there is, it s said, a DISCOUNT by a factor of X/(X+x) on each year of futurity, and a discount of (X/(X+x))^t on t years of futurity. Mathematically speaking, this amounts to no more than the obverse of the law of compound interest growth.

In evaluating the conservation value of species S, the economist sums the combined material, recreational and scientific value of the species for each year of the individual's life span thus:

Conservation value = V + V (X/(X+x)) + V(X/(X+x))^2... + V(X/(X+x))^T

where V is the annual combined value and T is the individual's life-span.

As we prolong T, this converges quite rapidly on

Conservation value = VX/x.

What a society of N individuals then would lose with the extinction of species S can be no more than NVX/x.

Less dramatically, a single individual of species S is worth killing if the discounted value of the stream of benefits due to its reproductive capacity is less than its instantaneous value if killed. In general, it will continue to be worth killing individuals of S while the discount rate, defined as x/X, exceeds the net reproduction rate. In terms of the modern industrial economy, it is the misfortune of marine mammals to be burdened with a long reproduction cycle. Neither, as a result of their size, are they afforded the economic protection of being exceedingly costly to find and kill when population densities are low. Thus the economist may not only be able to explain the course towards extinction of the great whales: he may also show that, in the system as defined, this course is a perfectly rational one (Clark, 1973).

Is Conservation an Undefinable Value?

It is in response to such coldly quantitative probings by their economic colleagues that biological scientists are apt to become least rational, reasserting with greater fervour the absolute right of S to survive as a species, and very likely calling into question (imprecisely) the validity of any economic reasoning that they have not troubled to understand. But the economist, his curiosity aroused by this behavioural characteristic, may be moved to enquire further: for what represents to the biologist an inscrutable and inviolable value judgement is for the welfare economist the very essence of his chosen sphere of study. The economist recognizes no absolute good to be asserted in making ECONOMIC choices, only a trading, in principle quantifiable, between different, competing desires. And, if the choice is NOT economic, that is, if trading of values is prohibited by some ethical constraint, he will wish to test the nature of the constraint, so that at the very least he can quantify the cost of foregoing the courses of action (extinction of species S) which the constraint forbids. The economist will want to know if the right of S to exist springs from its ability to meet our present needs, a potentiality to meet the purposes of the future (which cannot be served without its present conservation) or from a value independent of man altogether.

There is one school of economic thought which says that utility exists only to the extent that man believes that it exists. Then the interpretation of the statement that species S has the right to exist is simply that we value its right to exist, from which it is two short steps to saying that we value its existence, and that its existence supplies us with products that we value. But if we are saying no more than this, the obvious imperative for the economist is to go out and measure as precisely as possible the willingness to pay for the attributes of species S relative to those of species T, or of bread, or motor-cars; he will certainly wish to resist any attempt to obfuscate the issue by the introduction of ethics.

Very likely objection will ensue from the biologist, that not all values stemming from conservation enter the economist's market-place, so the full range of choices of value cannot be quantified in terms of willingness to pay. What of aesthetic delight? What of the satisfaction of armchair conservationists who never visit nature reserves? This certainly presents a difficulty, but not an insuperable one. Many techniques have been devised of revealing willingness to pay where no market exists, as the proliferation of books on this aspect of cost-benefit analysis shows (Freeman, 1979; Mooney, 1977; Pearce and Nash, 1981; Price, 1978; Sinden and Worrell, 1979).

Nevertheless we MAY choose to question the assumption which underlies nearly all of welfare economics: that individuals are the best judges of their own welfare, and make choices accordingly. Perhaps conservation is better for people than they know, and better than they are prepared to reveal through willingness to pay. Perhaps we are entitled to assume that they would only miss species S when it had become extinct .....

This approach, however, raises doubts about what collectivity it is that constitutes 'we', and what right this one section of society has to impose its judgements of value on other sections. Training in biology, far from producing impartial judgement of the relationship of biological to other values, yields a predisposition to overrate conservation per se. A cynical interpretation of the statement that species S has the right to exist can be made as follows :

> 'Decision-makers and nature conservationists and economists in the environmental field are part of a group whose interests lie more squarely in nature conservation than the interests of consumers in general do. Thus there are ulterior motives for loading the evaluation dice in favour of nature conservation values. If the values identified by the consumers themselves appear insufficient to give the required weighting to nature conservation, it is convenient that there should be a theoretical reserve which can move decisions in the "right" direction. If it is a value hard to quantify and even to qualify, so much the better for the inscrutability of the decision !' (Price, 1983).

So that what poses as a selfless concern for the rights of species S might in fact rather be a self-interested denial of rights to group H within human society, who would prefer funds to be spent other than on conservation projects, and who would support freedom to exploit any particular species. In this view vehemence in asserting unquestionable rights is a cover-up for a judgement which the biologist knows in his heart is at variance with that of the majority, who care nothing for whether the dugong survives or not.

Compiling such varying judgements has in fact provided one of the major impasses of welfare economics. What can be said with certainty, when individual I prefers condition A to condition B, but individual J prefers condition B to condition A? The simple summation of willingness to pay for the products of alternative course of action (the expedient adopted by one school of cost-benefit analysts) unjustly penalizes those consumers who are constrained by poverty. The philosopher John Rawls (1971), in his influential work 'A Theory of Justice', suggest that ground rules for just policies are those that would be agreed in an 'original position' by representatives of all humanity, who would be prevented by 'a veil of ignorance' from knowing the human form (scientist, politician, subsistence fisherman) to which they would be born. Under these conditions, Rawls argues that no group's preferences or interests would be particularly weighted, except that priority would be given to the advancement of the less favoured. This philosophical position is reflected in the work of another school of cost-benefit analysts (UNIDO, 1972 ; Squire and van der Tak, 1975) who assign greater weight to the willingness to pay of poorer groups within society.

Under these rules we might expect less weight to be given to their preferences of affluent scientists whose daily bread is assured, and less to the pro-conservation voices from developed countries, while the capacity of ecosystems to supply the immediate wants of impoverished groups would be accorded greater significance. (It has to be said, however, that this last argument is more relevant to subsistence fishing economics than to the highly capital-intensive whaling industry.)

Conservation, Utility and future Generations

If consideration of the just desires of present generations fails to establish the case for conserving species S, a further argument prevalently urged by conservationists is the right of future generations to enjoy whatever benefits accrue from the continued existence of S. According to this viewpoint, while this generation is entitled to make its own judgements as to the relative merits of conservation and extinction for its own purposes, it has no right to impose the deprivations consequent upon extinction on future generations.

Economists of the western tradition have normally treated utility to future generations by extension of the discounting process adopted by present individuals. Some of them (e.g. Marglin, 1963) have argued that it is authoritarian of present generations to assign any particular set of preferences to future generations, whom we cannot directly consult, and that therefore our only basis for valuing future utilities is through the relative evaluations of present and future made by those whom we CAN consult. The end result of this process is that the value in perpetuity of conserving species S in only some small multiple (X/x)oits present annual value, and the proportion of utility ascribed to each future generation shrivels to infinitesimal within two or three generations.

However, it is rather evident that it is not really a matter of WHETHBR our decisions embody a set of preferences for future generations, but of WHICH set of preferences we adopt. For if our choices between present and future embody only our own preferences, we implicitly assume either that future generations have no preferences at all, or that they will concur with our judgement that utility accruing to our generation is far more important than utility accruing to their own.

By contrast, adopting the Rawlsian original position, in which we do not know the generation into which we will be born, we may conclude that justice will be served only if we assign equal weight to every generation. Discounting is the prerogative of each generation only within its own life-span. Kula (1981) has attempted to devise a modified system of economic evaluation, which allows only intra-generational discounting, thereby according with Rawlsian justice while respecting the intertemporal choices of present generations. But this system produces bizarre consequences (Price, 1984a), and does not surmount the problem that conservation values of a species saved from extinction are jointly consumed by members of all generations. If members of the present generation discount their share of future conservation benefits, that reduces the value of conservation projects, and so reduces the probability that benefits will be realized infuture. Less emphasis is thus given Overall to future than to present generations, and Rawlsian justice is not served. The resolution of these perplexes is only to be found through re-examining the implications of individuals' intertemporal choices as follows :

> '(1) individuals prefer to consume now rather than in future ;
>
> (2) individuals would also prefer to consume now rather than to have consumed in the past ;
>
> (3) this is consistent with general preference for consuming now rather than at any other time : it is not consistent with general preference for consumption earlier rather than later ;
>
> (4) since each point in time is equally now only once, there is no reason for consumers to prefer consumption at one point in time, simply because it is earlier ; and
>
> (5) the argument is not obvious, because choices, as opposed to preferences, must always refer to present and future, the past being immutable ' (Price, 1984a).

Discounting on the basis of consumers' impatience for consumption is, simply, a mistaken interpretation by economists of the behavioural pattern of consumers. That argument may seem obvious enough to biologists, but to western economists it appears so much of a heresy that it is hard for them to accept it. It certainly opens up an entirely new perspective on the economics of extinction, for a discount-free evaluation assigns indefinitely large value to the perpetual conservation of a desirable species. (It must be added, by way of a caveat, that a single conservation-orientated act does not of itself assure a perpetual stream of benefit, and that economic evaluations must take into account the risk of extinction occurring through some uncontrolled cause.) Furthermore, decisions on the breeding stock within an exploitation system depend no longer on reproductive rate, but on the efficiency of the processes of capture, with implications of much higher optimal stocking levels.

And yet, just as in interpersonal comparisons, so in comparison of generations, justice requires us to give lesser priority to those generations more favoured by affluence. This constitutes the economist's strongest ethical case for discounting, to the extent that it is assumed that future generations will continue to benefit from the economic growth which has characterized the last 200 years in the western world. Several reservations must be noted, however:

1. Not all individuals partake equally of economic growth, and discounting based on average national growth rates is quite inappropriate for utility accruing to members of a static subsistence economy (Price and Nair, in press).

2. The past trend of economic growth may not be sustainable into the indefinite future (Meadows *et al.*, 1972), and while uncertainty prevails about this the validity of discounting should not be assumed (Price, 1984b).

3. Even if material products become continuously more abundant, there is no guarantee that the environment will improve. Some economists (Fisher and Krutilla, 1975) have argued on this basis that material values will ultimately become trivial relative to the recreational and educational attributes of natural resources: the value of species S comes to rest less and less with the material goods its exploitation can furnish, more and the more with the values ascribed to its very existence-values which we have no basis for supposing will be any less in 10, or 100, or 1000 years time. Indeed, as this knowledge becomes available to a progressively larger proportion of a growing human population, we may expect its summed value to increase.

Conservation for itself

And so we return to a valuation of existence for its own sake. When we say that species S has a right to exist, do we mean to include it in our scheme of natural justice so completely, that their members of the collectivity devising the rules of justice in the Rawlsian original position would not know whether they would be born man or dolphin or dugong, or whether a future extinction might preclude them from existence altogether? Do we allow marine mammals the possibility of sitting in judgement on the utility to be assigned to nature conservationist as much as vice versa? It is to be assumed that nature conservationists have utility to a dolphin in so far as they increase the probability of its own survival, but is that a strong enough argument against their extinction, if nature conservationists compete with dolphins for resources? These far-pressed extensions of Rawls's viewpoint at least serve to challenge our assumptions.

If we do not go so far, what DO we mean? That marine mammals have a right to the utility that they derive from being marine mammals being respected, however we choose to assess it? A few years ago questions like this might have been deemed utterly laughable, but they are being seriously debated now. If we are prepared to discuss the disutility to a whale of having an explosive harpoon stuck in it, we are bound to extend the discussion to whether there is some countervailing utility in the whale's prior life, and, if not, whether we ought not, as a long-term service to whaledom, to accelerate extinction, so bringing to an end a collective existence whose net product is distress. Can we be—does our scheme of value allow us to be—have we the imagination to be—so anthropomorphic? Or do we in reality still take the anthropocentric view, that we value, for our own sake, the knowledge that species S exists (which is not at all the same as saying that we are, altruistically, prepared to recognise the utility derived from life by species S)? Even the anthropocentric position bears further dissection. Is our valuation of nature conservation for its own sake a separable collection of valuations for individual species? If an individual species vanishes, is the satisfaction mankind derives from a knowledge of its existence permanently and constantly impoverished (With indefinitely large loss of utility) or will we in time transfer our interest to some other species which might otherwise have existed in conservational obscurity (in which case the time scale of loss is restricted)? Or do we value the IDEA of nature conservation or the notion of natural justice as an indivisible whole which is bruised by each affront to the natural system and disjointed by each significant extinction? And how long does the injury last? We remain offended, 200 years later, by that most famous of all extinctions, of the dodo; our offence is if anything heightened by the creature's celebrated ineptitude, which our anthropomorphism links to our feelings towards helpless babies and the physically and mentally handicapped of our own species. But for creatures of lesser renown will the sense of affront to natural justice remain so long, particularly as the list of extinctions lengthens and so diminishes the allocation we can make to each from our budget of concern? Natural justice may in principle be affronted as much by the extinction of an obscure ground-dwelling insect as by that of a great whale. But what the economist enquires into is our SENSE of natural justice, the extent to which affront causes us dissatisfaction, and the course through time of that dissatisfaction. Biologists may find that approach repugnant: but if they still assert natural justice as a good in some more absolute sense, they set themselves formidable metaphysical problems.

Conclusion

Under the apparently baleful eye of the economist, the biologist may find himself repudiating altogether the validity of the economic approach and simply reasserting that species S has an absolute right to exist. Or he may embark on a course of constantly shifting his ground: to avoid appearing selfish he invokes benefit to all mankind; to avoid appearing paternalist, he appeals to a sense of natural justice; to avoid appearing metaphysical, he subsumes the satisfaction of a creature's own existence within the satisfaction he feels at the creature's existence.

But the economist, if he has cultivated the humility which should be commonly prized among research workers, does not ask his questions with a sense of arrogant superiority. Rather he applies stimuli to the subject of his study—man—in an attempt to produce a behavioural response which he can interpret.

The fact is that conservation offers many values, material and aesthetic, physical and metaphysical, present and future. An application of the methods of welfare economics may help to sharpen our perception of those values. If we do not like the conclusions that welfare economics provides, we are free to examine the arguments leading to conclusions. To identify, specific flaws in the arguments is more constructive than to execrate the whole philosophy. And indeed, this paper has revealed that the process of discounting, as normally embodied in cost-benefit analysis, is defective in relation to conservation values, which may be expected greatly to exceed the figures conventionally credited.

Uncertainty is a strong characteristic both of the physical future of mankind, and of our perception of value in natural systems. On the other hand, nothing could be more certain than that if we bring about the extinction of species S, it will not exist for whatever purposes future generations might discover. Economists have recently developed the theory of rational choice when consequences of action are irreversible, but values uncertain (Henry, 1974). Their conclusions may cheer conservationists and incline them to think that economists may be their brothers after all: under the stated conditions, to deprive future generations species S is an affront not only to natural justice, but also to economic rationality. That is not, however, a valid reason to abandon enquiries designed to reduce the scope of our uncertainty.

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HISTORIC DATA AND SPERM WHALE MANAGEMENT

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ABSTRACT

Historic data demonstrate that the nineteenth century kill of sperm whales was (1) not large by present standards, yet (2) severely reduced the availability of these whales for capture. The mechanisms for reconciling these two inconsistent observations are probably a complex combination of, *first*, relatively large numerical kills in some specific whaling populations, such as in the Galapagos breeding ground, *second*, selective capture of large breeding bulls, and *third*, behavioural scarcity resulting from increased ability of the whales to escape detection and capture.

INTRODUCTION

PRODUCTIVITY analysis demonstrates that American whaling rendered the Pacific Ocean economically scarce of sperm whales by 1845 just half a century after that fishery commenced and less than two decades after it first attained prosperous 'Golden Age' levels. Between 1825-1829 and 1845-1848, sperm whaling barrel yields per ship ton-month were reduced by more than half, (Shuster 1972). The causes of this rapid decline have major implications for sperm whale management today, but they are difficult to isolate. There is an apparent paradox that the drastic decline occurred even though the number of sperm whales killed from 1820 through 1849 was not particularly large compared either to the catch rate in recent decades or to the then probable stock. Best (1983) contrasts figures of about 6,000 sperm whales killed in the 1830s to recent figures approaching 30,000 ; my own estimates show a peak of 8,300 sperm whales killed in 1837, still well short of modern levels. There are two major hypotheses which could explain a rapid decline in productivity without large numerical catches : (1) behavioural scarcity and (2) size selectivity. This article sets forth the historical evidence for each and the implications for the assessment of current sperm whale stocks and policies.

BEHAVIORAL SCARCITY

Economic scarcity from the viewpoint of whalers need not imply biological scarcity from the viewpoint of whales. If it was possible for whales to perceive danger at sufficient distances, if they benefited from a learning curve of deadly encounters and especially if they were able to communicate the presence of the threat to each other, the assaulted sperm whales could make themselves 'scarce,' Shuster (1975), Best (1983). Support for the behavioural scarcity hypotheses consists of both subjective and objective evidence.

The subjective data consists of the remarks of contemporary observers, but unfortunately there is a direct conflict in the opinion represented by such accounts. On the one hand there was the view that :

> 'Voyages are lengthened more on account of diminished numbers of whales, than by their going in schools or their wildness.' Davis, quoting Captain George Covill of New Bedford (1874).

On the other hand, there was the opinion exemplified by Beale's assessment of the 'Japan Ground.' Even though that ground had been much visited by 1839 :

> '.... the whales scarcely appear to be reduced in number. But they are much more difficult to get near than they were some years back, on account of the frequent harassing they have met with from boats and ships ; so that they have become now well aware of the reckless nature of their pursuers and they evince great, caution and instinct in avoiding them.' Beale (1839).

Other contemporary observers also pointed to the 'wildness' or 'shyness' of sperm whales, Davis, quoting a Captain West (1874) ; Browne (1846) ; Olmsted (1841) ; Nordhoff (1855) and Starbuck (1878) refers to both 'the scarcity and shyness' of sperm whales.

Despite the conflict, however, the subjective evidence of behavioral scarcity is impressive. The contemporary remarks about 'shyness' are complemented by the practices actually used or contemplated by whalemen. It was, for example, noted that :

> 'Sperm-whales have a means of communicating with each other at long distances ....The means are a mystery, but every whaleman has observed the fact and has based his operations in the chase upon it.' Davis (1874).

As a result of 'the wonderful way in which these whales realise at a great distance, if the slightest sound is made, the presence of danger,' whalemen took the 'most elaborate precautions to render their approach to a whale noiseless' (Bullen 1898), including the use of paddles and sails instead of oars, (Haley 1967). And one frustrated captain even suggested that whales should be hunted from balloons because :

> 'It is evident that the fear of the whaleboat has been transmitted until it has become instinctive and we must attack them from the air.' Davis, quoting Captain Butler of New London (1874).

Objective tests to resolve the controversy of opinion between numerical and behavioural scarcity must be carefully evaluated in light of many complex considerations. For example, data demonstrating decreased sightings per voyage can be reconciled with either explanation. Melville noted decreased sightings but favoured a behavioural explanation (Melville 1851). Similarly, even the measure of whales taken per sighting, at first blush a potential discriminant, could reflect either (1) decreasing numbers if such took the form of smaller schools and/or(2) greater escape and warning techniques. There is also a substantial complication in the fact that even within the major ocean for the sperm whale fishery, the Pacific, there may be separate stocks of whales.

A final geographical complexity depends on the interaction of a whale captain's objective to maximise barrels (not whales taken) and the distribution of larger sperm whales in higher latitudes, both north and south. A captain could achieve his objective either by many smaller whales or fewer larger ones, thus admitting of the possibility that numerically abundant areas might be depleted first, creating a crossover at a given point in time to higher latitudes with fewer, larger whales. Data, only preliminary at this point, suggest that in the 1830s the area within 20° north and south of the equator was heavily favored in terms of percentage of whales taken. In the 1840s there appears to have been a shift to the highest latitudes, with a small increase in average size per whale. This increase, without the geographical explanation, would be the opposite result anticipated if numerical scarcity was developing. In the 1850s there was an apparent return to areas closer to the equator, with a concomitant decrease in average whale size, Shuster (1983a).

With these qualifications, however, it is possible to focus on one particular whale ground as an example. Preliminary logbook data for the Galapagos Islands ground (defined for data purposes as 10° North to 10° South latitude, 80° West to 100° West longitude), suggest a pattern at least in that ground more consistent with numerical depletion. This was apparently always a breeder ground of many smaller sperm whales (largely cows and calves), (Stackpole 1972; Melville 1854). Comparison of the 1830s, 1840s and 1850s shows a pattern of decreasing average barrel yield (37 to 33 to 23 in the decades respectively) combined with no decrease in whales taken per sighting (Shuster 1983b). Observers labeled the ground as a 'favorite' as late as 1841 (Olmsted 1841), but referred to it as an 'old' ground with 'pretty dry cruising' subsequently (West 1965). These findings are more consistent with numerical depletion than with behavioural scarcity. It is not known, however, whether other grounds, perhaps representing separate sperm whale stocks, would exhibit the same pattern. It is conceivable that the divergence of subjective opinion among whaling captains may reflect a divergence of the relative importance of numerical and behavioral scarcity on the particular grounds which they happened to frequent, since different grounds may have represented discrete sperm whale stocks (Best 1974).

Size Selectivity

If numerical scarcity did indeed characterise the Galapagos ground, and perhaps others, how then can it be explained in the absence of any showing of large numerical kills? Mitchell has articulated the hypothesis that 19th century sperm whalers may have practiced some selectivity in favour of the large 'harem-masters' in their encounters with sperm whale schools, the consequence of such a preference being the potential for a far greater influence on sperm whale populations than the mere numbers killed would suggest [Mitchell (1977); Mitchell (1983); Chapman (1973)]. This hypothesis is based on the combined biological facts that (1) breeding harems have only one or a few breeding bulls and (2) sexual dimorphism is extreme in the sperm whale species, the breeding bulls being much larger than the females (Leatherwood, Caldwell and Winn 1976). It would provide another explanation in addition to behavioural scarcity to reconcile information on whales killed in the 19th century fishery with the dramatic reduction of yield per unit of effort.

Best (1983) has reviewed some of the contemporary whaling accounts on a preliminary basis to discern whether these would indicate a preference strategy and has found such a preliminary review to be inconclusive. There is, however, both subjective and objective evidence that such selectivity was practiced.

Whalemen were notoriously secretive about their whaling strategies, yet size selectivity is mentioned in several accounts, as for example:

> 'After making a little *detour*, we again stood toward the school and the mate singled out one huge fellow nearest us and happily the largest of the school, as our prize.' Nordhoff *(1855)*.

> 'Whales usually swim along in groups like a line of soldiers and the boat steerer always picks out the fattest and largest one, and in order to get him he must go between the flukes of two of them, which he must be very careful in doing . . .' Crapo *(1893)*. See also *Hart* (1834).

Even apart from deliberated strategy, there is also evidence that in the heat of the hunt whalemen so preferred larger whales that the preference controlled emergency judgments:

> '. . . there was an upheaval in the water just ahead and up came a back like a keelless ship bottom up. Out came the head belonging to it, and a spout like an explosion burst forth, denoting the presence of an enormous bull-cachalot. Close by his side was a cow about one-third his size, the favoured sultan of his harem, I suppose. Prudence whispered, 'Go for the cow'; ambition hissed, "All or none—the bull, the bull." Fortunately emegrencies of this kind leave one but a second or two to decide, as a rule; in this case, as it happened, I was spared even this mental conflict, for as we ran up between the two vast creatures, Samuels, never even looking at the cow, hurled his harpoon, with all the energy that he had been bursting with so long, at the mighty bull.' Bullen *(1898)*.

Interpretation of the selection strategy of whalemen must be made in light of the reactive behavior of sperm whale schools upon one of their member being harpooned. There is some inconsistency in the accounts, even by the same author, between those identifying a response of immediate alarm and flight by the other sperm whales upon one of their number being struck, (Chatterton 1925; Nordhoff 1855; Olmsted 1841) and those describing a 'heave-to' response among sperm whales, *i.e.*, circling and seeking to succour the stricken whale (Chatterton 1925; Davis 1874; Jenkins 1921). The latter would of course enhance the probability of multiple catches from the same lowering. There is an apparent reconciliation of these accounts, however, which makes the reactive behavior of the sperm whales a function of the type of the first whale struck:

> 'Dart an iron into a bull whale, or *gallie* him by going on his eye and almost simultaneously with his cutting flukes in the air the whole school will show alarm by running and cutting their flukes, or by disappearing from the surface and coming up miles to windward and running head out. It if be a cow that is struck, the bulls are arrested in flight and are apt to gather about her and offer chances for more than a single whale. Again, when a school of cows and calves are running frightened to windward and a calf be struck, the whole school will "bring to," and gather closely around the wounded young, sometimes so closely packed that the inclosed boat will not dare to use the lance; and they will thus remain as long as the calf is alive, or the iron holds. But should the iron draw or the calf die, the whole school will instantly scatter' (Davis 1874).

This same observation is made by Scammon (1874), Beale (1839) and Hart (1834).

This divergent reactive pattern is important in interpreting the objective data. Logbook data in the period 1830-1869 were analysed for whales captured from plural sightings (schools) to eliminate the effect of the well known fact that single sightings are predominantly large bulls. A sample of approximately 500 whales taken from plural sightings was compiled from logbooks which gave the individual barrel yield of the whales taken.

These data indicate a marked difference consistently present in each decade, between the average size of whales caught where only one was taken from a school and those where two or more were taken (Table 1).

TABLE 1. *Average size (Barrels) of sperm Whales caught in multiple sightings by decade*

Decade		Average barrels where 2 or more caught		Average barrels where 1 whale caught	
1830s	..	24.3	(114)	42.6	(76)
1840s	..	24.8	(69)	40.7	(51)
1850s	..	26.4	(101)	41.3	(58)
1860s	..	32.7	(23)	60.7	(24)

NOTE: Number of whales in sample given in parentheses.

Where only one whale was taken from a school, there was a far greater proportion of whales in the largest categories, that is, of 50 barrels or more and 80 barrels or more (Table 2).

TABLE 2. *Percentage of large sperm Whales (50 and 80 barrels minimum) caught in multiple sightings by decade*

Decade		Percentage where 2 or more caught: 50 or more barrels		Percentage where 2 or more caught: 80 or more barrels	Percentage where 1 whale caught: 50 or more barrels		Percentage where 1 whale caught: 80 or more barrels
1830s	..	11	(45)	0	41	(76)	9
1840s	..	4	(55)	0	33	(51)	8
1850s	..	7	(59)	0	34	(58)	7
1860s	..	11	(9)	11	55	(20)	45

NOTE: Total number of whales in sample, of which percentage taken, in parentheses.

A third to a half of the whales taken alone from plural sightings were 50 barrels or more ; only ten per cent of the multiple catch whales were of that size.

Overall, of all whales taken from schools, 26 per cent (94 of 363) were 50 barrels or more, i.e., large bull size.

Observers are unanimous that only one, Haley (1967), or possibly two or three, Scammon (1874) ; Ommanney (1971) ; Beale (1839) large bulls would be present in a given school. Schools comprised fifteen or twenty up to five or six hundred individuals, Beale (1839) ; Scammon (1874) ; Berzin (1972) reports on the basis of a review of the literature that the ratio of males to females in a harem may not exceed one to twelve. Berzin doubts, however, that large males were members of harem schools, a concept rejected by most other authors and belied by the numerous examples to the contrary in the logbook data in the present study. Best (1974) indicates that a male becomes a 'harem-master' at the age of 25-27 years, at a length of 45 feet and that there are at least 10 to 16 mature females per bull. In short, since the proportion of males to females taken from schools was at least one in four, a strong nineteenth century whaling selection for the large harem-masters is demonstrated.

The same size distinction between single and multiple catches from sperm whale schools persisted not only over time but also over space. Although in general, larger sperm whales were taken the greater the distance from the Equator, the difference between the average size of whales taken from schools depending upon whether a single or plural whales were taken was present at all latitudes (Tables 3 and 4).

TABLE 3. *Average size (barrels) of sperm whales caught in multiple sightings by latitude*

	Average barrels where 2 or more caught		Average barrels where 1 whale caught	
over 30° South	36.3	(20)	57.0	(36)
10—29° South	27.7	(35)	53.1	(26)
0— 9° South	24.6	(81)	34.2	(58)
0— 9° North	21.6	(52)	30.4	(35)
10—29° North	26.2	(13)	50.2	(12)
over 30° North	33.8	(17)	76.7	(3)

NOTE : Number of whales in sample given in parentheses.

The fifty-barrel cutoff is high enough to separate out nearly all, if not all, cow whales but it may also exclude some of the bulls. If

TABLE 4. *Percentage of large sperm whales (50 and 80 barrels minimum) caught in multiple sightings by latitude*

Latitude	PERCENTAGE WHERE 2 OR MORE CAUGHT 50 or more barrels		PERCENTAGE WHERE 2 OR MORE CAUGHT 80 or more barrels	PERCENTAGE WHERE 1 WHALE CAUGHT 50 or more barrels		PERCENTAGE WHERE 1 WHALE CAUGHT 80 or more barrels
Over 30° South ..	29	(14)	14	58	(36)	19
10-29° South ..	6	(17)	6	62	(26)	15
0-9° South ..	5	(61)	5	24	(58)	2
0-9° North ..	0	(41)	0	6	(31)	3
10-29° North ..	20	(10)	0	42	(12)	17
Over 30° North ..	38	(13)	0	100	(3)	33

NOTE : Total number of whales in sample, of which percentage taken, in parentheses.

so, the above sample data, particularly if combined with single sighting and catch data (almost always large bulls), corresponds remarkably well to the following contemporary account quoted by Browne (1846) :

> 'It is said that an equal proportion of bull and cow whales are taken. It is, however, admitted that the latter are the most numerous ; and the probable reason for the equality of the number taken may be, that the bull whale, being the largest, is most sought after. The bull whales yield, on an average, from thirty to one hundred barrels of oil, while the cows seldom exceed forty-five barrels and at times yield no more than five barrels.'

The objective data thus confirm that there was a significant tendency for large bull whales to be selectively taken from sperm whale schools by the American whalemen. There is a consistent difference between the size of whales taken singly from schools and the size of those in multiple catches. It is probable that this difference resulted both from strategy considerations by whalemen and the reactive behaviour of the whales themselves. Whatever the causes however, it is apparent that the American whalemen registered a far more than proportional impact on the larger members of the sperm whale schools encountered than random capture would produce.

Implication for Current Sperm Whale Management Policies

There are thus several mechanisms by which the nineteenth century kill of sperm whales, though not large by present standards, may have severely reduced the availability of these whales for capture. In certain grounds, such as the Galapagos Islands, the kill may have been severe enough to create numerical scarcity. Furthermore, the selective capture of large bulls have had a proportionately far greater impact on surviving numbers than the mere number killed would suggest. Finally, even in areas where numerical scarcity was not created, behavioural scarcity may have contributed to the productivity decline. Further refinement of the relative importance of these possibilities in the nineteenth century has important implications for sperm whale management today.

Until recently, it has generally been assumed that a combination of an aggregate limit on numbers taken with an individual minimum length would provide a sensible regime for management of sperm whale stocks. The reason for minimum length constraints is that the pronounced sexual dimorphism and polygamy in sperm whales permits the establishment of a length limit which protects the females at the expense of the presumably surplus males. In 1965, for example, Mackintosh concluded :

> 'Meanwhile there is a precautionary rule in operation which, if it is strictly observed, should go some way to safeguarding the supply of this particular species. This is the minimum length fixed by the (International Whaling) Commission at 38 feet for factory ships and 35 feet for land stations. The point is that in sperm whales, though not in baleen whales, the males grow to much larger sizes than the females. Beyond 35 feet the numbers of females falls off rapidly so that the limit should put the weight of catching on to males and protect most of the females. Now sperm whales are almost certainly polygamous, though the sex ratio appears to be about equal, and although there could be a biological need for some surplus males, it is a fair assumption that males are more easily spared from the populations of a polygamous species than from those of a monogamous species. That being so we have a good type of omnibus regulation in the minimum length, for it serves to protect breeding stocks, and at the same time, by concentrating the catching on the larger whales, it makes for higher production per whale killed.'

Though salutory in the conservation of some animal species, the establishment of a minimum without a maximum length for sperm whales may have precisely the opposite and undesired effect. Protection of the breeding stocks requires the protection of the few breeding bulls if anything more rather than less than protection of the breeding cows. The biological analysis of Mitchell (1977, 1983) points in the direction of not destroying the breeding of an entire 'harem' by killing its only 'harem-master'. The historic analysis supports the same conclusion. If the severe productivity decline in the nineteenth century can be attributed even in part to size selectivity, then it would exemplify the significant decimation to sperm whale stocks that such a policy, exacerbated by minimum length regulations, creates. In an era in which modern electronic devices, air reconnaisance, speedy catcher craft and the like minimise the changes for behavioural scarcity to protect sperm whale stocks, the factor of size selectivity takes on heightened importance.

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WHALES AND WHALING—AN INTERNATIONAL PERSPECTIVE AND ITS BEARING ON INDIAN OCEAN'S CONSERVATION EFFORTS

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Abstract

The 1979 declaration calling for ' Indian Ocean Sanctuary ' to study and conserve the endangered species in the region marked not only one of the milestones in the history of world-wide conservation campaign, but provided an unique opportunity to put into motion the scientific and technical machinery to embattle the issue in time. However, the ' conservation machine ' is not yet well-oiled, therefore seeking further improvements.

This paper concerns the search of finding better means and seeking more efficient measures which would strengthen both scientific and management approaches to study and conserve marine animals in the region.

In order to meet this objective first, I have presented an international perspective on marine mammals emphasizing commercial whaling *vs.* conservation response in the Antarctic, Pacific and Atlantic. Against this backdrop, I have proposed guidelines to evolve national and international policies and organizational strategies geared for successful conservation and utilization of marine animals in the Indian Ocean.

It is proposed that the *Indian Ocean Conservation Commission* (IOCC) be established to implement a formal and a cooperative approach toward conservation and management of life in the Indian Ocean. The IOCC, among other things, would serve as an executive coordinating organization bringing together all coastal nations rimming the Indian Ocean for a critical, albeit for a common cause, of conserving endangered sea animals. Also, it is proposed that IOCC should encourage establishment of national level chapters, thus permitting each sovereign coastal state to formulate its respective conservation and management policies applicable within its 200 miles economic zone (or, if it has adopted, in the Exclusive Economic Zone). India is considered a case in point for IOCC—national chapter.

Introduction

The worldwide efforts to save marine animals, notably whales, dolphins, porpoises and several others, stems from the growing fundamental notion ' sea mammals are common heritage of mankind'. Despite this universal belief, the merciless, and thoughtless slaughtering of whales for commercial purpose by a handful of nations continues to undermine the conservation efforts, particularly in the Antarctic, Pacific and Atlantic.

The Indian Ocean, in relation to other major oceans as mentioned, offers two distinct advantages from a conservation standpoint. First, the declaration of 1979 calling for 'Indian Ocean Sanctuary' that would encompass 50 million square Km between lat. 20° E and 130°E, and long. 55°S for scientific research intended for the endangered species in the region. Second, this ocean is rimmed by the developing nations that are committed to take on one more crucial challenge of combatting the conservation and prudent utilization of marine resources including living ones. In other words, the Indian Ocean offers a dawn of international cooperation in scientific, management and technological fields to fight toward a common cause of conservation of life. The Indian Ocean, since it is still relatively free from the intensive commercial whaling as is the case elsewhere, notably in the Antarctic, warrants timely conservation efforts to protect these mammals not yet subject to their full economic exploitation.

In terms of mammalian demography, the Indian Ocean is enriched by over 30 species of cetaceans—whales and dolphins. The commonly hunted cetaceans include the pygmy blue whales (Genus: *Kogia* Gray), Indian pilots or short-fined blackfish (*Globicephala melaena*), the Ganges dolphin (*Plantanasia gangetica*), the Irrawaddy River dolphin (*Orcaella brevirostris*) to name a few. Furthermore, some whale, for examples fin whales from the Atlantic, migrate to breeding grounds in the Indian Ocean, and in the process, get hunted.

The term 'conservation' in this paper refers to the art of preserving and utilizing living resources at an adequate population level, thus benefiting themselves and to man. Allen (1975) suggested that marine animals, notably mammals, are subject to death due to four causes. These are (1) damage to their habitat brought about for example by anthropogenic reasons—oil spills ; (2) direct destruction resulting from certain human activity directed for some other purpose such as dredging ; (3) some segment of mankind regarding these animals to be inimical to its interest and (4) deliberate killing for commercial purposes.

It is the ruthless and deliberate killing of marine animals, notably whales, that has received the greatest concern from many conservationists throughout the world. Albeit, helping to start a global conservation movement in our modern time.

However, it must be noted that the threat to survival of mammals in the ocean from other sources, particularly from pollution related causes and other indirect causes such as coastal development, offshore mining, and pelagic fishing must neither be underestimated nor ignored. In this context, marine mammals in the Indian Ocean are no exception to the rule.

There are two primary objectives of this paper. (1) To offer an international review of conservation measures which are applied for whales, thus far in the Antarctic, Pacific and Atlantic. That is, provide a comparative perspective to assess the Indian Ocean and (2) to propose guidelines geared for executing a successful conservation effort in the region. The international comparative perspective and the guidelines are essential parts for searching and developing a viable international/national policy, and in setting organizational strategies for the future survival of marine animals including cetaceans.

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The Whaling Scenario

The drama of commercial whaling for profit purposes had begun centuries ago. Specifically, the first era prevailed between the fourteenth and nineteenth century during which mostly right and sperm whales were hunted by hand harpoons from sailing boats. The infant whaling industry was then confined in the North Atlantic, and the principal whalers included the Basques, Norwegians, Dutch, British and Americans. Because of intensive hunting of right whales, this species was greatly depleted in number by mid-Nineteenth century, consequently it had reached the point of extinction. Whereas, the sperm whales were a bit luckier in the sense that their hunting was slowed down in response to the decline in the market for oil.

The second era began since 1870 with the introduction of the harpoon gun that would trigger an explosive harpoon. As a result new and more efficient whaling operations became possible, thus the corresponding growth of the industry as whalers began hunting blue and fin whales in the whole Atlantic. By 1930, the whaling operation rapidly expanded into the Antarctic as over three-fourths of the whale catch was accounted for from this region. Since World War II, inevitably the commercial whaling rapidly spread into the Pacific, thus once again causing a serious depletion of sperm and blue whales in these oceans.

Today, unfortunately, the commercial hunting of whales is an inhumane act indeed, especially when whalers mercilessly chase the whole school on all oceans of the world. Modern whaling fleets are now extremely sophisticated and quite deadly in the act of killing. The whaling fleets are equipped with spotter helicopters, radar and sonar, and supply factory and hospital ships. The harpoon fired from the cannon has at its tip an explosive grenade which bursts within the whales stomach causing a protracted death over a period of an hour or more. Once the victim is hunted, it is inflated with air and left to float. Meanwhile, other whales in the vicinity are hunted down. A radio beacon, radar reflector and marker flag left in the carcass permit the fleet to relocate it when hunting operations are ended for the day. The hunted whales are transported, and subsequently processed aboard the factory ship, or towed to the shore facility.

In recent times, especially in the 1970s, the bulk of the world's whale catch was accounted for by a few nations with the Soviet Union 43%) and Japan (42%) dominating the whaling industry. Other nations included Peru (5.3%), South Africa (2.8%), Norway (2.5%), Canada (1.7%), Australia (1.4%), Spain (0.8%) and the United States (0.5%). At present, both the Soviet Union and Japan continue to dominate commercial whaling operations as these two nations slaughtered over 70% of all whales killed on a worldwide level. The other nations include Norway, Spain, Peru, South Africa, Chile, South Korea, Taiwan, Brazil and Portugal.

International efforts

International efforts to curb the commercial whaling have been underway for some time, for example, at the United Nations, two principal agencies are engaged with the issue of whale conservation. These are the United Nation's *Environmental Programme* (UNEP) and *Food and Agricultural Organization* (FAO). Also, *The International Whaling Commission* (IWC) has been regulating the whaling industry since 1946. From time to time, the issue of whaling and conservational measures has been explored at the *United Nations Law of the Sea Conference* (UNLOSC).

The global concern over conservation of whales was epitomized in 1972 at the *U.N. Conference on the Human Environment*, Stockholm, Sweden where an important resolution calling for a ten-year moratorium on commercial whaling was overwhelmingly approved. In a sense, the Stockholm moratorium reaffirmed the basic concept 'Ocean resources are common heritage of mankind.' As expected the response to the moratorium was somewhat mixed from those nations engaged in commercial whaling. Japan asked for an amendment calling the ten year moratorium to be applied to the depleted stocks only, whereas the Soviet Union remained absent. However, other nations took limited cooperative measures, for example Britain put a ban on baleen whales, Canada shut off her whaling stations, Australia banned whale imports from non-IWC countries, and New Zealand cut down the import of whale products. In the United States, legislative actions were taken to combat the issue of conservation of whales. As a result, in 1975, under the *Fisherman's Protection Act*, the Pelly Amendment gave the necessary legal teeth to ban fisheries imports from any nation which tended to undermine the international conservation efforts including to save whales. The Pelly Amendment was intended against the whaling nations such as Japan, The Soviet Union, and others as previously stated.

In 1979, International Whaling Commission adopted two important conservation policies :

(1) The Indian Ocean was declared a whale sanctuary, thus permitting protection of all species in this ocean, and (2) imposing a ban on factory ships in all major oceans except the Antarctic. In 1981, once again, IWC continued to tighten its regulations on commercial whaling by imposing a temporary ban of sperm whales in the North Pacific, and by declaring further ban on the deployment of the 'cold' harpoon. Also, IWC's action called for the inclusion of Mink hunting as of 1983-84. In 1982, IWC proposed to set zero catch limits for all species of whales beginning with the 1985-86 whaling season. As expected, the four leading whaling nations : Japan, Norway, Peru and Soviet Union objected to the move of zero catch limits by the IWC.

It must be noted, however, that IWC's measures to regulate the commercial whaling have resulted to considerable extent due to the worldwide growing public concern backed by a number of active conservation organizations in the United States, Canada, Europe and elsewhere (Table 1).

The United States has been the major country that has committed to launch an effective campaign against commercial whaling. It is important to note that throughout the 1970s, conservationists relied upon two principal strategies to meet their objective to curb the commercial whaling, thus to save the whales. First, to continue to keep the issue of whales' fate in the limelight through news media,

TABLE 1. *Principal International and National Conservation Organizations Active Today*

Organizational Name	Address
Allied Whale	College of the Atlantic, Eden St. Bar Harbor, Main, (USA).
ACT	Marine Mammal study center, Smithsonian Institute, Washington, D.C. (USA).
Friends of the Earth	Several chapters throughout the world in Australia, Britain, France, New Zealand, Sweden and USA.
Greenpeace	2007 West 4th Avenue, Vancouver BC, Canada.
International Society for the Protection of Animals	106 Jermyn St., London, U.K.
International Union for the conservation of Nature & Natural Resources	1110 Morges, Switzerland.
Project Jonah	22 Duff Street, Turramurra 2074. Australia.
Project Jonah	P.O. Box 42-071, Orakei, Auckland, New Zealand.
Royal Society for the Prevention of Cruelty of Animals	The Manor House, Horsham, Sussex, U.K.
Sierra Club	220 Bush Street, San Francisco, CA (USA).
Wildlife Fund	29 Greville Street, London, U.K.
World Life Fund	1319 18th Street N.W., Washington, D.C. (USA).

demonstrations and picketing and so forth. In this fashion, they gained public support on one hand, and kept on applying pressure on government officials and public officers to take a stand against whaling on the other. Second, to win over the support of individuals and organizations in whaling countries. The first strategy did successful work in favour of the conservationists as evident from the introduction of the *Pelly Amendment* to the *Fisherman's Protective Act* in 1975. Moreover, an amendment to the Pelly Amendment was introduced in the U.S. Congress (Magnusson/Dingell, H.R. 15039) to further strengthen the Pelly Amendment. As a result, it was possible to strengthen the Pelly Amendment, imposing a ban on imports on any product from any country which did not cooperate with conservation efforts to save the whales. The second strategy to gain public support and organizations from whaling countries resulted in a partial success. This strategy was executed, for example, by a joint international Japanese-American Environmental Conference in Yokohama in 1978 and a tour of Japan by conservationists to inform the citizens there concerning the excruciating plight of the whales. Also, popular music stars and other celebrities were sent to Japan in order to bring the whale issue as a news event.

Strategies for the Future

In contrast to other major oceans—Antarctic, Pacific and Atlantic, the Indian Ocean is relatively free from the intense controversy concerning commercial whaling. Nevertheless, the conservation measures are in order since survival of marine mammals can be jeopardized by habitat disruptions and other related reasons as already mentioned. In this context, development and application of scientifically viable and technologically sound conservation strategy for marine mammals must be initiated now, and if already in existence, then it must be further strengthened.

To meet this end, it is proposed that the *Indian Ocean Conservation Commission* (IOCC) be established (Fig. 1). The IOCC would be an executive body comprising all coastal nations rimming around the Indian Ocean. The IOCC authority would remain in an overwhelmingly agreed upon Convention defining its objectives and powers, and it would incorporate series of regulations that would be open to amendment by the Commission. The IOCC's main objective would be to conserve, develop and maintain optimum utilization of the living resources including marine mammals at all times and at all places in the Indian Ocean.

The IOCC's machinery would be characterized by three principal councils : the scientific, the technical, and the administrative. The Scientific Council would be engaged in the collection of biological information on the stocks of all species of sea mammals, research and development of marine sanctuaries programmes, and to advise on their conservation. The Technical Council would be concerned with the enforcement, collection of statistics, and appointment of inspectors. The Administrative Council would handle the financial, publicity and coordination of IOCC activities such as holding the annual meeting, scheduling of various conferences and so forth. The IOCC will be required to publish a yearly report on its activities.

The IOCC would also maintain ties with the United Nations especially with its two major agencies, the Department of Environmental Programmes and the Food and Agricultural Organization (FAO) by appointing liaison officers on the Commission. The IOCC would maintain close communication with the International Whaling Commission (IWC), and various conservation groups (Table 1) by inviting them to the observation of IOCC, or selected representatives be invited as advisors.

The IOCC would differ greatly from other organizations, especially IWC, in a number of

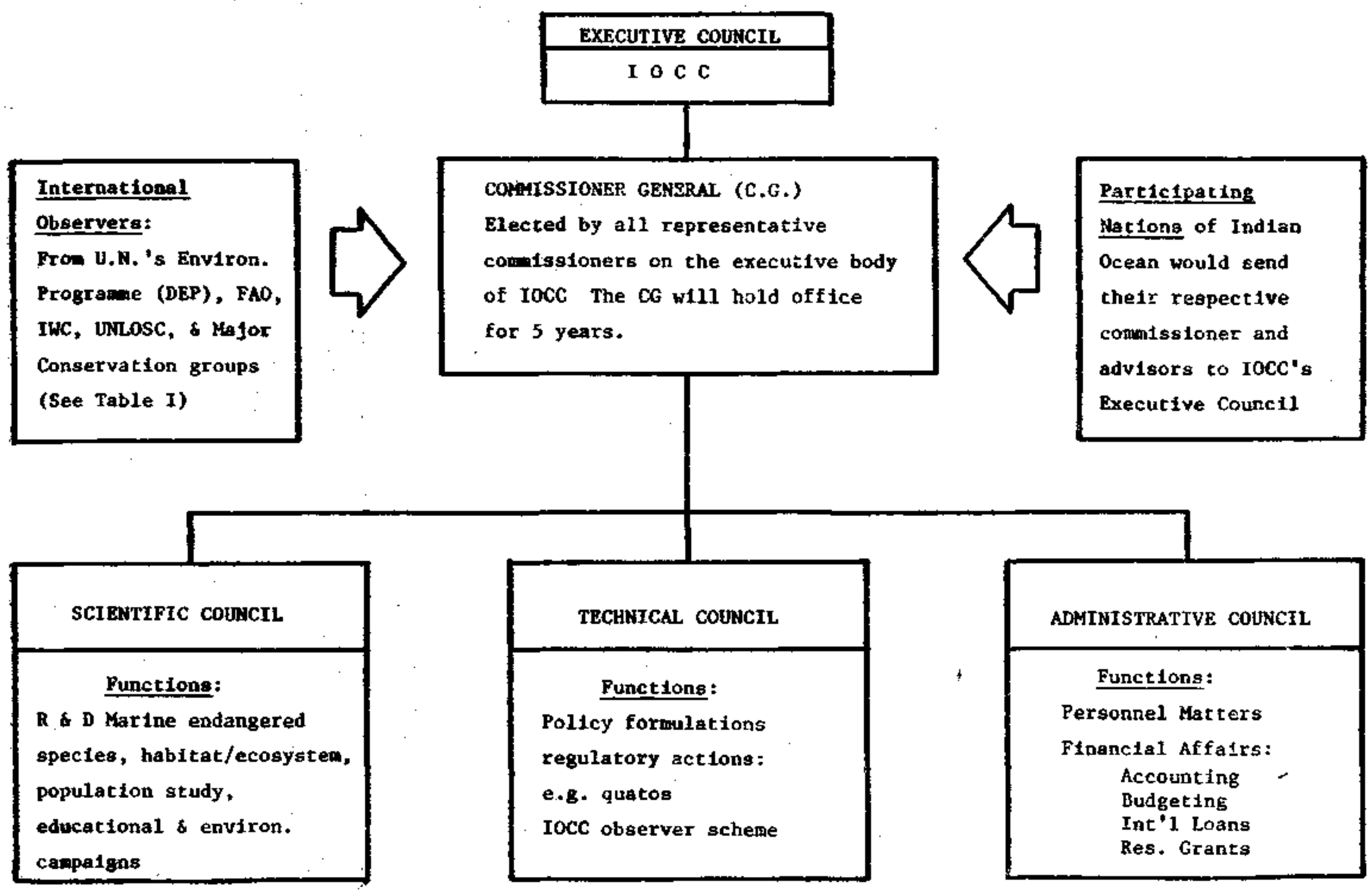

FIG. 1. Proposed Indian Ocean Conservation Commission (IOCC) : Organizational structure.

respects. At IWC, only 17 nations are members, the remaining 150 member countries are excluded from the decision-making process of the Commission. The IOCC would be an inclusive body since it would permit participation of all nations in the Indian Ocean. The role of IWC is mostly confined to whaling. The IOCC would have a comprehensive purpose of saving not only whales but all other animals as well.

The funding for IOCC would come from the participating member countries, from the United Nations, and from conservation organizations, and marine industries—fisheries, petroleum and shipping. The IOCC would assist its member nation in evolving legislation like the U.S. styled *Endangered Species Act*. It would encourage to establish International Observer System by deploying satellite monitoring, and first hand observations at sea by scientists and technicians. It would help develop economic incentives for fishermen and hunters (whalers) who would cooperate with conservation efforts in the region. Also, the IOCC would enforce its policies in the form of quotas, where necessary impose moratorium, and launch educational campaigns to increase public awareness.

The IOCC would handle the Indian Ocean in a broad manner. However, in view of the existence of 200-mile economic zones, and the latest—by the birth of the exclusive economic zone, the IOCC role must be modified by permitting each participating nation to develop its own strategies which are in accordance with its overall objective. As a case in point India is considered.

India offers an excellent opportunity in the development and eventual expansion of its conservation efforts to save sea animals within her 200 mile economic zone. Specifically, except for its northern territorial border dominated by the mighty Himalayas, India is surrounded by Indian Seas. Numerous marine mammals: whales, dolphins, porpoises, dugongs, turtles and seabirds populate these seas.

In recent years, India has expressed her growing concern over the commercial whaling by foreign countries, and the accidental catch of dugongs, turtles and dolphins in fishing operations. In fact, many species of cetacea and turtles around the Indian seas are either endangered or quite vulnerable to be extinct.

Against this backdrop, India took necessary measures first to embattle the issue of conservation of wildlife, as exemplified by the creation of the *Indian Board for Wildlife* (1952). In recent years, India passed a milestone legislation, *Wildlife (Protection) Act of* 1972 geared for protection of wildlife. However, it was the establishment of Department of Environment (DOEn), that provided organizational set-up to address the issue of conservation of marine life and its ecosystem. India's conservation movement is also supported by private and voluntary organizations : Indian Board of Wildlife, Bombay Natural History Society, to name the two major ones.

It is suggested that in order to further strengthen India's conservation efforts to save marine animals, this country should adopt the following strategies for the future :

(1) Pass a formal legislation emphasizing the sole control over the protection and utilization of marine animals living in the Indian seas and the estuaries. Specifically, the legislative bill would be similar to the *U.S. Marine Mammal Protection Act of* 1972. In this fashion, India would be able to extend protection to all cetaceans. If India desires to expand her legislative scope in the matter, she could adopt a modified version of the Marine Mammal Act by titling at *Marine Animals Protection Act*, thus enabling her to extend protection to all sea animals including cetaceans, dugongs, turtles and seabirds. Regardless of titles of the legislative piece, the emphasis of the Act must be to evolve the concept of managing sea animals for an optimum ecological value rather than simply paying attention to

their number only. That is the conservation effort must be translated into the balancing of ecological, economic and environmental aspect.

(2) India's conservation pursuit to save sea animals would be greatly benefited if principal private and voluntary organizations such as Indian Board of Wildlife, Bombay Natural History Society, and World Wildlife Fund-India along with the support from marine scientists would form a coalition such as *Save Indian Sea Life Committee* (SISLC). The SISLC would work as an independent, but collaborating group for conservation related affairs. The primary function of SISLC would involve : (1) collection of sound knowledge of matter affecting the marine animals, and their habitat, and (2) to undertake wide publicity of this information to the general public through advertising, journalism, poster distributions, stickers (stamps) to be used on envelopes and letterheads. Also, the SISLC would seek to expand the number of national marine sanctuaries and marine parks. As a point of interest, in Australia, *Save the Barrier Reef Committee* played a critical role in promoting a successful reef conservation movement. In the United States, Canada, and Britain similar organizations have played important roles, sort of catalysts of the conservation campaigns in their respective places.

(3) The SISLC along with the formal group representing India at IOCC would work out their joint strategies, thus permitting a more effective participation at the international level. India would benefit by establishing first on its own turf, a legislative, management and scientific strategy—all embroidered into a national conservation policy. Then to represent this policy at IOCC, thereby helping in evolving an international conservation policy for the Indian Ocean. The IOCC in turn would colloborate with the United Nations, notably with its agencies—Department of Environmental Programme, and Food and Agricultural Organizations. The IOCC can represent at the International Law of the Sea Conference (UNLOSC) and International Whaling Commission's annual meetings. In this way, a viable 'local to global' strategy for conservation of life in the ocean may be achieved before the end of this century. Perhaps one of the best gifts mankind can offer to ocean life is its own survival, and opportunity to do so is awaiting before us.

'. . . . where great whales go sailing by
Sail and sail with unshut eye
Around the world forever and aye.'

(Mathew Arnold's
The Forsaken Merman)

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THE BILLION DOLLAR BABY

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ABSTRACT

Whaling industry economics is undergoing rapid and radical transformation. Whales are now worth far more alive than they are dead. The most extreme example of this is the case of *Orcinus orca*. Sea World Inc. of the U.S.A. is undertaking a large scale live capture program in Alaskan waters aimed at breeding the first captive orca baby. Success will secure future revenues of billions of dollars. Given the state of current knowledge about reproduction in the species, the project has a very low probability of success. However, even the attempt will produce assured revenues of more than one billion. The morality of this financial exercise is questioned.

INTRODUCTION

TEN years ago the most common argument in favour of continuing commercial whaling was the economic hardship that would result from cessation. In Japan in 1974, whaling involved 50,000 jobs, and was important to numerous local economies. When Brazil first considered terminating its single whaling station, in 1980, the proposal was quickly dropped because of vociferous protest over the loss of 200 jobs. In the Kingdom of Tonga, just two families were involved in humpback whaling in the '70's. The cry of economic hardhship was the same, and it too, was heeded.

In countering this economic obstacle, the anti-whaling movement pointed to the growth of non and low-consumptive whaling revenues : from benign merchandizing, whale-watching and live display of captive animals. By 1983 these industries were generating hundreds of millions of dollars of revenue, and were expanding rapidly. In contrast, traditional whaling income and profitability has plummeted.

There can no longer by any question : whales are now worth far more alive than dead.

The species *Orcinus orca* provides perhaps the most vivid example of the new reality.

This social odontocete occurs in low to moderate numbers in temperate and cold waters, adjacent to diverse fisheries in the zone of northern and southern hemisphere continental shelves, and in larger number in Antarctic waters. Its body weight is low (to 5000 kg or so), and the product yield small. With the exception of a commercial catch of 920 by one Antarctic fleet in 1980, the species has attracted little interest from the traditional industry. The largest annual take, Norway's, was, until very recently, sustained only by a government subsidy (2 kronor per kilo), that ensured at least some return for the catching effort.

In 1964, in British Columbia, Canada, an orca was accidentally taken alive during a collection effort by the Vancouver Aquarium. Erroneously named Moby Doll, he survived for three months. In 1965, a second male, given the name Namu, was trapped by a drifting net near a northern British Columbia fishing community. Sold for $5,000, he was transported in a towed pen some 1500 km to an inlet in Washington's Puget Sound, where he was used in a movie. Later that same year, for the same amount, Sea World Inc. of San Diego, Calif. acquired the first intentionally-captured orca.

Less than two years later, when the Vancouver Aquarium made its first purchase—of an animal named Walter (later, Skana) at the local Boat Show—the price had risen to $20,000. Thus began an inflationary spiral which today sees the delivered price of a live orca at around $250,000. Offers up to $1,000,000 have been rejected for individual trained captives.

These numbers make the orca the most valuable animal in history, dead or alive, and irrespective of size.

But they pale in comparison to the prize now sought by Sea World Inc. of the U.S.A.: the breeding of captive orcas. Success would guarantee future revenues of billions of dollars and an expansion potential rarely matched in peacetime corporate history.

THE ORCA BREEDING PLAN/SCAM*

Harcourt, Brace, Jovanovich Inc., is a U.S.-based publisher grossing about $1/2bil. In 1980, it acquired Sea World Inc. of San Diego, Calif., a three-unit marine amusement park chain. The cost was $194 mil. Sea World presently provides about 25% of the parent's gross, but what makes it of exceptional interest is its capacity for growth.

In 1982, HBJ Inc. allocated some $31.5 mil to Sea World, for orca habit at improvement, ($30 mil, including a new $ 15 mil pool at the Orlando site), and for research ($1.5 mil).

In 1983, Sea World applied to the U.S. government for permission to take 100 Alaskan orcas, 90 for science and 10 for tanks. The permit, after official review and public comment, was granted.

By this move, HBJ Inc. had assured a fifteen-year guaranteed Sea World gross of $2bil (based on 1983 revenues of $120mil, and a captive life-expectancy of 10 years). Given inflation and a product growth situation, the end cash flow could be far higher.

Only the opposition of the government and citizens of the State of Alaska prevented immediate implementation of the plan.

REPRODUCTIVE BIOLOGY/BEHAVIOUR OF *Orcinus orca*

In Norwegian waters, where mortality is high (due to human harvesting), orcas exhibit very high adult female pregnancy rates (50%). In British Columbia and Washington State waters, where natural mortality is the predominant factor in a previously exploited population, recruitment is very low (2- 4%). Low reproductive rates may be normal and signal long-term population stability in the species.

Sexual behaviour, as a social activity, is commonly observed, in the ocean and in captivity. It is unclear what role this plays. Just one captive pair has produced offspring (4, no survivors). Mature and fertile free females sometimes space babies by 10 years or more. Some females may never breed. Male-male pairings, such as that reported at the Vancouver Aquarium, are quite common, and presumably serve no reproductive purpose.

In the ocean, orcas are organized socially into pods and communities of pods that share home-range ocean spaces, and nomad groups that traverse longer zones. Breeding practices are unclear. It is not even known whether breeding occurs mainly within or between pods, though it is assumed that residents and tran-

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***SCAM: A devious scheme, usually for the benefit of a single side of a transaction, often without regard for the other.**

sients do not mate. Cytogenetic and acoustic/behavioural studies could reveal the critical relationships within a few years (Bain *et al.* 1983).

Biological/Financial Conclusions

Not enough is presently known about reproductive biology and behaviour in orcas to provide a scientific basis for selection of individuals for participation in a captive breeding programme.

Regardless, should the collection plan succeed, Sea World will, after five years, have added ten animals to its inventory (8 in 1984). This alone should be sufficient to guarantee a 15 year future for existing facilities, and safe development of at least one more.

The Orca Cost

Certainly, for the directors of HBJ Inc., Sea World's Alaskan orca plan must have the allure and excitement of a big-money game where there's little to venture, lots to be made, and nothing to lose.

On the other side of the equation, there are mostly questions. The selection of tanked individuals would be haphazard, and the impact of such a low level of removals, *e.g.* on pod survival, probably never known.

The impact would presumably be less than that caused by the dynamite bombings and machine gun strafings endured by other orca populations in the recent past.

But, is there not to be a moral point to be raised here ?

Are we entitled, whether it is for our financial, educational, or other benefit, to subject orcas to pursuit, capture and confinement ?

Our perception of the cetaceans is undergoing rapid change. It may soon be the norm to regard them as peaceable aquatic neighbours to whom we grant rights and protections under our laws. Certainly, the argument for their advanced evolutionary status is ironclad. Sentience in the cetaceans is a widely-accepted probability.

Given that we are still struggling with issues relating to fairness and equality of treatment amongst members of our own species, it seems unlikely that we will easily resolve the moral point at issue here.

However, should we succeed, we may well have accomplished something of immense importance, not just to the cetaceans, but for ourselves as well.

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CETACEAN HABITATS AND CONSERVATION PROBLEMS, WITH SPECIAL REFERENCE TO THE INDIAN OCEAN

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ABSTRACT

With the cessation of most industrial whaling after 1985-86 conservation of many species now takes on a new dimension as funds for study are decreased in many countries. In this paper the concept of 'habitat' for such animals is explored, with special reference to feeding and breeding requirements, which differ from species to species. Several major ecological groupings of species are provided, together with a summary of the major cetacean components in the ecosystem of the greater Indian Ocean region. The present status of these species is noted along with any immediate or long-term threats to their viability which are perceived. Potential solutions to some problems of cetacean conservation are discussed, with particular reference to incidental catches by fishing gear, which pose an increasing problem in many parts of the world, especially to the smallest species of Cetacea.

INTRODUCTION

IT is hardly necessary to comment that great controversy attended the commercial exploitation of marine mammals and cetaceans in particular, during the last few decades. One of the first alarms in fact, was sounded by Bryant (1927), in an article in which he concluded that the then current rate of exploitation of Blue whale stocks would lead to the economic and possibly total extinction of the species in Antarctic Seas. All that followed is now no more than tragic history and one would hope (but with limited optimism), perhaps a lesson learned. Unfortunately, while many governments in the world finally seem to appreciate that the living resources of both the terrestrial and marine systems of the biosphere are limited, awareness of the particular fragility of marine ecosystems and the delicate stability of aquatic food web relationships is hardly extensive. Recognition that marine mammal habitats might be in danger in certain parts of the world has been slow to develop, largely because the concept of 'habitat' has until recent years been vague and frequently undefined for such species. In this article the author wishes to address the problem of definitions of habitat for cetaceans (without making reference to the sirenians and pinnipeds with which he is much less well acquainted) and to indicate not only profitable lines for research but also conservation steps which might be taken to prevent the further deterioration of such life zones.

At the most basic level a habitat must provide sufficient food supplies to support, over the long term, at least enough individuals to maintain the genetic viability and continuity of the population. It must also provide suitable conditions for reproduction to occur with at least the level of success indicated above. Such a definition is essentially dynamic, not rigid, and avoids some of the pitfalls and limitations of habitat considered purely from the spatial and physical point of view. It encompasses the natural fluctuations, often considerable, which occur over a period of time within any natural animal or plant population. In the case of relatively large and long-lived homoiotherms such as cetaceans these changes will occur slowly in the absence of intensive hunting, simply because the reproductive cycles are long. Nevertheless, given a data base of decades, (such is available for several exploited species in the Antarctic and North Pacific), long-term trends can be identified. Very few existing management and conservation frameworks for marine resources take these kinds of fluctuations into account, and the difficulties of assessing slow habitat changes cannot be under-estimated. Even in a ten-year programme of field observations we may only be able to observe a segment of a longer, more complex cycle and the dangers of misinterpretation are always present.

Problems of Defining Feeding Habitat for Cetaceans

Some large species such as the Right whale *Eubalaena glacialis* and the Sei whale *Balaenoptera borealis* take very small prey, principally copepods such as *Calanus*, *Pseudocalanus* and *Acartia* spp. Unless this type of food is particularly concentrated, as occurs seasonally off Cape Cod in the spring when surface densities of as many as 3,000m^2 have been reported (Winn, 1982), they may require large individual feeding spaces to 'skim' feed, mouths open, either at the surface or below it. In the case of animals feeding on organisms such as euphausiid shrimps (*Euphausia* spp., *Meganyctiphanes* spp., and *Nyctiphanes* spp.) for example, the total number of individual prey is far less but the concentrations in local areas are often so great ('krill' patches) that they can be exploited by species such as Blue and Fin whales with great energetic benefit. The same situation applies for those whales such as Humpback, Minke and many dolphins and porpoises which are essentially feeders of pelagic shoaling fish such as herring (*Clupea harengus*) and anchovy (*Engraulis* spp.). Large local concentrations of pelagic shrimp and the smaller pelagic fish species tend to be associated with specific oceanographic phenomena on geographic scales ranging from thousands of km (Ocean Fronts) (Nemoto, 1959 ; Gaskin 1982) to tens of m (Local shears and upwellings) (Hamner and Hauri, 1977 ; Smith *et. al.*, 1984).

Not all cetaceans necessarily take pelagic shoaling prey ; the Gray whale is essentially a bottom feeder, while some tropical and temperate zone small odonotocetes such as the Humpbacked dolphins and White whale move systematically from one location to another foraging for benthic or demersal fishes. The size of a feeding population of cetaceans within any given area too, is as likely to be determined by the distribution and accessibility of prey as the absolute abundance. Whales and dolphins often inexplicably leave a particular area after being semi-resident for extended periods ; this may often be the result of the density of accessible prey falling below that energetically economic for the upper trophic level animals to exploit. There is no doubt that the energetics of foraging dictate that these animals should exploit concentrated prey in areas where it occurs regularly and predic ably, thus reducing the cost of foraging to a minimum. Unfortunately, the same economics then dictates that fishing industries will also seek out such concentration zones, and their activities will certainly have some detrimental impact on the competing marine mammals if the fishery in question becomes so intensive that the biomass of the common prey stock declines significantly. Even simple interference or disturbance of feeding patterns may greatly decrease the intake of these mammals without this being evident. Several discussions have taken place in recent years about the 'hidden' impact of whale-watching for example. On the other hand there is no doubt that some species, Humpback whales for example, appear to move freely among closely spaced fishing vessels (on the Grand Banks in the North Atlantic), and some workers (D. E. Sergeant, personal communication) suspect that they may have learned to follow the boats to prey beyond their own immediate detection range.

Naturally, maintenance of conditions for successful reproduction is of absolute importance, but determining just which factors are critical in this respect is much more difficult than drawing conclusions about the nature, quantity and distribution of food species. Feeding and breeding grounds may lie thousands of miles apart ; again the Humpback whale is an example. Protecting one of the vital sectors of such an animal but not the other could ultimately be nothing but an expensive exercise in futility ; close cooperation is essential between all the nations with coasts or marine activities on the migration routes of cetaceans making this kind of annual movement.

Problems of Defining Breeding Habitat for Cetaceans

If a cetacean species periodically disappears for part of the year from a particular location it is not unreasonable to assume that the species is migratory to a greater or lesser extent. On the other hand, if some individuals can be seen in any month of the year this does not, to the contrary, prove that the species is *not* migratory. Many sub-mature baleen whales and odontocetes may not complete annual movements as extensive as those of their sexually and socially mature counterparts ; if a sexual stimulus/response is lacking then they may be reacting to local movements in food supply only. To determine how much movement is actually taking place is very difficult ; the use of individuals with recognizable markings and radio telemetry are virtually the only methods presently in use ; whale-marking using *Discovery* darts produced limited data for baleen whales generally because the whale operations and seasons were restricted to certain times and certain areas.

A number of smaller species, such as the Harbour porpoise *Phocoena phocoena*, appear to calve in areas closely adjacent to the major feeding grounds of the summer months. Whether or not there are any special breeding areas or major seasonal movements for the majority of sub-tropical and tropical small odontocetes remains to be determined. Virtually all calving and mating by Sperm whales takes place in tropical latitudes in all the great oceans. Mating activities of baleen whales are more diverse ; while it is generally believed to occur in warmer waters in the case of most species it cannot be physiologically limited by external temperatures in any general sense. The Bowhead carries out its whole life-cycle in the frigid waters of the Bering and Beaufort Seas while North Atlantic Right whales mate in the coastal shelf waters of eastern Canada where the surface temperature rarely exceeds about 15°C. Even in the case of these two species, however, the areas in which mating is carried out are very specific. In the Bay of Fundy recognizable individual Right whales return to the same locations year after year, and this has also been documented in the patagonian population by Dr. Payne.

The Humpback whale has very clearly defined breeding grounds in the tropics of both the Atlantic and Pacific Oceans (Gaskin, 1982 ; fig. 1.8) ; the situation in the Indian Ocean, except for the coastal margin of Western Australia (Chittleborough, 1965) is less well known. In the breeding grounds on the northern and eastern margins of the Caribbean Sea this species congregates in large numbers over a few specific platform reefs. These structures may serve to break up the force of sea action and reduce wave impact on newborns and perhaps also minimize the problem of predation of these neonates since many of the dangerous species of shark might not penetrate over the reef platform, but tend to stay on the edge of the deeper water. In the Pacific region Humpbacks are associated with lagoon areas or the edges of fringing reefs (Dawbin, 1966). Rorvik (1980) noted considerable numbers of Humpback whales during a cruise off the coast of Mozambique ; his sightings however, appeared to be clustered on the margin of the continental shelf. The breeding grounds of the Gray whale in Lower California are well-known and all shallow water. There may be other reasons why these animals require warm water for breeding, as suggested by the author (Gaskin, 1982), but data are non-existent. Certainly, any attempt to relate either the absolute necessity for warm water or shallow water for breeding by large baleen whales can be disproved in a general sense, by the Bowhead example given earlier in the former case and by the fact that Fin, Blue and Sei all seem to breed on the continental margin over deep water. Nor do the latter species seem to have discrete breeding areas like the Humpback whale or if they have, they have never been found.

General Categorization of Cetacean Habitats

One can define and assemble the different types of cetacean habitat at the simplest level by applying two criteria, distance from shore and depth of water :

1. Fluvial (*e.g.* River dolphins Platanistidae).
2. Estuarine (*e.g.* Bottlenose dolphins and White whale).
3. Inshore coastal zone (*e.g.* Finless propoise, Irrawaddy dolphin, Humpback dolphin, Cochito, Tonine, Gray whale and Humpback whale).
4. Coastal and continental shelf (*e.g.* Dusky dolphin, Common dolphin, Fin whale, Right whale).
5. Continental shelf margin (Sei whale, Blue whale, Sperm whale).
6. Open ocean and Convergence zones (Spinner dolphins, Striped dolphins, Beaked whales).

None of these categories can be considered absolute, except perhaps in the case of the true River dolphins. Otherwise overlap is apt to occur in just about every species named. Work in the eastern tropical Pacific Ocean in recent years for example, has shown that large populations of Bottlenose dolphins can be found along the Tropical Convergence and other adjacent watermass boundaries and interfaces ; this is a species which would have been regarded ten or more years ago by most cetologists as virtually confined to the inshore coastal belt.

The Indian Ocean contains a striking array of cetacean species and in fact a high proportion of the total global fauna of this Order of Mammalia has been reported, or probably occurs, within its boundaries. Certain platanistid dolphins, some species of the genus *Sousa* (*e.g. chinensis*), the Irrawaddy dolphin (*Orcaella brevirostris*), and the Finless porpoise (*Neophocaena phocaenoides*) are unique to the region and its warm water extensions into Australasia and to southern Japan, China and Korea. The major upwelling regions and current boundaries, especially in the temperature and sub-Antarctic region, but also in the northern Indian Ocean, support significant populations of many of the species of large baleen whale. The pelagic and northern region contains many thousands of Sperm whales, one of the focal species of the Indian Ocean Cetacean Sanctuary Proposal. The baleen whale populations of the northern Indian Ocean are still little-known, but could be of great interest to science as they may well represent the *only* community of rorqual populations which have not been hunted during the recent long phase of industrial whaling by Europe and Japan. This is not the case with the Sperm whale population of the same region, which has been exploited at intervals by factory ships on their way to and from the whaling grounds in the Southern Ocean. It is possible that some degree of interchange between the northern Indian Ocean feeding grounds and the Antarctic feeding grounds, occurs but so little research has been done that one can only speculate. The current directions, timing of the northern upwellings and productivity peaks and the distances involved would seem however, to point to a strong degree of segregation between the northern and southern animals in the region. Nevertheless, the Humpback whales from the southern sectors may traverse the whole ocean during their migrations. On the other hand, the animals encountered on the southern feeding grounds may be supplied entirely from the East African and Western Australian stocks and the northern 'Sri Lankan' animals may be segregated and carry out more local migrations. We simply do not know.

Problems of Conservation of Cetacean Habitats

The need for a massive conservation effort to preserve natural marine habitats in this region is largely unrecognized by the body of sympathetic public opinion in the 'Developed' nations. The effort by the government of the Seychelles to establish a whale sanctuary in the central Indian Ocean, largely protecting the population of Sperm whales in the region, was an important focus for such necessary public attention in recent years; as a result of coverage in the western media the problems of the region are now recognized at least by several important international agencies, and one would hope also by increasing numbers of concerned biologists.

While the majority of the nations fringing the Indian Ocean have yet to attain anything like the levels of coastal zone modification and urban/industrial effluent that characterize much of western Europe, the european USSR and eastern Europe, and parts of the eastern and western seaboards of the USA, problems are nevertheless developing rapidly. In general, the tropical and subtropical ecosystems are likely to be more structured and less resilient than those of the temperate seas (Steele, 1974). All through the tropics, the growth of urban agglomerations such as Sao Paulo, Hong Kong, Bombay and greater Calcutta has been exceedingly rapid, largely uncontrolled, and presents fearful human and environmental problems. With the growth of Third World industries has come an accelerated demand for water and electric power.

It would be difficult at this stage to gather any information which would clearly indicate if the development of large coastal cities with little or no waste treatment, and the industrialization of big rivers, estuaries and bays has caused reductions in the range of some coastal cetaceans in the Indian Ocean margins. Animals which might have been locally affected adversely include the Irrawaddy dolphin, Finless porpoise and Humpback dolphins. The main problem of course is the lack of even the most elementary data collection in most areas, let alone actual research programmes, in virtually every underdeveloped nation of the region. Only South Africa and Australia have had research programmes of any extent and even these have been much reduced since the two countries ended their commercial whaling operations. Despite the new interest by some international agencies, and some pelagic programmes launched by World Wildlife Fund for example, simple lack of money and expertise in the majority of nations will dictate that no rapid improvement in the situation can realistically be expected.

Initially therefore, the perception of the magnitude of the problem and the difficulties of beginning and maintaining programmes of study leads to some depression. Nevertheless, the initiatives which have been taken, including not only the development of support for an Indian Ocean sanctuary and the fact that the present symposium is taking place, but also growing international interest in the wildlife of this unique region, must surely contribute to a more optimistic outlook. The first steps have been taken, and at this stage it is useful to review the cetacean fauna under consideration, and the relative level of threat to each group, so that high-risk genera and species, or communities, can be pinpointed.

Indian Ocean Cetaceans : Requirements, and the Nature and Status of Threats

1. *Baleen Whales*

Blue, Pygmy Blue, Fin, Sei, Bryde's, Minke, Humpback, Right and Pygmy Right whale, have all been recorded or probably occur within the greater Indian Ocean region. All but the last two have been extensively hunted in the temperate zones of this ocean, and the Right had already been exploited down to relict population status long before modern factory ship and industrial land station whaling began. The last two named probably do not normally occur in the northern parts of the Indian Ocean.

Threats : Since all these species are already protected by the IWC, or will be once the Moratorium takes effect, direct hunting is no longer going to be a problem. Whether or not some populations have already been so seriously damaged that they will not recover is a contentious matter. In some parts of the world Right whale populations, for example, appear to have stabilized at a very low level for reasons which may include loss of reproductive habitat, competition for food supply, or pressure from predation on calves by sharks or disease which, while of no great significance in a population of large absolute size could exert a dramatic constraint on a very small population's ability to recover. The major threat to all these species of baleen whale today is likely to be the continuing development of industrial pelagic fisheries for both fish and shrimp in upwelling areas or along ocean fronts (convergence zones) where the mammals congregate to feed on concentrated prey, with the concomitant introduction of a serious competition factor not present before. While the development of the 'krill' fishery in the Southern Ocean is the most frequently cited example, and perhaps the one likely to have the most far-reaching consequences, this is a global problem and one so far not recognized in any detail. Operation of set fishing gear, especially gill nets and stake traps is a relatively minor problem of baleen whale populations as a whole, but occasional entanglements do occur and sometimes, as in Newfoundland in the early 1980s, it can be quite a serious problem for inshore species such as the Humpback whale. Coastal developments of industry, including hotel complexes which tend to be close to the best reef and beach areas, will certainly lead to more pressure on breeding habitat of Humpbacks, as is now threatened also with Right whales on the coast of Patagonia, and Gray whales in Baja California now the latter is being opened up for development. Fortunately at least the government of Mexico has introduced some strict legislation for controlling access to the breeding grounds.

2. *Toothed Whales*

A. Sperm whales

The great Sperm whale (Cachalot), and at least one of the two small members of this family (Dwarf and Pygmy Sperm whales) occur in the Indian Ocean. The latter are of no commercial importance, are sometimes taken in nets, and sometimes mistaken for sharks because of their peculiar morphology, especially that of the jaws. The Sperm whale on the other hand, was hunted intensively throughout the region in the early days of European and American whaling (*c*. 1780-1870) and during the factory ship phase (1920-1980s). Sperm whales, almost invariably males, were taken in large numbers in sub-antarctic latitudes, especially in the post-World War II period. Both sexes, including many females below the legal size limit for the time, were taken by factory ships in tropical latitudes on their way from or to Japan and Europe. This hunt has now ceased.

Threats : While the directed catch has now ceased there is little doubt that significant distortions in age class structure and social structure have occurred in almost all sperm whale stocks, including that of the Indian Ocean. The result of this may be to slow considerably rate of recovery both in numbers and population biomass (Holt, 1981). Nevertheless, despite these disturbances the species is still relatively numerous in the region in comparison to several of the large baleen whale species. Because the species is primarily a squid feeder, except on coastal margins where it takes considerable quantities of bathypelagic fish (Gaskin, 1982, for summary of references) as well as benthic species, there is little likelihood of its food supplies being depleted by competing commercial fishing enterprises. The Sperm whales feeds on a wide variety of squid species, many of them in deep waters while commercial fisheries are concentrated on a few inhabiting the upper layers, such as *Todarodes* and *Illex*. As long as hunting continues to be prohibited therefore, a recovery in numbers and biomass, albeit slowly because the net rate of reproduction is relatively slow, can be expected.

B. *Beaked whales*

Most of the comments about the Sperm whale in the previous section apply to the little-known species of several genera of the family of Ziphiidae found in the Indian Ocean. They have not been hunted in the southern hemisphere at all, although the Norwegian 'small whale' industry has taken North Atlantic Bottlenose whales of the genus *Hyperoodon* for many years and there is also a small coastal hunt for *Berardius bairdii* by Japan. All species are medim-sized whales, the smaller species of the genus *Mesoplodon* are 14-20 ft while larger species of *Berardius* and *Hyperoodon* may exceed 30 ft. From what has been gleaned about their diets from stomach contents of stranded specimens they appear to be exclusively squid eaters. In habit they are largely pelagic, occurring in the outer regions of continental shelves and along the large convergence zones of the Indian Ocean, and also in dynamic and topographic upwelling regions near seamounts.

Threats : No immediate threat to these animals can be identified. The Southern beaked whale *Hyperoodon planifrons*, Cuvier's beaked whale *Ziphius cavirostris*, Southern bottlenose whale *Berardius arnuxi* and several species of *Mesoplodon* (and possibly *Tasmacetus shepherdi*) are known to occur in the Indian Ocean, especially the temperate southern region.

C. *Globicephalid whales*

This grouping, which taxonomically represent nothing more, in the opinion of most specialists, than somewhat modified large delphinid species, contains the Pilot whales, Killer, False Killer, Pygmy Killer and Melon-head whales. They all belong to the Delphinoidea, tend to be social or gregarious, sometimes travelling in pods of several scores or even hundreds, and the Pilot and False Killers are particularly notable for their unfortunate habit of stranding *en masse*, usually on shelving sandy beaches. Long-term social stability has been demonstrated in some of these species, especially the Killer whale, and in this respect their behaviour resembles that of the Sperm whale as described by Best (1979). In the developed countries the mass strandings generally result in rescue attempts usually futile but in Third World nations the same event represents a welcome bonanza of red meat in large quantities.

Threats : Many of these species will come close to boats and can then be opportunistically harpooned, as in the subsistence hunt of St. Lucia and St. Vincent in the Caribbean. There is no information concerning the extent of such activities in the Indian Ocean. The level of such hunting is generally not high enough in any one region to present much of a threat in most cases. In a few areas, however, numbers of boats are used to drive whole schools ashore or into shallow bays where they can neither escape or avoid eventual slaughter. If schools are systematically harvested by this method in large numbers a population collapse can occur in a relatively short period of time ; that of the Pilot whale *Globicephala melaena* in Newfoundland waters was documented by Mercer (1975), for example. Pilot whales and other species are also trapped in set fishing gear in coastal regions. This type of capture may occur frequently in locations in the Indian Ocean where gill nets are used ; given the exceedingly sparse distribution of marine mammal researchers in the region, however, such catches are rarely reported.

D. *Pelagic dolphins*

This group is comprised of several genera, each with one or more species : *Delphinus, Grampus, Lagenodelphis* and *Stenella* are characteristic of warm waters ; *Lagenorhynchus* and *Cephalorhynchus* of the cooler waters to the south. The latter have been reliably reported only from South African waters.

Threats : Delphinus and *Stenella* have suffered considerable mortality at the hands of the tropical Pacific tuna industry operating from California ; these captures have been well-documented in many publications by the South West Fisheries Centre in La Jolla from 1969 onwards. The extent to which such catches are made in the Indian Ocean is not well known ; generally the dolphins are taken only when the fishery is based on the purse seine and when the net is shot around the dolphins to take the tuna swimming below them. Many of these pelagic species feed on myctophids and other fish which characterize the Deep (Acoustic) Scattering Layer. While proposals for commercial exploitation of such fish have been advanced in recent years, the actual development of fisheries is still embryonic and probably, given the large biomass involved, do not present a current threat to the dolphins. Since they tend to be offshore species the only type of gear which represents a threat is the surface gill net, which is not very extensively used away from the immediate coastal zone.

E. *Coastal and Estuarine Dolphins and Porpoises*

While many of the ' pelagic ' species of the genera listed above may frequently penetrate coastal waters on occasion, the most commonly sighted inshore dolphins and porpoises form a conglomerate with somewhat different feeding habits and behaviours. These animals include the Indian Ocean Bottlenose dolphin *Tursiops aduncus* and the Humpback dolphin *Sousa plumbea* (*see* Ross, 1984), and further north and east, the Irrawaddy dolphin *Orcaella brevirostris* and the Finless porpoise *Neophocaena phocaenoides*. The feeding habits of such species were alluded to earlier in this paper.

Threats : Directed hunts probably take place in several locations in the Indian Ocean on an opportunistic basis but data are generally lacking. Nevertheless, the greatest threat to the maintenance of such populations probably comes from fish traps and gill nets. As human coastal populations continue to grow and more gill nets are deployed in more areas the danger to this particular group of cetacean species must grow in proportion and we must seek ways to minimize the impact of this development and seek ways to reduce the mortalities (see Discussion).

F. *River Dolphins*

Two species occur in the Indian Ocean region; *Platanista indi* the Indus River Susu, and *P. gangetica* the Ganges Susu in the Ganges and Brahmaputra river systems. General accounts of the biology and distribution of both species have been given by Pilleri (1970, 1975) and Jones (1982), but the feeding habits are not well known, the diet seems to consist of benthic shrimp and fish, including various species of catfish.

Threats: By the very fact that these animals inhabit the limited volume provided by rivers rather than the open sea one would immediately conclude that their vulnerability to human influence is acute. This is indeed the case, not only are they frequently taken in set gear for fish, but until recently there was an uncontrolled directed hunt in many areas as well for *P. indi*. Efforts have been made to decrease catches of the latter species, which may well be approaching a critical level (Jones, 1982). The same author concluded that *P. indi* was not only threatened by hunting, but also by declines in water levels as a result of diversions for irrigation projects and the construction of hydro-electric barrages. Similar adverse influences, although fortunately without the added pressure of a directed hunt, face the much larger population of *P. gangetica*. Jones concluded that this species had declined in numbers in the Ganges proper, but that in the upper reaches of the Ganges/Brahmaputra region and the Gangetic Delta the populations were probably stable, and in river systems in Bangladesh it seemed to actually be increasing in numbers.

The pressure on *P. indi* is believed to have eased somewhat as a result of a prohibition on hunting issued by the Sind Government in December 1974 (Pilleri and Bhatti, 1978); in the area upstream of the zone controlled by that provincial government hunting continued after 1974. Nevertheless, the population in the 60-80 mile protected stretch of the river did seem to increase between 1974-78 according to the above authors, although no census methodology was provided in their paper.

The growth of irrigation projects in India, Pakistan and Bangladesh, of industries pumping untreated effluent into the rivers, and the waste from the burgeoning urban conglomerations in these nations all pose a steadily increasing threat to the wellbeing of the river dolphins. Given the parlous economic state of the region international support for protective measures will probably have to be maintained for a long period of time.

Discussion

Potential Solutions to the Problems of Cetacean Conservation

The first step is to make more naturalists' organizations and government agencies aware that whales and dolphins do indeed have definable habitats and may in fact require two or more quite discrete environmental systems at different times of year. *Breeding* habitats may be definable by: Distance from shore, depth of water, shelter from predators, shelter from prevailing winds or strong currents, subsurface topography and substrate (mud, sand or platform reef), water temperatures, salinity (perhaps higher density gives neonates more buoyancy) and presence of other whales (social protection and epimeletic care). *Feeding* habitats may be defined by distance from shore, water temperature and salinity (perhaps sharp thermoclines or haloclines with significant density increase in the lower water mass serve to retard zooplankton or phytoplankton fallout), oceanographic boundaries of a greater or lesser scale, substrate (Gray whales feed on muddy bottom and echolocation by odontocetes may be more efficient over smooth substrates), turbidity levels, current velocities and, most importantly, concentrations of prey (often strictly seasonal) sufficient for the energetic requirements of the individual whales in each locality or series of localities available for foraging.

Only sound, well-planned research studies will permit reasonably exact definitions of habitat and range in each season of the year in terms of time and spatial requirements. Once the basic parameters are recognized and understood we should be in a position to interpret shifts in distribution and concentration and appreciate their specific significance. The same is true of long-term changes in age structure or behaviour ; we can then determine with some confidence whether a particular change is 'normal', *i.e.* part of a long-term regular cycle, or 'abnormal', *i.e.* the result of some genetic or physiological change in a significant number of individuals, perhaps as the result of some external or even human interference with the habitat.

The second step is to identify major habitat for clearly endangered species, those which can be regarded as ecologically important, or are of potential scientific or public interest within the Indian Ocean region. If funds are restricted, the priorities should obviously be selected in the order given above. If key habitat cannot be included in a single national park framework then inter-provincial or international cooperation is imperative. *Platanista indi* for example would certainly fall into the first category, and while it is currently protected within part of its range this may not be nearly enough if there proves to be insufficient individuals in the one population to maintain genetic stability. While the River dolphins are the most vulnerable species in many respects it is actually probably easier to frame legislation to protect them than in the case of the open ocean species.

It is relatively easy, given cooperation by other nations and 200 mile national limits, to protect a significant area of the Indian Ocean and close that entire area to directed hunting. If pelagic dolphins or coastal species are subject to intensive mortality from fishing gear, however, it is much harder to justify closure of huge areas to legitimate and lucrative enterprise by fishing fleets, especially in a region with significant protein and lipid shortages. In this case it is better to try to work with the industry rather than in opposition to it, and encourage modifications to traps and gill nets so that they will take fewer small cetaceans without significant diminution of the catch per unit effort of commercial fish species. The US tuna industry and the National Marine Fisheries Service were able to achieve such a goal with an intensive gear-modification program over a period of years with respect to the *Stenella* and *Delphinus* species of the tropical Pacific Ocean. Simple prohibition of incidental catches is pointless ; the fishermen cannot stop the small cetaceans entering their gear, but just stop reporting the catches for fear of prosecution and as a result valuable biological information is lost. Licencing the incidental catch, or granting permits (at cost to the fishermen) of exemption has exactly the same result. These are hard lessons learned from application of the United States Marine Mammal Protection Act which, while well-meaning, was not entirely wisely framed.

It is to our advantage in such situations to have each industry involved realize from the outset that while we regard the protection of endangered cetaceans to be the major priority, we have every intention of working with them to avoid even temporary closure of the fishery. If a basis for mutual trust can be established then accurate reporting of incidental catches is likely to follow, and better data will be available for formulating solutions. Are the catches age, size or sex-specific, for example? Do they occur in limited seasons? It may not in fact be that difficult to minimize catches. A study by Dr. J. Lien of catches of *Phocoena phocoena* off the south-east coast of Newfoundland in 1982 for example, revealed that of 100 gill-netters surveyed, only about 24 men ever took porpoises in their nets, and of those, about 5-6 were responsible for a very large fraction of the total mortalities, indicating that the catches were exceedingly site-specific. In such cases it should not be impossible to negotiate relocation of the nets without significant reduction of catch per unit effort, as these were not necessarily the nets which consistently took the best catches of fish. Captures of medium-sized cetaceans often lead to considerable damage to gear; it is usually not too difficult to obtain cooperation from fisherman in this case to minimize contact and hence their financial loses, providing they are approached in the right way and have their basic fishing rights upheld.

If the nation is poor then international aid may be a necessary prerequisite to a solution, but at the same time each local problem must be regarded individually, as a solution which will work in one particular area will not necessarily work in another. In adjacent islands in the Caribbean for example, dolphins are regarded either with superstitious respect, or simply as food. It may be possible to train fishermen to replace gill nets with long lines; not only does this remove a great threat to small cetaceans, but also usually results in lower operating costs and a better quality of fish. On the negative side of the balance long lining requires a different type of skill and men may be reluctant to change, and in some areas sharks will take a high percentage of the hooked fish but sometimes avoid the nets.

If gill nets *must* be used, then there are steps which can be taken to minimize mortalities. The use of acoustic pingers to deter dolphins and porpoises, and also large baleen whales in some areas of the western North Atlantic has been moderately successful. The cost of such items, and the high proportion of maintenance time, together with equipment loss and damage, make it quite prohibitive for any Third World nation's fisheries. More promising research being carried out jointly by the Japanese and United States government agencies simply involves making the nets more acoustically visible to porpoises and dolphins, while not doing anything that would improve their actual visibility to fish. The method employed is to include a certain proportion of panel rope which has a hollow, air-filled centre which is acoustically opaque and can be detected by echo-locating animals. Initial results seem to be quite promising, but more research is needed (Kasuya and Jones, 1983).

Nevertheless the simplest and cheapest solution to these problems may lie with obtaining a better understanding of the interactions between the prey and predators and mapping their dynamic distributions within local contexts so that a considerable measure of separation of set gear and cetacean feeding distributions can be developed. As indicated above, there is no proof that the fisherman and the cetaceans, even though they are essentially competing for the same resource, necessarily need to do so in precisely the same time and spatial location. Nets are often set where they are least affected by currents and flotsam and can be most easily retrieved with the gear available on each vessel, not necessarily where catches are likely to be greatest. The fishermen must continually offset the potential gain in catch against the potential loss if gear is damaged or destroyed. For similar reasons the cetaceans, and other marine species, may not always concentrate at maximum prey density. The behaviour of prey has a great effect on its catchability and behaviour of predators is dictated by the selection pressures which have moulded their previous biological success. One of the complex pressures is the requirement for maintaining a net positive energetic intake increment during foraging. In studies on a pelagic seabird in the North Atlantic (Braune and Gaskin, 1982) we found that Bonaparte's Gulls consistently opted for areas with only moderate prey densities but where occurrence of prey was regular, and only in fact exploited areas where prey densities were much higher but occurrence was irregular on a purely opportunistic basis.

The author is confident that with a positive attitude and a diplomatic approach (coupled with considerable on-the-spot improvization and ingenuity), great progress can be made in providing a significant measure of protection to the unique and diverse assemblage of cetacean species which comprise the fauna of the great Indian Ocean Basin and its coastal margins. One can be fairly confident that initial resistence will be encountered in any attempts to request changes in fishing practices which may seem to fly in the face either of tradition or maximum economic return, or when coastal Marine Parks are proposed which seem to threaten unbridled use of resources in the future. Nevertheless, the more progress which can be made on the basis of voluntary restraint conservation and cooperative interest and awareness, the less legislation will need to be framed. The less legislation involved, the smaller the perceived threat to individual freedoms and the less need to strain the already chronically overstretched, meagre Protection and Conservation staffs in the nations of this region.

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INDIAN OCEAN WHALE SANCTUARY—BACKGROUND AND UPDATE

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INTRODUCTION

A GENERAL account of the establishment by the International Whaling Commission (IWC) of the Indian Ocean Sanctuary for whales is given by Holt (1983) and Ferrari (1983). The legal authority for this decision, taken in 1979 on the basis of a proposal by the Delegation of the Republic of Seychelles, supported by Indian Ocean coastal states, both Members and non-Members of IWC, is contained in Article V of the International Convention for the Regulation of Whaling, 1946. Paragraph 1 (c) of that Article provides that the Commission 'may amend from time to time the provisions of the Schedule by adopting regulations with respect to the conservation and utilization of whale resources, fixing (*inter alia*) open and closed waters, including the designation of sanctuary areas'.

The Schedule referred to in the above quotation is defined in the Convention's Article I as 'an integral part' of the Convention itself. The Schedule is revised and published each year, after the annual meeting or, exceptionally, a Special Meeting, of the IWC has decided on amendments to it. Such amendments require for their adoption a three-quarters majority of Member States which cast votes. Most amendments made are changes in annual quotas for each 'stock' of whales, which the IWC refers to as *catch limits*. But in 1975, in 1979, and in several years since, the amendments have included substantive texts which, together, create a nearly comprehensive system for the management of whaling. The 1979 decision to establish the Indian Ocean Sanctuary must be seen in that context.

The important 1975 decision is embodied in what is now Paragraph 10 of the Schedule. Under it all stocks of whales must be classified in one of three categories, according to the advice of the Scientific Committee of the IWC. Specific rules are then given for the formulation of proposals for catch limits, based on the classification and the assessed state of each stock. These rules establish what was initially referred to as The New Management Policy (NMP), subsequently called the New Management Procedure. From the perspective of this paper a crucial feature of the new policy was that if a stock was found to be numerically somewhat less (specifically, 10% less) than the number which it was thought would give a maximum sustainable yield, then commercial whaling on it should cease. Such a stock is called a *Protection Stock*.

At the time of the adoption of the NMP a number of *species* of whales were already designated as *Protected Species*. This had been done, at various times during the history of the IWC, under another provision of Article V (1) of the 1946 Convention—sub-para, (a) which empowers the Commission to fix 'protected and unprotected species'. In 1975 the Protected species included all the right whales, the gray whale, the humpback and the blue whale (including the pygmy sub-species). The Commission decided that all stocks (populations) of the Protected species should be classified as Protection Stocks (PS). They have remained so to this day, with the exception of the eastern population of the Pacific gray whale which is considered to have recovered sufficiently from early exploitation to deserve removal from the PS category. There are, however, doubts in the minds of some scientists whether this is in fact so, and the matter will be critically re-examined at the meetings of the Scientific Committee and of the Commission in June-July this year. The matter is of substantial importance because the 'recovery' of the grey whale might give information about the potential of baleen whales generally to recover from over-exploitation, and might even indicate the possible levels of sustainable yield that could be expected from such whales. The recovery of the grey whale is in marked contrast with the lack of evidence of significant increase in the numbers of blue whales in the southern hemisphere since they were 'protected'.

I will not pursue this matter further here, except to note that the criteria for designating a species as 'protectea , and a particular stock as a PS stock, are quite different. The former criteria were never formally spelled out by the IWC, but the general idea was that a species should be protected (and it might be protected only in a part of its range) when continued commercial whaling might threaten its existence ; this decision was usually reached about the time the species had been so reduced that it had very little value as a resource. Until 1975, if a species was depleted— presumably to below its level of maximum sustainable yield (MSYL), but did not yet appear to be endangered, the Scientific Committee sought to recommend catch limits somewhat lower than the calculated MSY so that—if the calculations were right—the species could be expected to increase. How *much* lower, and how fast an increase was desirable, was, in the absence of any clear guidelines, immensely controversial. The NMP provided a solution to that recurring controversy, but a rather drastic one, involving a fairly sharp cut-off of whaling on depleted stocks.

It has proven much more difficult than was expected at the time to classify stocks and estimate sustainable yields from them. This has had many consequences, one of which is to encourage the whaling countries to seek to revert to the earlier, looser policy—or, when they fail to convince others of this, to use their statutory right of 'objection' to any decision by the IWC in order to release themselves from the obligation to abide by catch limits and classification decisions. Such actions are facilitated by disagreements among the scientists—and remember, the Scientific Committee is composed almost entirely of scientists employed by and owing allegiance to their governments. In cases of such disagreement, which have become increasingly common, whaling countries have been able to say, in effect, 'since the scientists cannot agree whether or not a particular stock should be classified PS, and since it is not apparently 'threatened', then it should not be classified PS and the catch limit should not be zero'. This is, to give a current example, the Japanese argument regarding the catching of sperm whales in the Northwest Pacific. But it is clearly contrary to the *policy* adopted in 1975 which was to protect whales from commercial whaling as a measure towards optimization of the potential yield from them as resources, not merely to prevent their extinction.

That particular point of policy was, indirectly, reinforced by a decision taken in 1982. This established a specific procedure for stocks which are subject to so-called 'aboriginal subsistence whaling'. The procedure is enshrined in Paragraph 13 (a) of the current Schedule. It provides that there can be catching 'to satisfy aboriginal subsistence need' from a stock that is a Protection Stock with respect to *commercial* whaling, provided that it has not been depleted to below some (as yet unspecified) threshold level. That level is understood to be a l vel at which extinction becomes a real possibility, so that it has some loose correspondence with the level at which, in earlier years, a species might have been designated as a 'protected species'.

The only 'aboriginal subsistence whaling' taking place in the Indian Ocean is on a very small scale in Indonesia. Since that country is not a Member State of the IWC it is not bound by its policies, procedures or regulations. This whaling, which involves capture of both baleen and sperm whales, and which is essentially unmonitored, should be of concern to Indian Ocean coastal states, to ensure that it does not, perhaps with encouragement by commercial interests outside the region, grow into a larger and technically more advanced operation, especially as whales become somewhat more abundant—as we hope—under protection elsewhere in their ranges.

The NMP established an additional criterion for 'protecting' a particular stock. This applies to the category 'Initial Management Stock' (IMS), which is one considered to be at more than 20% higher in number than the level judged necessary for maximum sustainable yield. (In the absence of evidence to the contrary this latter is assumed by the Scientific Committee to be, for baleen whales, at 60% of its 'initial' number—that is the number thought to be living before significant exploitation began. This means that an IMS stock is one which is somewhere between 72% and 100% of its original size.) Three rules are defined for determining the catch limits from IMS stocks. Two of these apply to stocks that are already being commercially exploited. If, however, exploitation has not yet begun then it 'should not commence until an estimate of stock size has been obtained which is satisfactory in the view of the Scientific Committee'. That means the catch limit for such stocks is automatically zero until the size of the stock has been estimated. It is worth noting that this is the only specific provision in the NMP which is facultative: *should* rather than *shall*. Nevertheless, this facet of the NMP is a very important precedent, not only with respect to whales, but also in principle to other forms of wildlife. In practice it moves the burden of proof from those concerned with conservation to the would-be exploiters. It has been decisive in preventing, so far, the exploitation and—in the present state of whale science—the inevitable depletion—of Bryde's whale populations in the tropical western Pacific south of the equator, and in the Indian Ocean. It came too late to save the population of this species in the tropical Atlantic which were depleted by so-called 'pirate whalers' (factory-catcher boats flying flags of convenience and producing whale meat for shipment to Japan) and in the North Pacific by Japanese and Soviet factory ships and, continuing now, by Japanese land-based catcher boats operating from the Bonin Islands.

The 'protection' of some IMS stocks, until the whales have been counted, is an anomalous measure, although it is the *only* one applied under the NMP which has actually *prevented* depletions, rather than merely slowing them or halting whaling after depletion has occurred. It is anomalous in this sense: most stocks of those species of whales of which commercial exploitation is still permitted are now *unclassified*—a status for which there is in fact no provision in the Schedule. This is simply because of great uncertainty among scientists as to their numbers or demographic conditions. Logically, one might suppose that it would be more important to set zero quotas for such stocks, especially as many of them are possibly greatly depleted, than to protect the completely unexploited stocks. But logic does not rule in such matters. Instead, vested interest ensures that what has been started is difficult to stop. The situation reminds me of house construction laws in some European countries. In theory, a new house may not be constructed until certain prior planning conditions have been met. In practice, if someone can, with the help of neighbours and a full moon, get four corners erected overnight, and some kind of a roof over them, then he can continue his building at leisure without further worry !

The Sanctuary Decision

The NMP was based upon a Resolution adopted by the IWC at its 1974 meeting, referred to at the time as 'The Australian Amendment'. This was because it had been conceived as an amendment to another resolution which would have established a general moratorium on all commercial whaling, as had been called for by the U.N. General Assembly in 1972. Certain details had to be filled in before appropriate changes could be made in the Schedule and, among other things, the Scientific Committee was asked by the Commission whether it felt it would be able to fulfil the rather stringent new scientific requirements. At that time the Committee believed it could do so, especially as the Commission had also decided to embark on a massive new programme of research on whales. The Committee emphasised, however, that 'it understood that the adoption of the proposals (for the NMP) would in no way limit its advice to the Commission within its terms of reference'. Equally, the Commission itself understood that the adoption of the NMP did not in any way limit its power, and possibly its need, to take *other* measures for conservation and management as defined in some detail in the 1946 Convention. It did merge, as I have explained, the decisions on Protected Species with the new rules for PS stocks. It had never 'fixed unprotected species' under Article V (1) (g), it being assumed that anything not 'protected' was 'unprotected', This omission had more than trivial consequences. It meant that the Commission never defined the species scope of its competence to regulate whaling, because a 'whale' is not defined in the original Convention, nor has an explicit definition been included at any time by amending the Schedule. I shall return to this matter later. In fact the NMP decision was limited to providing policy guidelines and explicit rules for the application, in part, of Article V (1) (e), which empowers the Commission to fix 'time, methods, and intensity of whaling (including the maximum catch of whales to be taken in any one season)'. Measures empowered by other sub-paragraphs of Article V (1), such as establishment of minimum size limits for each species, provision of statistical records, fixing types and specifications of gear and appliances which may be used in whaling, fixing open and closed seasons, were all retained, and amended and added to from time to time subsequently. Nevertheless, the attention of the Scientific Committee was for a few years almost completely focused on the identification of 'stocks', their classification, and the estimation of sustainable yields.

The first effect of the NMP was to secure protection of many of the most depleted stocks, for which data were more or less adequate—to demonstrate depletion, if little else. But by the late 1970s it was becoming obvious to some Governments that the NMP, which had been Conceived as an alternative to a general moratorium, was not going to be effective in preventing further depletions, or even in identifying all those that had already occurred. This was mainly because data for the traditional 'pelagic' whaling operations in the Antarctic and North Pacific were quite good, but data from the land-based whaling operations, and so-called 'small-type' whaling with small catcher-factories (especially in the North Atlantic) were lacking. Furthermore, since 1972 an entirely new industry for the catching of the small minke whale in the Antarctic had been established by the USSR and Japan, whaling by non-Members of IWC was increasing, and plans were being quietly developed for a great expansion of whaling in the tropics for the Bryde's whale.

Something had to be done. In 1973 the IWC scientists had said that the call by the U.N. and by some Member States for a moratorium was scientifically unreasonable or unnecessary. By 1978 a few of them had begun to change their minds about that, and more Governments were ready to opt for a moratorium—but not enough of them to secure the necessary three-quarters majority in the commission. Starting in 1979 new countries, favouring a moratorium, joined the IWC, but so also did a number of countries which had hitherto been operating outside the IWC, and which—of course—were set strongly against a moratorium. This inflow of new whaling Members had one cause and two reasons. All were whaling in order to supply Japan with whale meat. Japan was under great pressure to halt imports of meat from non-Members. Before it enacted domestic legislation to that end the Japanese industry virtually instructed client governments to join IWC: it was in a position to do so not only because it controlled the market for meat but also because it controlled much of the application of the technology of modern whaling.

The results of these influxes were, firstly, that the likelihood of a vote in favour of a moratorium temporarily diminished. Secondly, even votes in response to cautious scientific advice in the context of the NMP became much more difficult to secure. Politically and economically the new whaling Members wanted as large catch limits as they could get, and scientifically they had very little to offer, in many cases not even having maintained reasonably accurate records of their catches.

In 1979, in these circumstances, two new approaches to whale conservation were tried, and both partially succeeded. Some countries considered that the greatest threat to the remaining whales came from the continued operation of floating factories and their associated fleets of catcher boats, in the Antarctic and the North Pacific. They proposed an indefinite moratorium on all such operations. They failed to secure this but did succeed with a compromise, involving the exclusion of the minke whale from the moratorium. Thus the Soviet and Japanese operations were allowed to continue in the Antarctic, and the Norwegian operations, with smaller factory-catchers could continue to take minke whales in the North Atlantic. This decision, in 1979, did, however, contribute very greatly to the protection of the sperm whale, about the status of which there was perhaps more uncertainty than about any other species. It also brought to a prompt end an incipient Soviet industry for killer whales (orcas) in the Antarctic.

The second action in 1979 was the creation of the Indian Ocean Sanctuary. Here again a compromise was necessary in order to make any gains for conservation. The original Seychelles proposal envisaged a sanctuary extending southward to the Antarctic ice and thus including both the feeding and the breeding areas of all the baleen whales and the sperm whale. This would, however, have interferred drastically with the Soviet and Japanese pelagic operations for minke whales, which all take place well southward of 55 degrees South latitude. At that time, apart from the expected opposition from the two pelagic whaling countries, some others felt that the southern minke whale could not have been seriously affected by the seven seasons of whaling and that it could better be conserved through the application of a modified NMP. Thus the southern boundary of the approved sanctuary came to be set at 55 degrees South. Although this excludes the feeding grounds of the male sperm whales and of all the baleen whale species except Bryde's, they—with the exception of the minke—are for the time being 'protected' by the moratorium on factory ship operations and by zero catch limits.

To secure the Commission's approval of the sanctuary another compromise had to be made. The sanctuary was established initially for only ten years, from 24 October 1979 ' with provision for a general review after five years, unless the Commission decides otherwise '. These provisions, with the precise definition of the area concerned, are included in Paragraph 7 of the current Schedule. This paragraph applies explicitly and only to *commercial whaling*, so in that sense it is parallel with the NMP. Commercial whaling has never been formally defined but is usually understood to mean any whaling which is not ' aboriginal subsistence '—which *has* been defined.

Apart from the initial interest by the Government of Seychelles a number of other factors entered into the decision that any sanctuary to be established at that time should be in the Indian Ocean rather than elsewhere. Most important was perhaps that no Indian Ocean coastal states were themselves then engaged in whaling; South Africa and Australia had both recently pulled out of the industry. Then, as previously mentioned, there was much sympathy within the governments of Indian Ocean states that had never been involved in whaling and had had no opportunity, historically, to benefit from the whale resources. Furthermore, it was known that ' pirate whalers ' who had been profiting from unregulated whaling in the Atlantic and the Pacific were turning their attention to the Indian Ocean. Joint actions by all the Indian Ocean states could make their operations there very difficult. And, lastly, it should be mentioned that the International Union for the Conservation of Nature and Natural Resources (IUCN) had, at a special meeting on Cetacean Sanctuaries, identified a large sector of the Indian Ocean as a first priority for an open ocean sanctuary.

The Next Steps

At its 1984 meeting the IWC decided that the general review prescribed in Paragraph 7 of the Schedule would be undertaken immediately preceding the 1986 annual meeting, the presumption being that further decision as to the future of the Sanctuary might be taken at the 1986 meeting.

In 1982 the Commission accepted in principle the suggestion by its Scientific Committee that the review should be preceded by a special scientific meeting to examine the results of research in the Sanctuary and to give scientific guidance for future actions. In 1983 the Scientific Committee drew up a draft agenda for its special meeting and suggested who should participate. The Commission accepted the suggestions. These were that the meeting ' should consist of members of the Scientific Committee nominated by their Governments together with representatives of non-member countries in the Indian Ocean region, and selected individuals invited by the Scientific Committee. ' Further, ' the IWC should send formal invitations to such non-member Governments to send representatives and that FAO, UNEP and IOC should be invited to co-sponsor the meeting. ' The scientific meeting will be held in the Indian Ocean region. The Government of Seychelles has offered to host it but before a final decision as to the location is taken it will consult with the other Indian Ocean states which are members of the IWC (Australia, India, Kenya, Mauritius, Oman and South Africa). It is envisaged that the scientific meeting will be held a few months before the review, around March-April, 1986.

In 1982 the IWC took the major decision that ' catch limits for the killing for commercial purposes of whales from all stocks for the 1986 coastal and the 1985/86 pelagic seasons and thereafter shall be zero '. This decision in practice establishes the general moratorium called for by the U.N. in 1972, except that the time-scale for its implementation is differently defined. The start of the moratorium period was delayed for three years to enable whaling countries to make arrangements to ease any economic or social dislocation that a pause in all commercial whaling might cause, but the moratorium is, in principle, indefinite. That is, the zero catch limits stand unless and until the Commission decides otherwise. However, it was agreed that the 'provision will be kept under review, based upon the best scientific advice, and by 1990 at the latest the Commission will undertake a comprehensive assessment of the effects of this decision on whale stocks and consider modification of this provision and the establishment of other catch limits' (Paragraph 10 (e) of the current Schedule).

Most whaling countries accepted the 1982 decision for a pause in commercial whaling. The three biggest, however —Japan, Norway and USSR—have formally objected to it. While their objections stand the decision is not applicable to them. Much current diplomatic activity is now being devoted to persuading them to withdraw their objections, but the outcome is at present quite uncertain. For the purpose of this paper what matters is that there is no surety that pelagic catching of minke whales in the Indian Ocean sector of the Antarctic will pause after the present season has ended.

A matter of more immediate concern is that both Japan and the USSR have objected to the catch limits for southern hemisphere minke whales for the present season (1984/85-1985) which were set by the IWC at its 1984 meeting. These were, overall, about 40% lower than the limit for the 1983/84-1984 season, the reduction being justified by the fact that the Scientific Committee reduced its estimates of the numbers of minke whales by about that percentage. The reason for *that* reduction was that the estimates made in 1983 were an average of two sets of estimates—one from marking experiments, the other from sightings surveys—and in 1984 the marking estimates were rejected as invalid because there was probably an unquantified but high rate of shedding of marks. If such shedding is not taken into account the estimates from marking experiments will be much too high.

In objecting to the current catch limits the Soviet Union announced its intention to take the same number of minke whales as it had the previous season. Japan will presumably do the same.* It is not known, however, what proportion of the total will be taken from the Indian Ocean sector and what from the other oceans. I shall later examine that question further.

It has been suggested that if a moratorium were to come into effect it would no longer be necessary to maintain the sanctuary. This is a matter that will no doubt be examined from many aspects during the next few years. The IWC began, in 1981, a process of examining the general concept and characteristics of whale sanctuaries. A Technical Working Group studied the question in 1982, taking account of comments from the scientists, and began to draw up guidelines for future actions under that particular provision of the 1946 Convention. There is as yet no consensus on these matters among Member Governments. It has been agreed that any future sanctuary proposals will be assessed and reviewed by a small group of Commissioners selected by the Chairman and Vice-Chairman of the Commission, prior to formal action by the Commission as a whole. It is not clear whether that agreement relates exclusively to proposals for sanctuaries in other areas (it was in that context that the review procedure was discussed) or whether it would be applied also to any proposals for modifying the standing provisions for the Indian Ocean. In any case, the questions regarding the Indian Ocean which need to be looked at closely between

* An announcement to this effect was made by Japan on 6 January 1985.

now and the 1986 IWC meeting include the following:

- —the species scope of the sanctuary decisions;
- —the boundary of the sanctuary;
- —the state of the whale stocks in the sanctuary;
- —scientific research in the sanctuary;
- —the relation of the sanctuary provisions to the other regulatory measures under the 1946 Convention;
- —the relation of the IWC decision to the provisions of other international agreements and instruments.

The Species Scope

There is no doubt that the Indian Ocean sanctuary provisions apply to all the species of cetaceans the commercial catching of which is at present regulated by the IWC. That is, all the southern hemisphere species of baleen whales and the sperm whale. Since the killer whale, *Orcinus orca*, is defined as a 'whale' in Section I INTERPRETATION of the Schedule, and the capture of this species by factory ships or whale catchers attached to factory ships is expressly forbidden under Paragraph 10 (d) there is, I think, no doubt that the IWC has accepted regulatory responsibility regarding tl is species and therefore that it too is fully protected from commercial exploitation under the sanctuary decision. The regulations specifically refer to prohibitions on 'taking, killing or treating of whales'. The precise scope of these terms is yet to be clarified. 'Treating' is not yet defined in the Convention, although Paragraph 1 of the Schedule implies that it is what happens to a whale after it has been 'landed'. To 'land' is explicitly defined, as to 'retrieve to a factory ship, land stations or other place . . .'. The question yet to be formally resolved is whether the prohibition on taking killer whales includes a prohibition on taking them alive for purposes of public exhibition. A killer whale is worth very much more alive than dead, to the extent that it is desired by the operators of commercial oceanaria. Until now animals have for this purpose been taken from the North Atlantic and the North Pacific. There is, however, a growing resistance by the public in many countries to the keeping of this species in captivity, and many scientists also are opposed to the practice. It seems quite possible that as more and more countries restrict the licensing of live capture of killer whales, or even completely prohibit this in waters under their national jurisdictions, there will be some moves by dealers in live cetaceans to take the species in the Indian Ocean. Few Indian Ocean states as yet have appropriate domestic laws about the live capture and treatment of cetaceans, and meanwhile the existence of the sanctuary is a discouragement to would-be traders.

As to other species of whales, there is no consensus as yet amor g IWC members. A few argue that in the context of the 1946 Convention all marine cetaceans are 'whales'. The current Schedule refers, in the INTERPRETATION section, to the following species found in the Indian Ocean, as 'whales':

- Hector's beaked whale (*Mesoplodon hectori*)
- Ginkgo-toothed beaked whale (*M. ginkgodens*)
- Gray's beaked whale (*M. grayi*)
- Andrew's beaked whale (*M. bowdoini*)
- Blainville's beaked whale (*M. densirostris*)
- Straptooth beaked whale (*M. layardii*)
- Cuvier's whale (*Ziphius cavirostris*)
- Arnoux's beaked whale (*Berardius arnuxii*)
- Southern bottlenose whale (*Hyperoodon planifrons*)
- Long-finned pilot whale (*Globicephala melaena*)
- Short-finned pilot whale (*G. macrorhynchus*)

Two points must here be made with respect to the above list. One is that since the Schedule is that part of the 1946 Convention that can be amended by vote, any of those species could in principle be removed from the list at a future date by a three-quarters majority vote of the Commission. Similarly, one might expect that other species could be added to it by the same process. Here, however, we come up against the second point, which is a 'constitutional' one. One Member state (Denmark) has contended that the IWC has no jurisdiction over species of cetaceans/whales that are not included in a Table of Nomenclature that was appended to the Final Act of the diplomatic conference that drew up the 1946 Convention. The specific case at issue, at the 1983 and 1984 meetings of the Commission, was one of the bottlenose whales, baird's beaked whale (*Berardius bairdii*). This is included with three other bottlenose whale species in the INTERPRETATION paragraph of the Schedule, but only the northern bottlenose (*Hyperoodon ampullatus*) is included in the Annex referred to. Although most legal experts who have commented on this matter reject the Danish argument, and it has found little support from other Governments, it is possible that if the matter were raised there would be no consensus that Arnoux's whale and the southern bottlenose whale fell within the scope of the sanctuary as at present defined. It may be noted, however, that by the Danish argument the Commission's *de facto* regulation of killer whale catching is unconstitutional because that species is also not included in the annexed Table of Nomenclature.

A more serious problem is that some Member states maintain that what they refer to as 'small cetaceans' and which they say live mainly close to coasts, come under their national jurisdictions over 200-mile zones and are hence no concern of the IWC. There is no consistency in these arguments, which are wholly political and opportunistic. Until a few years ago the minke whale was referred to by the IWC as 'a small cetacean' or 'a small whale', and its catches so recorded in statistics. And many of the 'small' species, including the majority of those listed above, are in fact oceanic species, biologically speaking.

It is unlikely that this problem of species competence will quickly be resolved by the IWC itself. But the universal acceptance of the principle of Exclusive Economic Zones up to 200 nautical miles in breadth has come from the protracted negotiations in the United Nations towards a new law of the sea. The Law of the Sea Convention has been signed by most Members of IWC and by all Indian Ocean states.* Although the Convention is not yet in force, many of its provisions are already treated by many states as customary international law. This is particularly true of the non-controversial Articles dealing with fisheries matters. Article 64 of the U.N. Convention seeks to ensure that all states concerned co-operate in conserving and optimally utilizing highly migratory species within and beyond their EEZs. 'Highly migratory species' are defined in an Annex to the Convention; the annex includes nearly all the cetaceans, even species that may not be 'highly migratory' in the biological sense. Co-operation is encouraged through appropriate international organizations, and there is no doubt that the negotiators had in mind the IWC as the 'appropriate organization' as far as whales were concerned. It seems therefore that the U.N. Convention gives strong arguments for the IWC to take responsibility for the management at least of those cetaceans that we can agree to be 'whales'. The 1946 Convention 'applies to all waters in which whaling is prosecuted .....' (Article 1 (2)). It also of course applies to waters in which whaling is not prosecuted because it is for the

* Except South Africa.

time being prohibited. Article 1 (2) is usually taken to mean that the Convention applies to waters within national jurisdictions as well as to international waters (high seas). This matter is examined in greater depth from the scientific point of view by Holt and Remond-Gouilloud (1984). For the present it should be noted that all present whaling is within EEZs, except that in the Antarctic—this exception arising only because all claims of national jurisdiction in and around the Antarctic continent are held in abeyance under the Antarctic Treaty. Nevertheless, no Member state of IWC has rejected *in principle* the power of the Commission to promulgate regulations regarding the cathing of whales in its zones of jurisdiction.

In the light of the above considerations it seems that a reasonable case can be made for the Indian Ocean sanctuary decision to apply at least to the species listed above and also to other species of cetaceans that are commonly regarded as 'whales', that are included in the list of 'Highly Migratory Species' annexed to the U.N. Convention, and that are indeed biologically oceanic and/or migratory. These, I suggest, include:

Pygmy sperm whale (*Kogia breviceps*)
Dwarf sperm whale (*K. simus*)
False killer whale (*Pseudorca crassidens*)
Pygmy killer whale (*Peresa attenuata*)
Melonhead whale (*Peponocephala electra*).

The Boundary of the Sanctuary

It is generally recognised by biologists concerned with conservation that there is need to protect threatened populations of animals throughout their range and, specifically, for migratory animals, where they breed, where they feed and along their migratory paths. There is a great confusion of terminology in the matter of 'protected areas' and the like, and I shall not attempt to sort that out here. There is also a recognised need for special protection to be given in certain cases to particular small areas within the range, where particular biological functions, such as calving, are performed, and the stability of which may be threatened by localised human activities, which are not necessarily intentionally directed to the animals in question. At the 1983 meeting of IWC the Commissioner for Mexico drew attention to these distinct, though connected, needs when he referred to the distinction between a *refuge*—a place where special protection for activities such as breeding occurs—and large areas designated as sanctuaries in the sense of Article V(1) (c) of the 1946 Convention. He surely had in mind, as refuges, the lagoons in western Mexico where gray whales go to breed and, as sanctuaries, not only the Indian Ocean Sanctuary but also the only other sanctuary that has ever been established under the 1946 Convention—a large part of the South Pacific. The latter was first suspended, then abolished by the IWC on the insistence of whaling nations when they had depleted all other parts of the southern hemisphere of the larger baleen whale species—blue, fin and humpback.

The history of the South Pacific sanctuary is illustrative of several matters that can arise with respect to protected areas. One is that mis-management of exploitation outside the sanctuary increases the pressure to abolish the sanctuary and permit exploitation within it. Another is that unless special efforts are made there is a tendency for scientists to ignore sanctuary areas. Throughout the life of the South Pacific sanctuary virtually no investigations were conducted in it, so that an opportunity to learn about the dynamics of whale populations for example by comparisons between exploited and unexploited populations, was irretrievably lost.

I shall return to the matter of research use of sanctuaries, but now we should look at the specific boundary question in the Indian Ocean.

This was examined most recently by the Symposium on Marine Mammals of the Indian Ocean, convened in Colombo, 22-25 February 1983 by the National Aquatic Resources Agency, Sri Lanka (Nara, 1983). The symposium resolved that the Indian Ocean Sanctuary had 'already shown its value in creating an awareness of marine mammals in the region that had not been there before and in attracting funds for research'. There were, however, some criticisms. One referred to the uncertainty regarding species coverage, which I have discussed in detail above. But the main criticism was of the inadequacy of the present boundaries. There was a consensus that *all* cetaceans should be covered, and if that could not legally be achieved under the IWC then some other International legal instrument for the purpose must be sought. An implication of covering all cetaceans is that river systems and estuaries within which some of the dolphins live for at least part of their lives should be included. Furthermore, the eastern boundary should perhaps be modified where it passes among the islands and peninsulas of southeast Asia, and that southward of Australia it should be moved eastward from 130 degrees E. to about 145 degrees E. I think this proposal needs further study, and consideration by the scientific review meeting in 1986.

The strongest recommendation was that the southern boundary should be where the Governments of the Indian Ocean States had originally proposed—at the edge of the Antarctic Continent or the fast ice. The present boundary was described as 'ecologically unreasonable'. But the problems to be faced are now political more than either ecological or economic. Governments that have various interests in the sanctuary not being strengthened, or even continued, are beginning to say, unofficially, that the new Commission for the Conservation of Antarctic Marine Living Resources CCAMLR), which has begun its work since 1979, must now be taken into account. CCAMLR can, in principle, deal with the conservation of cetaceans, as well as of fishes and krill etc., but will no doubt leave the regulation of whaling to the IWC unless the IWC appears to be collapsing. There have been hints that the major whaling countries might see a transference of responsibility for Antarctic whaling from the IWC to CCAMLR as advantageous to them. This is because of the restrictive Membership rules for the latter, with more weight to the richer countries that are conducting research in Antarctica and hence are Parties to the Antarctic Treaty itself, and to those wishing to exploit living resources now rather than conserve them. This hint that something is afoot is given more credibility by a very recent official communication to the IWC from the Government of Japan concerning the future of the IWC (currently the subject of study by a special working group of IWC established by its Chairman). This communication is used as the opportunity for a strong attack on the role of non-whaling countries in the IWC (especially those more recently joined) and on its Scientific Committee—because the findings of the Committee are increasingly contrary to the short-term interests of the whaling industry.

But for the moment these are only straws in the wind. Is there really any convincing political reason for the IWC to refrain from changing the southern boundary of the Sanctuary? I think not. The IWC catch limits already cover the CCAMLR area, and for most species they are zero in that area. Other regulations are in force under a number of clauses of Article V of the 1946 Convention; there is no legal reason why the sanctuary provisions under the same Article should not be applicable. Furthermore, the Sanctuary as at present defined and the CCAMLR area *already* overlap. In the Western Indian Ocean sector the boundary of CCAMLR is ten degrees northward of the southern boundary of the Sanctuary. An increase in the overlap, by moving the Sanctuary boundary southward, would create no new precedent. And since the only regulatory measure under the sanctuary provision of the IWC is that there should be no commercial whaling, a southward extension of it would not in any way impinge on whatever rights or prerogatives the Parties to CCAMLR and to the Antarctic Treaty consider they may have in the areas to which those agreements apply. Lastly, good co-operation has already been established between CCAMLR and the IWC at both scientific and administrative levels, so there exists a mechanism through which any problems that did happen to arise could be resolved.

Possibly the strongest reason for moving the southern boundary is that it would facilitate the preparation and conduct of a long-term and comprehensive programme of effective research on the whale populations of the region. The need for this becomes apparent when we look at the present status of those populations.

Status of Whale Populations

I shall not here attempt a general review; I presume, that will be a major task of the 1986 meeting. Since the NMP was instituted virtually all research under IWC auspices in the Indian Ocean has been focused on sperm and minke whales, especially the latter. The 'assessments' of sperm whales have all been inconclusive. There are many reasons for this state of affairs but they include, essentially, the lack of satisfactory estimates of numbers of whales or of trends in those numbers over time, and inadequate knowledge of the social biology of the species'. Thus mathematical models cannot be tested nor stocks monitored by methods used so far. Science relied almost entirely on data from the whaling industry itself and this has failed to yield the desired results.

The situation of the minke whale is rather different. A considerable effort has been made over the past six years to estimate numbers by conduct of sightings surveys in the summer near the ice edge where the whales aggregate—and where they are killed. Marking has also been carried out; as already mentioned this has not yielded reliable estimates of numbers, but it has told us something about the movements of the whales longitudinally. During this period advances have been made in the theory of planning and analysing sightings surveys. Theory was inadequate, there are still some problems, but it is increasingly realised that this is really the only good way we have to estimate whale numbers.

The Scientific Committee assumes that there are two 'stocks' of minke whales in the Indian Ocean, the western stock occupying the longitudinal sector 0 to 70 degrees E., the eastern stock the sector 70-130 degrees E. Thus the western stock extends into the Atlantic. The two stocks are designated 'III' and 'IV' among the six presumed southern hemisphere stock. However, from marking experiments two important facts have emerged. One is that there is mixing between stocks III and IV. The other is that at least some of the minke whales that feed in the Atlantic sector of III breed in the Atlantic, off Brazil (where they are caught). However, because of lack of agreement on alternative stock boundaries the Scientific Committee continues to make its assessments for the whole of Areas III, and IV separately. I can therefore only give approximate results for the Indian Ocean itself.

Before large scale whaling began in 1972 there were about 110,000 minke whales. There are now about 80,000. These are calculated numbers, based on catches in that period, assumed values of parameters in a simple population model, an assumption that the unexploited populations were stable, and on a survey in area IV in 1979 giving an estimate of 53,000 then in that area, and a survey in 1980 of Area III, giving an estimate of about 36,000 in the Indian Ocean sector of that Area.

Nearly half the total catch of minke whales so far has come from the Indian Ocean sector of the southern hemisphere. Of all sectors of the Antarctic it has been the scene of the most intensive exploitation over the longest period. Whaling has been selective, with far more females than males being killed, most of them mature and with a high proportion being pregnant. The present number of females is perhaps now about 70% of their original number. Thus these stocks are unlikely yet to be in PS status under the NMP, but equally they are probably now well below their numbers at the time the U.N. first called for a moratorium.

For a few years, until very recently, it was thought that the minke whales might not have been stable before whaling began, but might have been increasing, taking advantage of increased food supplies (krill) presumed to be available to them after the blue whales had been depleted. Intensive studies of the supposed evidence for this have shown that the hypothesis is untenable. So arguments we have heard from whalers that minke whales should be 'culled' to allow the depleted blue whales to recover must be dismissed.

Studies of the minke whale have been confined to the region south of the sanctuary. Practically nothing is known about the north-south migrations of the species or its breeding areas, and even though the whaling industry now largely depends on this species for its existence no effort has been made to elucidate its natural history. This is typical of the research carried out by using catcher boats as the observation platforms, even when they are used to try to count live whales rather than to dissect dead ones.

Some use has been made of the sightings surveys to look at other species of whales. Because the distributions of the various baleen whale species differ, even when they overlap, the only useful data have come for the blue whale which has a distribution very similar to that of the minke. These indicate that the blue whale is now very much more rare than had been thought. There may be only a thousand or so left in the southern hemisphere, and there is no hope at all of being able to monitor any recovery except perhaps over a long period of several decades or even centuries.

There are no current assessments of any other stocks of whale species in the Indian Ocean, of the extent of their depletion or of possible recoveries. The numbers of remaining fin and sei whales were estimated at the time they were classified as PS stocks in the 1970s, but the methods then used have been superceded ; they were almost certainly biassing upward the numbers of whales and under-estimating the degree of depletion. This should be bourne in mind when considering the following results of the Scientific Committee's work in the 1970s.

It was estimated that there were originally about 170,000 fin whales in the Indian Ocean sector (let us say in 1920, before the advent of large scale pelagic whaling in the Antarctic) and that in 1975 there remained about 32,000, i.e. less than 20% of the original number. If they have been increasing since then it is unlikely to have been at a rate exceeding 2% per year, so that there would still be less than 40,000 fin whales.

The last comprehensive assessment of the sei whales was attempted in 1977. Most members of the Scientific Committee concluded that there had been about 50,000 in 1930 (Exploitation of sei whales started later than that of blue and fin whales, and in fact only became important after about 1960 when the others had been depleted.) About 9,000 were left by 1976 so their depletion was to about the same degree (to less than 20%) as that of the fin whale. The Japanese scientists, however, maintained that there were only about 34,000 initially, but they had been depleted to a much lesser degree, with 24,000 remaining in 1976. The wide difference between these two sets of conclusions comes to a large extent from the evidence that the sei whales had *apparently* been increasing natually, before intensive exploitation started, it was presumed because they could take advantage of food 'surpluses' resulting from the earlier depletions of the larger species, especially the fin whale. This evidence, which of course was indirect, must now be questioned as a result of the rejection, on methodological grounds, of similar evidence regarding minke whales. Thus the Japanese scientists' claims are even less tenable now than they were in 1977.

There are no estimates of the greatly reduced and still possible endangered humpback whales, nor of the endangered right whales. This is in sharp contrast with the situation elsewhere —for example regarding the right whales of the south Atlantic studied from Argentina, the humpbacks of the North Pacific studied at Hawaii and the North Atlantic humpbacks, all of which have been the subject of intensive research for several years.

Minke whales are now the most numerous of the baleen whale species that feed in the Antarctic zone. But if differences of size are taken into account the fin whale remains the largest component of baleen whale biomass, having a biomass about three times that of the minke. The sei biomass might now be only about one fifth of that of the minke. Lastly, it should be said that the numbers and biomasses referred to are for animals of a size big enough to be considered by whalers as worth killing, or which they were legally permitted to kill; thus they exclude calves and juveniles, but they do include adolescent animals.

As mentioned earlier, an attempt by Japanese scientists to obtain satisfactory estimates of the numbers of Bryde's whales in the Indian Ocean, by conducting sightings from catcher boats specially deployed for the purpose, and by killing large scientific samples of the species for examination of the carcasses (an action which is permitted, outside catch limits, under Article VIII of the 1946 Convention), failed. These studies were not made in accordance with a procedure which would now be regarded by the Scientific Committee as likely to give even approximate estimates of the numbers of whales in a population or of the important parameters in population models that might be constructed.

Scientific Research in the Sanctuary

Since the sanctuary was established the whaling nations have conducted no research in it. A detailed programme of work was drawn up by a special meeting of scientists convened in Zeist, Netherlands, in September-October 1981 (Anon, 1982). So far it has been possible to implement only a very tiny part of the proposed activities. It was expected at the time that the IWC itself (which co-sponsored the meeting) and the U.N. Environment Programme would support some of the proposed research, but so far no contributions have come from those potential sources. Nevertheless, the countries in the region have, with the help of international non-governmental organisations, been able to make some useful beginnings.

The International Fund for Animal Welfare carried out a preliminary aerial survey of part of the EEZ of the Republic of Seychelles, in 1980. The main object of interest was the sperm whale, which had once been abundant in that area. It had been the practice, however, since Antarctic pelagic whaling re-started after the second World War, for whalers on their passage to and from the Antarctic to take sperm whales in the tropical zone; this was permitted, and unregulated, although the taking of baleen whales north of 40 degrees S. was prohibited. On several occasions numbers of sperm whales were taken in this way in the 1960s and 1970s, in the central Indian Ocean. Thus any recovery of this species in the region from more than a century of almost continuous exploitation was unlikely. There are, however, groups of sperm whales still to be found on the breeding grounds close to the equator. The World Wildlife Fund and IUCN decided that close study of such groups from a small sailing vessel would be productive. The original intention was that the study would be conducted in the zone explored by the IFAW project, but it was found that groups off Sri Lanka were more accessible to such work, and a project there was undertaken for the three years 1982-1984, using the vessel TULIP, under the direction of Dr. H Whithead, and with the close co-operation of NARA.

The TULIP project has yielded results out of all proportion to the relatively small expenditures incurred. These included the first good underwater movies of the species, observation of the birth of a calf, location of distant whales from their sounds and, most important, the finding that individuals of this species can be recognised. Individual recognition is now common-place for humpback and right whales and the technique is yielding remarkable information about the biology of those species. There seemed originally to be little hope that the technique would be applicable to the sperm whale, but repeated sightings of identified animals in the three year TULIP cruises have shown that it *is* applicable and thus potentially a very powerful tool for elucidating aspects of sperm whale natural history that have so far evaded us.

The TULIP project also yielded other completely unexpected results. A previously unknown population of the blue whale was found, off NE Sri Lanka. Animals can regularly be seen quite close to shore, so that not only could a research programme conveniently be undertaken, but also the possibility exists for a small 'whale-watching' industry. This possibility is being investigated by NARA.

A few other small research activities have been recorded in the Proceedings of IWC in recent years. There is potential to study the biology of the humpback whale off Oman. Specialists have a particular interest in the 'song' of this population, and how it relates to those of populations in the North Atlantic and North Pacific.

Apart from a few bird species and marine turtles, the great whales are the animals with the greatest migratory ranges. Yet after decades of research based on the operations of whalers very little is known about these migrations. The animals are dispersed over wide areas of ocean and difficult to follow, although sperm whales and humpbacks can be tracked fairly close to shore on parts of their migration paths. The mode of 'navigation' by the whales has been a mystery. It remains so, but recent evidence has suggested that a magnetic sense might be the key to the mystery. The suggestion first appeared from the observation that strandings of cetaceans are closely associated with magnetic anomalies, on both sides of the North Atlantic. This gives greatly added weight to the recommendation from the Zeist meeting that there should be an intensified collection, exchange and examination of strandings data from the Indian Ocean. At the same time, now that the magnetic fields have been studied over the entire ocean by geophysicists, it should be possible to formulate a hypothesis regarding the distribution and movement of whales and to devise a research programme to test it. I believe this should now have high priority.

Relation of IWC Action to that by Other Authorities

I have already mentioned the relations of the IWC with CCAMLR and the new Law of the Sea. It seems possible that the (Bonn) Convention on Migratory Species could become an instrument to reinforce the sanctuary concept, but this has so far received little attention. The Convention on International Trade in Endangered Species of Fauna and Flora (CITES) is important with cetaceans because all species are listed on one or other Appendix of that Convention. In particular, all the great whales are now listed on Appendix-I, so that international trade in products from them is prohibited. Unfortunately, just as countries can escape from IWC regulatory actions by formally objecting to them, so they can take out reservations to actions under CITES, and whaling countries have done so with respect to the great whales.

From the time the IWC sanctuary was conceived it has been recognised that parallel declarations of protection of cetacean species within the EEZs of Indian Ocean coastal states was a desirable reinforcement. In 1979, the Republic of Seychelles declared cetaceans to be protected in its large maritine zone. Australia has also taken special actions regarding cetaceans in its EEZ. I understand that domestic actions by other countries are now under consideration. Domestic legislation would provide the opportunity for the creation of cetacean 'refuges' or other types of protected areas along the lines identified by the Mexican delegation to IWC. There is perhaps a need for international consultation about these developments with a view to harmonising them. The Government of Seychelles has gone so far as to propose that an agreement should be negotiated among Indian Ocean coastal states to establish 'An Alliance for Marine Conservation' in this region. I believe that any such agreement could be immensely beneficial for the objectives to which this symposium is addressed.

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ON THE CONSERVATION AND MANAGEMENT OF MARINE MAMMALS OF INDIA

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ABSTRACT

Increasing attention is being paid the world over for affording protection to, and conservation of marine mammals. They are the most vulnerable group of sea animals, excepting the sea turtles. Public awareness needs to be created to remove the prejudices towards marine mammals. There is need for their protection in modern times through regulations, up-dating existing legislations, collection of scientific data, establishment of sanctuaries, extending of financial and other support and inter-governmental and regional cooperation. The status of the dugong in the seas around India is cited as a case in particular for conservation and management through appropriate regulatory measures, intensified scientific study, establishment of sanctuaries in situ and regional cooperation.

INTRODUCTION

WITH the declaration of the Exclusive Economic Zone, coastal states have the rights for the exploitation and management of living resources of the sea upto two hundred miles from their shores. This also places a high responsibility with the States for rational exploitation. The new convention of the Law of the Sea stresses international cooperation including scientific research. Two of the clauses of the convention give the right to states to be more protective of whales, dolphins, seals and the dugong than of fish.

Marine mammals in the past have been extremely important in many coastal economies. Although, for many species, a very long period of careful protection is needed, we cannot be sure that they will recover from the devastation of excessive exploitation to which most of them have been subjected. Marine mammals are the most vulnerable group of all sea animals, with the possible exception of sea turtles. In all ancient cultures of coastal and island peoples, whales and dolphins were given special place. Recent references to whales in Indian Ocean (Alling *et al.* 1982 ; Brown, 1957) and whales and cetacea in world ocean (Anon, 1980 ; Watson, 1981) highlight the importance of these mammals.

The International Whaling Commission has declared that tropical, temperate and sub-Antarctic zones of the Indian ocean to be a sanctuary for the whales. The Commission also decided that commerical Whaling would be phased out everywhere by 1986. It is for the future to decide how to treat the whales better, whether as a continuing source of food or in other ways. Meanwhile, their life, habits and behaviour can be studied in order to learn more about them and also perhaps learn from them. It is feared that marine mammals, except for the herbivorous dugong, feed on fish and shell fish. They thus become serious competitors with fishermen. They are even accused of being the cause of some declining fisheries, which leads to the conclusion that they should be eliminated or at least kept down in numbers. This approach at annihilation of marine mammals should be critically examined. Therefore, there is an urgent need to create a wider awareness of the marine mammals of in the World Ocean and especially in Indian ocean and the needs to ensure their survival and their co-existence with humans who have been increasing their impact on the habitats of other mammals. Global measures are needed to regulate trade in products like meat, oil, skins from whales and other mammals and to reinforce the conservation measures taken by national governments and through international organisations such as the IWC. It is also necessary to look into the non-consumptive values of whales.

Since accidental and incidental catches of marine mammals in fishing nets is increasing greatly, these catches need to be monitored so that the numbers, species composition, seasonality and sizes are known and the possible effects on the populations can be evaluated. Some information on the stranding of whales (James and Soundararajan 1980) and capture of dolphins and porpoises (Jones, 1976a) along the Indian coast is available.

It is felt that the existing legislation may be far out of date. This has relevance to activities in the EEZ and to trade in animals and/or products from them in accordance with modern ideas concerning the need for conservation of marine mammals and their habitats.

It is desirable that, where practicable, other values of marine mammals be realised for the benefit mainly of the local populations. Whale watching is cited as an example. The non-existence of exploitation for commodities provides the need and also opportunities for useful benign (non-lethal) research. Scientifically significant and potentially economic results can be obtained from such research, besides creating public awareness on the conservation of marine mammals.

THE CASE OF THE DUGONG

The dugong occurs in relatively large numbers in the Gulf of Mannar and Palk Bay than anywhere else in the seas around India. Arrangements to collect data and information on the dugong in the region at a suitable place would be ideal. The Gulf of Mannar with a chain of islands, shallow water and abundant growth of sea grass is the ideal habitat for the dugong. The islands provide protection to the dugong from south-west and north-east monsoons when it could move to areas of safety with reversal of winds during the two periods. The proposed National Marine Park in Gulf of Mannar affords the best sanctuary for the dugong and facilitates measures for conservation and management. Maintenance of captive breeding stocks in situ will greatly enhance the chances of survival, propagation and establishment of free stocks.

The research and conservation programmes should be undertaken jointly by India and Sri Lanka, by establishing one Centre for Gulf of Mannar in India and another for Palk Bay in Sri Lanka. Both the countries have already declared the dugong a protected animal. However, the mechanism of monitoring of activities detrimental to the dugong and enforcement of the law must be tightened for achieving the desired results. Several authors have referred to the status of the dugong in Sri Lanka (Bertram and Bertram, 1976 ; Jonklaas, 1960) and India (Jones, 1980 and 1981) ; relationship with ecosystem (Heinshon, 1975 ; Heinshon *et al.* 1977) ; observations in captivity (Kataoka *et al.*, 1981) ; problems of conservation (Spittel, 1960 ; Jones, 1976b ; Marsh, 1981) and distribution in the world (Nishiwaki *et al.* 1979).

ACTION PLAN

In view of the above, for effective steps towards conservation and management of marine mammals of India, the following action plan appears to be urgently needed.

1. Appropriate action is needed to promote greater awareness and interest in marine mammals—to study their behaviour, habits and habitats in a systematic manner.

2. Up-to-date scientific data on marine mammals have to be collected for taking up specific measures for the conservation of marine mammals.

3. Research programmes on marine mammals have to be intensified, with special reference to conservation and non-consumptive development of marine mammals. Conservation and non-consumptive use of all species of marine mammals through inter-governmental and regional organisations should be ensured.

4. Financial and other support must flow from bilateral and multilateral donar agencies for research on conservation and non-consumptive development of marine mammals.

5. Immediate measures should be taken up for the conservation of the dugong occurring in the Palk Bay and the Gulf of Mannar on a cooperative basis between India and Sri Lanka. Specific research programme may be taken up on the habits, distribution and biology including its study in captivity and underwater observations.

6. Sanctuaries and marine parks must be quickly established for the protection and conservation of marine mammals.

7. Existing legislations should be up-dated, especially with reference to the EEZ, in accordance with modern ideas concerning the needs for conservation of marine mammals and their habitats.

8. In general there is little public knowledge, in many places within the region even of the existence of the marine mammals and certainly not of threats to them or their values. This should be corrected by vigorous national compaigns and by international/regional cooperation.

9. A data information-exchange and reference centre for marine mammal research be established at a suitable place.

10. Regular programme of recording the sightings of cetaceans (small and large) from fishing and research vessels and ships of opportunity in the coastal waters as well as in the Exclusive Economic Zone may be organised.

11. A separate research programme may be initiated for recording the strandings as well as capture of all cetaceans in standard proformae. Available data may also be brought under standard proformae for effective documentation of all information.

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ON THE FOOD OF STRANDED SPERM WHALE *PHYSETER MACROCEPHALUS* LINNAEUS AT TRANQUEBAR WITH A NOTE ON FOOD HABITS OF SPERM WHALES

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ABSTRACT

The present paper deals with the analysis of food contents of the stomach of the stranded sperm whale *Physeter macrocephalus* Linnaeus on 8th June, 1982 at Tranquebar on the east coast of India. Squids formed the major food item. A brief review of food of the sperm whales of the world oceans is given.

INTRODUCTION

IN RECENT years our knowledge on the feeding of the sperm whale *Physeter macrocephalus* Linnaeus has considerably grown. Most of the published information about the food of toothed and baleen whales comes mainly from the examination of the contents of the stomach of the whales either captured in the fishery or from strandings (Matthews 1932 ; Robbins *et al.* 1937 ; Mizue 1950 ; Pike 1950 ; Betesheva, 1954 ; Korabelnikov, 1959 ; Kawakami, 1959 ; 1976 ; Nemoto, 1959 ; 1962 ; 1970 ; Clarke, 1962 ; Okutani and Nemoto, 1964 ; Hisokawa and Kamiya, 1971 ; Kawamura, 1974 ; Clarke *et al.*, 1976). Eventhough, digestion appears to be very rapid in these animals (Matthews, 1978), some of the hardest parts of fishes, squids and other organisms which usually remain undigested may give a clue as to the identity of the food consumed by the whales (Fitch and Brownell, 1968). The parts of cephalopods that are not affected by digestion in whales are the horny beaks. Based on the cephalopod beaks that remain in the stomachs of the sperm whale, the feeding habits have been studied in various regions of the world oceans (Ishikawa and Wakiya, 1914 ; Clarke, 1954 ; 1955 ; Kawakami, 1959 ; 1976 ; Okutani and Nemoto, 1964 ; Clarke *et al.*, 1976 ; Okutani *et al.*, 1976). Further the, feeding habits of whales may also give an indication about their pattern of migration and movement (Buchanan, 1896 ; Pike, 1950 ; Betesheva, 1954 ; Clarke, 1957 ; Nemoto 1959 Hisokawa and Kamiya 1971 ; Mitchel, 1975 ; Sund, 1975 ; Kawamura, 1978 ; Rudge *et al.*, 1981). Such studies were also made on sperm whales which feed mainly on squids in various regions of the world oceans (Beale, 1839 ; Betesheva 1961 ; Akimushkin, 1963 ; Caldwell *et al.*, 1966 ; Berzine, 1972 ; Best, 1974 ; Clarke *et al.*, 1976 ; Slijper, 1979 ; Allen, 1980).

Though strandings of sperm whales along the Indian coasts have been reported by earlier workers (Blanford, 1891 ; Antony Raja and Pai, 1973 ; Bande *et al.*, 1980 ; James and Manivasagam, 1980 ; James and Soundararajan, 1980; Nammalwar and Thanapathi, 1982), only very few workers have reported on the stomach contents (Moses, 1940 ; Jacob and Menon, 1947 ; Daniel, 1963). Some of the remains of food in the stomach of the sperm whale can be ascertained even in the decomposed condition as it is possible to retrieve the beaks of cephalopods and skeletal parts of fishes. In this context, the food of sperm whales in Indian seas and other regions of the world oceans should be of interest. The present paper deals with the food items of a 9.06 m male sperm whale stranded at Tranquebar (11°0'N and 79°8'E) on the East coast of India on 8 June 1982. The carcass was cut open on the 8th day of stranding. The beaks of squids, squid remains and semi-digested sea grass were found in the stomach.

Among 158 beaks collected, 8 beaks (6 upper and 2 lower beaks) were removed and examined. The study revealed that they belong to the genus *Chiroteuthis*. It may be pointed out that *Chiroteuthis imperator* Chun, has been recorded from the Indian ocean (Chun, 1910 ; Massy, 1916) as referred by Clarke (1966) and Silas (1968). The soft part of the squid remains could not be assigned to any species as they were beyond identification.

Review of the food of sperm whales
Pacific Ocean

According to available data, 25 species of cephalopoda and 38 species of fishes have been identified from the stomachs of sperm whales around Japan and Kuriles waters (Mizue, 1950 ; Betesheva and Akimushkin, 1955 ; Betesheva, 1960). The main food items in this region are squid of the family Gonatidae. They were encountered in the stomachs of practically all sperm whales and constituted on an average 50-80% of all cephalopoda (Tarasevich, 1963). Betesheva (1961) reported that more than 24 species of fish, among them the macrurids taking first place were found in 33-60% of stomachs, while second and third in importance are sharks and Alepisaurus. The following demersal fish are of considerable significance for a sperm whale in this region, according to Betesheva (1961) ; Rays (*Raja spp.*) gobies (*Myoxocephalus* sp.,) anglerfish (*Oneirodes* sp.) cottidae and Walleye pollock. According to the data of Mizue (1950), based on the analysis of feeding data from the southern waters of Japan, the incidence of redfish (*Sebastodes* sp.) clupeids (*Sardina* sp.), mackerel (*Scomber* sp.) and krill can be added to the list of food items. Zenkovich (1934, 1937) and Tomilin (1936) reported that the stomachs of sperm whales taken in the northernmost komandorski-kamchatka region contained squids (*Gonatus* sp.), Octopods (*Octopus* sp.), and crabs. Rays (*Raja* sp.) and fishes (*Scorpaenidae*) were also found in sperm whale stomachs. Sleptsov (1952) reported that the sperm whales from Bering sea and of the kuriles feed on Pacific lamprey (*Entosphenus* sp.), Pacific cod (*Gadus* sp.) greenling (*Pleurogrammus* sp.) and on *Macrurus* sp.

Berzin (1959) reported that sperm whales from Komandorski area and western part of the Aleutian Islands feed on squid of the (family *Gonatidae*) species *Gonatopsis borealis*, *Meleagroteuthis separata*, *Galiteuthis armata*, *Onychoteuthis banksii* and *Chiroteuthis veranyi*.

The fishes found in sperm whale stomachs in the Bering sea and in the adjacent regions of the Pacific contained representatives of 8 families : Agonidae, Scorpaenidae, Plagyodontidae, Rajidae, Petromyzonidae, Cottidae, Cyclopteridae, and Macruridae. Okutani and Nemoto (1964) reported that the sperm whales near the Aleutian Islands, in the Gulf of Alaska and in the Bering sea feed on the squids *Mastigoteuthis* sp. and *Stigmatoteuthis* sp. Robbins, *et al.* (1937), reported the presence of *M. robusta* and *M. octopi* as well as of small cod and lamprey in the stomachs of sperm whales. Pike (1950) points out that the diet of sperm whale in the waters of British columbia includes large amounts of the squid *Gonatus* sp. and *M. robusta*. Rays (*Raja* sp.) and lampreys and salmons and eggs of squid were also observed.

Recently, Tarasevich (1968) reported that the food item of sperm whales from the north eastern Pacific showed the squid species *Taonius*

E. G. SILAS, P. NAMMALWAR AND R. SARVESAN

PLATE I

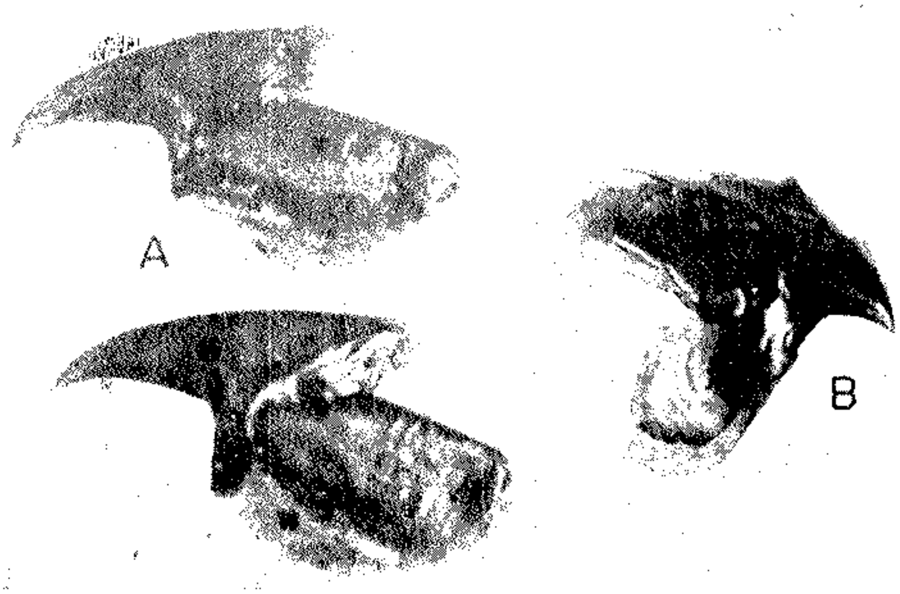

PLATE I. Beaks of squids belonging to the genus *Chiroteuthis* ; A. Upper beak and B. Lower beak.

pavo, *Chiroteuthis veranyi*, *Meleogroteuthis separata*, *Galiteuthis armata*, *Architeuthis japonica*, *Octopodoteuthis longiptera*, *Gonatopsis borealis*, *Stigmatoteuthis dolfeini*, *Onychoteuthis banksii*, *Alloposus mollis* and *Octopus gilbertianus*.

In the stomachs of sperm whales taken in the southwestern Pacific (regions of New Zealand, Chatham Island and Tasmania), the cephalopods *Stenoteuthis*, *Histioteuthis*, *Onychoteuthis* and *Architeuthis* and Octopoda were found. Among the fishes, representatives of the family *Scorpaenidae*, *Chimaeridae* and rays (*Raja* sp.) and their eggs and sharks were also noted. In addition, colonial tunicates (*Pyrosoma*) and shrimp were also noted as food items. Okutani and Satake (1978) reported the diet of sperm whales caught in the Pacific waters off North-eastern Honshu, Japan. They found that among the squids, *Histioteuthis doflenini* was the dominant species (52%) followed by *Octopoteuthis* (26%).

Atlantic Ocean

Clarke (1955, 1962), reported 8 species of squid form sperm whales in the northern part of the Atlantic ocean, particularly the area of the Azores and Madeira. *Histioteuthis bonelliana* and *Cucioteuthis unguiculatus* occur most frequently. Among the squids, *Architeuthis*, *Lepidoteuthis* and *Cucioteuthis* constitute about 7% of the total weight of molluscs. Octopoda and Cranchiidae constitute in mass about 3% of the total weight of molluscs. Clarke (1956) further reported the occurrence of four species of fishes, namely barracuda yellowfin tuna, and two species of anglerfish (*Ceratias holboeli* and *Himantolophus*). Tomilin (1957) mentions the discovery of a large eel (*Anguilla* sp.) in the stomach of a sperm whale. Backus (1966) reports, *Alepisaurus* and sharks (Cetorhinus) in the stomach of sperm whales. Matthews (1938) found that the stomach contents of sperm whales taken off the southwest shores of Africa (Southern regions of Atlantic ocean) constitute cephalopoda and teleosts. Akimushkin (1963) determined squid, *Octopodeuthis longiptera* from the stomach of the sperm whale taken in the south Atlantic.

Indian Ocean

There is hardly any data on the feeding of sperm whales in the Indian ocean. Matthews (1938) gave information on the quantitative stomach fullness of sperm whales from south-eastern Africa and a general indication as to the part played in the diet by cephalopoda and teleosts in this region. Tomilin (1957) reported that an unidentified species of shark was extracted from the stomach of a sperm whale in the same region. Hollis (1939) reported that sperm whales from the Australian coasts of the Indian ocean feed on Octopoda. In the stomachs of sperm whales taken from the Indian ocean in the region northwest and west of Australia as far as the islands of New Amsterdam and Heard and their vicinity the following species of squids were found: *Moroteuthis robusta*, *Histioteuthis bonelliana*, *Stenoteuthis bartrami* and *Architeuthis* sp. Among fishes, quite frequent occurrence of barracuda, *sphyraena* sp., Porcupine fish, *Diodon* sp. and representatives of the family Ceratiidae in the stomachs of Indian ocean sperm whales were observed.

Antarctic Ocean

Matthews (1938) carried out investigations on the quantitative stomach fullness of the sperm whales in the waters of South Georgia Island but did not specifically determine the food remains from the stomachs which were indicated only as presence of cephalopoda and teleosts in various stages of digestion. Korabel'nikov (1959) reported three species of squids in the stomachs of sperm whales captured in the southern Orkney Islands.

Evidently, *Onychoteuthis banksii* is of prime importance in the diet and predominates in the stomachs of sperm whales taken in all the whaling areas of the Antarctic. Remains of *Architeuthis* were found in the stomach of sperm whales captured from farther west in the region east of the South Shetland Islands. *Moroteuthis robusta* from the northeast of the Balleny Islands should be considered part of the food of sperm whales in the Antarctic. Korabel'nikov (1959) reported that fishes (*Micromesistius australis*) and rays (*Raja grisco-caudata*) were found in the stomach of sperm whale caught south of the Falkland Islands. Clarke (1954) and Solyanik (1963) have indicated that sperm whales feed on the anglerfish *Ceratias holboeli*. This review of available data shows that in the Antarctic, fish is of lesser significance for the sperm whale than in other regions of the world oceans. Korabel'nikov (1959) also mentions finding large crustacea in the stomach of some sperm whales.

Discussion

The basic diet of sperm whales in all regions of the world ocean is made up of approximately 40 species of cephalopoda, including 9 species of octopoda. Squid is of far greater importance than octopus everywhere, amounting to 80% of the entire food bolus (Akimushkin, 1955). Because of our knowledge of the feeding of sperm whales in the different oceans is uneven, it is difficult to make a complete analysis from the comparative geographical aspect. *Moroteuthis, Architeuthis* and *Onychoteuthis* are food items in all oceans.

More than 50 species of fish have been found in the stomachs of sperm whales inhabiting various regions of the world oceans, the large majority of these in sperm whales that were captured in the North Pacific. The poor species composition of cephalopoda and fish eaten by sperm whales in the Atlantic and Indian Oceans and in Antarctic waters is apparently explained by the scarcity of knowledge on feeding in these areas. Five species of deep-sea Gadidae are food for the sperm whale in all regions of the world ocean. The family scorpaenidae is represented by 6 species which are noted only in the stomachs of sperm whales from the North Pacific. Two families of sharks, squalidae and squatinidae are found in the diet of sperm whales in the Pacific ocean. Even a cursory analysis of the contents of sperm whale stomachs shows that their food spectrum is strictly limited to deep-sea organisms. The proportion of various food items can vary greatly in different regions and in the same region according to months, seasons and years and also depending on the sex and age of the whales; nevertheless, various species of cephalopoda predominate almost always and everywhere. At least 95% of the entire mass of food consumed consists of cephalopoda and about 5% of fish. Betesheva (1960) reported that a change of the species composition of the food depended on the distance of the feeding areas from the shore (*i.e.*,depending on depths). Whereas, the stomachs of sperm whales caught in the littoral waters of Japan, in the shallow waters of the Sarycheve, Onekotan, Paramushir and Shumshu islands (Kuriles) in the region of Cape Olyutorskii and in the shallow waters of the Komandorski islands, contained in addition to squid, small Octopoda, Scorpaenidae, and Gadidae, rays and gobies. The stomachs of sperm whales captured in the kuriles area at great depth disclosed mainly pelagic species: squid, sharks, and deep-sea fishes (Macrurus, Alepisaurus and anglerfish).

Hollis (1939) reported that crustacea may be present in the stomachs of sperm whales if they feed in the near-bottom layers, for instance remains were found of five species of crab namely, as *Paralithodes camtshatica, P. brevipes, Pagurus* sp. and two species of bivalve molluscs. Many researchers point out that demersal organisms-sponges, starfish, sea-cucumbers and ascidians find their way into the stomach of sperm whales

(Akimushkin, 1954 ; Clarke, 1956 ; Berzin, 1959 ; Nemoto, 1963 and Nazu, 1963). Mizue (1950) has noted krill in the food of sperm whales. Ash (1962) discovered shrimp and Andrews (1916) mentioned lobster to be part of the diet. The diet of sperm whales depends entirely on the composition of food items inhabiting the same horizons where sperm whales feed in a particular region. Thus according to Okutani and Nemoto (1964) the farther away from the Allutian Islands in the Bering sea, the more fish begin to prevail in the diet and on the other hand, in the littoral zone of the Gulf of Alaska, fish are predominant, while squid prevail in the middle of the gulf.

The stomach of the sperm whale is usually filled with remains of bodies of cephalopoda—heads with crowns of tentacles separated from the trunk (mantle), numerous chitinous jaws (rostra), belonging to cephalopods (Tomilion, 1957). Many published confirmation exist on the extreme abundance of shoals of cephalopoda (Akimushkin, 1955). Together with the shoals of squid that are relatively monotonous in regard to species, the stomachs of sperm whales may contain upto 22 species of cephalopoda simultaneously (Betesheva and Akimushkin, 1955). These data imply the presence of multi-species shoals (or concentrations) of cephalopoda in the deep waters.

Because of the fact that sperm whales are found to feed more frequently on cephalopoda and fishes than other organisms, Berzin (1972) suggested that sperm whales could be more appropriately called ' teuthoichthyophages '.

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SYSTEMATICS AND ORGAN WEIGHTS OF TWO DOLPHINS, *STENELLA LONGIROSTRIS* (GRAY, 1828) AND *TURSIOPS TRUNCATUS* (MONTAGU, 1821) OF PORTO NOVO, SOUTHEAST COAST OF INDIA

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ABSTRACT

Variations recorded in the morphological features between the spinner dolphin, *Stenella longirostris* and the bottlenose dolphin, *Tursiops truncatus* of Porto Novo waters, southeast coast of India, are presented. In addition, weights of brain, heart, lungs, liver, gut and kidneys of these two dolphins are also given in relation to their total body weight. The present study is the first detailed one on the systematics of these two dolphins from the Indian waters.

INTRODUCTION

SEVERAL species of smaller cetaceans, comprising the spinner dolphin, *Stenella longirostris*, the bottlenose dolphin, *Tursiops truncatus*, the black dolphin, *Sousa chinensis*, the humpback dolphin, *S. plumbea* and *T. aduncus* inhabit estuarine and marine regions along east and west coasts of India. Though adequate information is available on the systematics of the spinner and the bottlenose dolphins from the global waters (Walker, 1964 ; Daugherty, 1965 ; Norris, 1966 ; Perrin, 1975 ; Leatherwood *et al.*, 1976 ; van Bree and Perrin, 1977 ; Ellis, 1982 ; Leatherwood and Reeves, 1982), studies on these dolphins from Indian waters are limited (Lalmohan, 1982, 1983 ; Natarajan and Rajaguru, MS).

The organ weights of odontocete cetaceans are given by Slijper (1959) for *Phocoena phocoena, Lagenorhynchus acutus, Delphinus delphis Grampus griseus, Delphinapterus leucas* and *Physeter catodon* ; by Cowan (1966) for *Globicephala melaena* ; by Pilleri and Gihr (1969) for *Inia geoffrensis* and by Gihr and Pilleri (1969) for *Stenella styx*. Perrin and Roberts (1972) gave detailed information on the weights of heart, lungs, liver, kidneys and spleen of spotted porpcise *stenella graffmani* and the spinner dolphin *S. longirostris* occurring in the East Pacific.

The present study is the first detailed one on the spinner and the bottlenose dolphins from Indian waters and adds more knowledge to the virgin field of Marine Mammalogy in India.

We wish to express our appreciation to Mr. N. Kanniappan for providing the specimens of dolphins. We also like to extend our special thanks to the University Grant Commission, New Delhi, for financial support and the authorities of the Annamalai University for facilities.

MATERIAL AND METHOD

One specimen each of *Stenella longirostris* (Gray, 1928), the spinner dolphin, and *Tursiops truncatus* (Montague, 1821), the bottlenose dolphin (Delphinidae, Cetacea) were collected from Bay of Bengal, at Porto Novo (11°29'N; 79°46'E), on 15th and 25th of March, 1982 respectively. These specimens got entangled accidentally in a bottom-set gill net which was laid mainly for sharks.

The carcasses of the trapped dolphins were brought to the laboratory for a detailed systematic study. The measurements were made point-to-point on the right side of the specimens with a meter tape. In measuring the flipper width, the flipper was pulled out from the body to a position at which the skin was neither depressed nor elevated at the anterior or the posterior insertion, and the greatest width parallel to the body axis was then measured. All the morphometric measurements are listed in Table 1 and some important measurements are shown in Fig. 1.

Morphology of *Stenella longirostris* (Gray)

Name *S. longirostris* is derived from the Greek *stenos* for 'narrow', apparently referring to the long, narrow beak; from the Latin *longus* for 'long', and *rostrum* for 'beak, snout'.

Size

Total length	..	1130 mm
Total weight	..	18 kg

Description

The spinner dolphin is characterized by a long, narrow snout, and a vertical triangular dorsal fin that hooks so far forward. The head slopes gently toward the snout. Nevertheless,

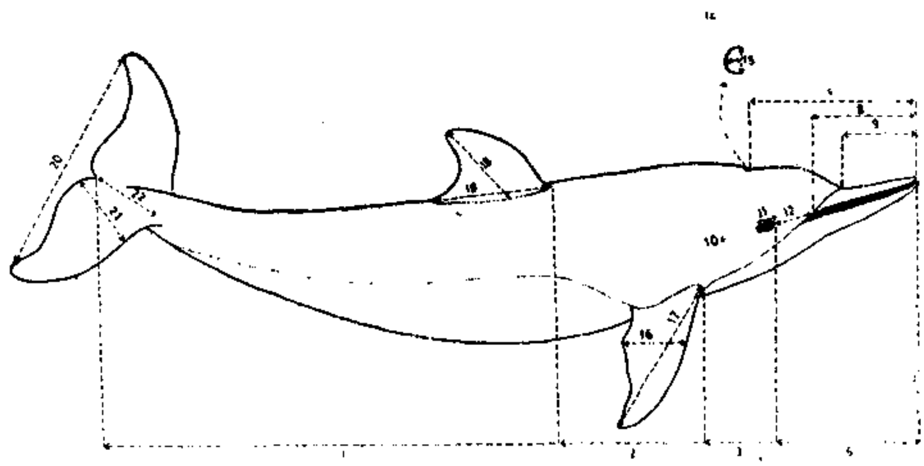

Fig. 1. External measurements of dolphin.

Before dissection, the specimens taken for study were weighed accurately to the nearest 0.1 kilogram. When each specimen was dissected, the brain, heart, lungs, liver, gut and kidneys were excised carefully and weighed precisely to the nearest gram. The formalin (10%) preserved organs of these dolphins are in deposit in the Marine Biological Station Reference Museum (MBSRM), Annamalai University.

there is a definite crease at the apex of the melon. A single crescentic blowhole is present on the dorso-median line of the head. The teeth are sharply pointed. The teeth count was 41-45 on one side of each jaw. The teeth are homodont.

Colour

The colour was dark gray in fresh condition. The back was lighter than the lateral area and the belly was even lighter. The change from dark to pale gray makes a distinct curved line along the sides of the body. A dark line runs from the eye to a point above the base of the beak. A paler diverging line runs back from the eye to the flipper which is dark gray on both surfaces.

The morphometric measurements of this specimen are given in Table 1 and Fig. 1.

ORGAN WEIGHTS OF *S. LONGIROSTRIS*

Weight of brain : 402 gm
i.e. 2.23% of total body weight.

Weight of heart : 105 gm
i.e. 0.58% of total body weight.

Weight of liver : 520 gm
i.e. 2.89% of total body weight.

Weight of lungs : 415 gm
i.e. 2.31% of total body weight.

Weight of gut : 1690 gm
i.e. 9.39 %of total body weight.

Weight of kidneys: 195 gm
i.e. 1.08% of total body weight.

TABLE 1. *Morphometric measurements of two Dolphins*

Sl. No.	Measurements		*S. longirostris* (mm)	*T. truncatus* (mm)
1.	Tip of upper jaw to deepest part of fluke notch	..	1130	1810
2.	Tip of upper jaw to origin of dorsal fin	..	535	895
3.	Tip of upper jaw to anterior insertion of flipper	..	335	490
4.	Tip of upper jaw to anterior edge of blowhole	..	250	335
5.	Tip of upper jaw to centre of blowhole	..	255	343
6.	Tip of upper jaw to anterior edge of eye	..	235	325
7.	Tip of upper jaw to centre of eye	..	244	337
8.	Tip of upper jaw to angle of gape	..	195	235
9.	Tip of upper jaw to apex of melon	..	115	130
10.	Height of eye	..	9	10
11.	Length of eye	..	17	23
12.	Origin of eye to angle of gape	..	49	67
13.	Centre of eye to centre of blowhole	..	127	178
14.	Blowhole length	..	10	15
15.	Blowhole width	..	15	25
16.	Flipper width	..	70	130
17.	Flipper length	..	190	310
18.	Dorsal fin height	..	120	245
19.	Dorsal fin base	..	165	305
20.	Fluke span	..	236	470
21.	Fluke width	..	80	140
22.	Notch of fluke to origin of fluke	..	55	105
23.	Tooth counts :		(Numbers)	(Numbers)
	Right upper	..	41	25
	Right lower	..	45	24
	Left upper	..	44	25
	Left lower	..	45	24

MORPHOLOGY OF *TURSIOPS TRUNCATUS* (MONTAGUE)

Name *T. truncatus* is derived from the Latin *tursio* for ' an animal like the dolphin ' and the Greek *ops* for ' face ' ; from the Latin *truncare* for ' cut off '.

Size

Total length	..	1810 mm
Total weight	..	64 kg

Description

The bottlenose dolphin is fairly large and stout-bodied. As its name implies, it has a prominent beak which is relatively short but defined by a crease. Its mouthline curves to give it an appearance of smiling. A single crescent blowhole is present at the highest point of the head. The pointed dorsal fin is vertical and centrally positioned on the back. The flippers are moderate in size and taper to a point. The fluke is notched and has a smooth, concave rear margin. The tooth count is relatively low, 25 on each side of the upper jaw and 24 on each side of the lower. It has long thin conical teeth, well suited for capturing fish.

Colour

The bottlenose dolphin has a well-defined dark cape. The sides are lighter and the belly still more, being almost white. There is no clear line of demarcation between the sides and the belly.

The morphometric measurements of this bottlenose dolphin are presented in Table 1 and Fig. 1.

ORGAN WEIGHTS OF *T. TRUNCATUS*

Weight of brain	: 1015 gm *i.e.* 1.59% of total body weight.
Weight of heart	: 355 gm *i.e.* 0.55% of total body weight.
Weight of liver	: 1695 gm *i.e.* 2.65 % of total body weight.
Weight of lungs	: 2415 gm *i.e.* 3.77% of total body weight.
Weight of gut	: 5230 gm *i.e.* 8.17% of total body weight.
Weight of kidneys	: 445 gm *i.e.* 0.70% of total body weight.

REMARKS

In the present study it was observed that the Porto-Novo specimen of the spinner dolphin has a very close resemblnce in colour and structure of the dorsal fin to those of whitebelly spinner dolphin observed by Perrin (1975) and Leatherwood and Reeves (1983) from the Pacific waters.

The range in the number of teeth currently observed for the spinner dolphin was 41-45 (on one side of each jaw) and it differs from the earlier observations (45-65 on one side of each jaw) made by Leatherwood and Reeves (1982, 1983).

Spinner dolphins are characterized by a long, narrow snout, and a perky, vertical dorsal fin that hooks so far forward (Ellis, 1982). By these characteristic features, *S. longirostris* is differentiated from the most closely related *S. clymene*, which has a short snout (Leatherwood and Reeves, 1983). The colour pattern of *S. clymene* also differs from that of *S. longirostris* as follows : the ventral margin of the cape below the dorsal fin dips toward the ventral margin of the lateral field in *S. clymene*, whereas in *S. longirostris* the two margins are parallel for most of the length of the animal ; the upper and lower margins of the flipper stripe converge markedly as they approach the eye in the former, whereas in the latter they are all but parallel, and the black tip of the beak is bordered dorsally with a distinctive pale-gray-to white blaze, instead of with the pale-to-dark-gray field that is adjacent to the black tip in *S. longirostris*.

According to Leatherwood and Reeve (*op. cit.*), there appear to be two ecotypes, a coastal form and an offshore form and differences between them are currently under study, though no consistent or reliable difference that would allow them to be distinguished in the field are known.

(18-26 on one side of each jaw) given by Leatherwood *et al.* (1982) and Leatherwood and Reeves (1983).

The rough toothed dolphin, *Steno bredyensis* has a close range of teeth (20-27 in one side of each jaw) as the bottlenose dolphin (18-26 on one side of each jaw), but can readily be distinguished on close examination by the absence of a crease dividing the beak from the forehead and by its relatively long and slender beak (Leatherwood *et al.* 1982).

The relative weight of the heart (0.58 %) of the calf spinner dolphin studied presently is higher than that of Calf spotted dolphin (0.41 %) studied by Perrin and Roberts (1972) (Table 2).

TABLE 2. *Relative weights of organs in Dolphins*

Sl.	Organs	Spinner* dolphin (*Stenella longirostris*) (calf)	Bottlenose* dolphin (*Tursiops truncatus*) (adult)	Spotted** dolphin (*S. graffmani*) (adult)	Spotted** dolphin (*S. graffmani*) (calf)	Spinner** dolphin (*S. longirostris*) (adult)	Spinner** dolphin (*S. longirostris*) (calf)
1.	Brain ..	2.23%	1.59%	—	—	—	—
2.	Heart ..	0.58%	0.55%	0.37%	0.41%	0.52%	—
3.	Lungs ..	2.31%	3.77%	2.82%	—	—	3.09%
4.	Liver ..	2.89%	2.65%	2.06%	—	2.10%	—
5.	Gut ..	9.39%	8.17%	—	—	—	—
6.	Kidneys ..	1.08%	0.70%	0.78%	—	0.69%	—

* Present Study.
** as given by Perrin and Roberts (1972).

Coffey (1977) considered *Tursiops gilli* to be subspecies of *T. truncatus* which is certainly very similar excepting the fact that the former species has more teeth. *T. truncatus* is black with dark flippers and flukes and lighter below, and can be differentiated from another related species *T. aduncus* by its dark green upper parts (Walker, 1964).

In the Porto-Novo specimen of the bottlenose dolphin, the range in teeth number on one side of each jaw is 24-25, and it falls within the range. But, the relative weight of lungs (2.31 %) noted in the present study is lower than that of the calf spinner (3.09 %) studied by Perrin and Roberts (1972). Except that of lungs the relative weights of other organs (heart, liver, gut, kidneys and brain) of the calf spinner dolphin are higher than those of the adult bottlenose dolphin, studied presently and those of adult spotted dolphin and adult spinner dolphin studied by Perrin and Roberts (1972) (Table 2).

The relative weight of kidneys (0.70%) of the present bottlenose dolphin is lower than that of the adult spotted dolphin (0.78%) and is equal to that of the adult spinner dolphin (0.69%).

Perrin and Roberts (1972) have stated that the relative weight of the organs to the total body weight of the dolphins decreases during development and this is yet to be confirmed.

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OBSERVATIONS ON THE BY-CATCH OF DOLPHINS *STENELLA LONGIROSTRIS, TURSIOPS ADUNCUS, SOUSA CHINENSIS* AND *DELPHINUS DELPHIS TROPICALIS* IN THE GILL NETS OFF CALICUT COAST, INDIA

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Abstract

Species composition, length distribution seasonal variation in occurrence and sex ratio of 174 dolphins from Calicut coast were studied for the period 1976 to 1980. The incidence of dolphins in the gill nets were found to be more during the colder months of the year from October to February. *Stenella longirostris* contributed 52.9% of the dolphins landed followed by *Tursiops aduncus* which formed 32.7%. *Delphinus delphis tropicalis* and *Sousa chinensis* were the other two species that occurred in the nets.

Introduction

Our information on the dolphins along the Indian coast is mainly confined to their distribution, strandings and taxonomy. (Blanford, 1891 ; Lydekkar, 1905 ; Pillay, 1926 ; Silas and Kumara Pillai 1961 ; Alagarswami *et al.*, 1973 ; Mohan (in press). Though the dolphins are caught in the gill nets set for fishes, we have no information on the magnitude of the catch, species composition, size range, seasonal variation and the sex ratio. The desirability of collecting more information on the above aspects has been expressed by earlier workers (Mitchell, 1975 ; Alling *et al.* ; Ross, 1979). In the present study 174 dolphins were studied for their seasonal variation in occurrence, length composition and sex ratio.

The common dolphin, *Delphinus delphis* occurring along the Indian coast is treated as a subspecies *Delphinus delphis tropicalis* (Mohan, in press). The *Tursiops* sp. is treated as *Tursiops aduncus* following the nomenclature of Ross (1979).

I am thankful to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute, Cochin for his guidance and encouragement throughout the study. I am also thankful to Dr. J. B. Graham Ross, South African Museum, Port Elizabeth for his help.

Material and Methods

174 dolphins belonging to the species *Stenella longirostris* Gray, *Tursiops aduncus* Ehrenberg, *Sousa chinensis*, Osbeck and *Delphinus delphis tropicalis* Mohan (Plates I and II) captured in the gill nets operated for fishes off Calicut, Kerala during 1976-1980 were examined. The gill nets were made of 0.5 to 0.7 mm nylon monofilament twine and measured 3-5 metres in wide and 10-15 m in length. Several such make a net. The nets were operated at 7-10 fathoms. The fishes commonly caught in the nets were *Scomberomorus guttatus, S. commersoni, Euthynnus affinis, Scoliodon* spp., *Galeocerdo* spp. etc. The nets were usually operated with sail boats. The dolphins get entangled when they attempt to prey upon the fishes gilled in the nets. Often the nets are damaged by the dolphins.

Body measurements were taken as suggested by Perrin (1975). The sexes were separated

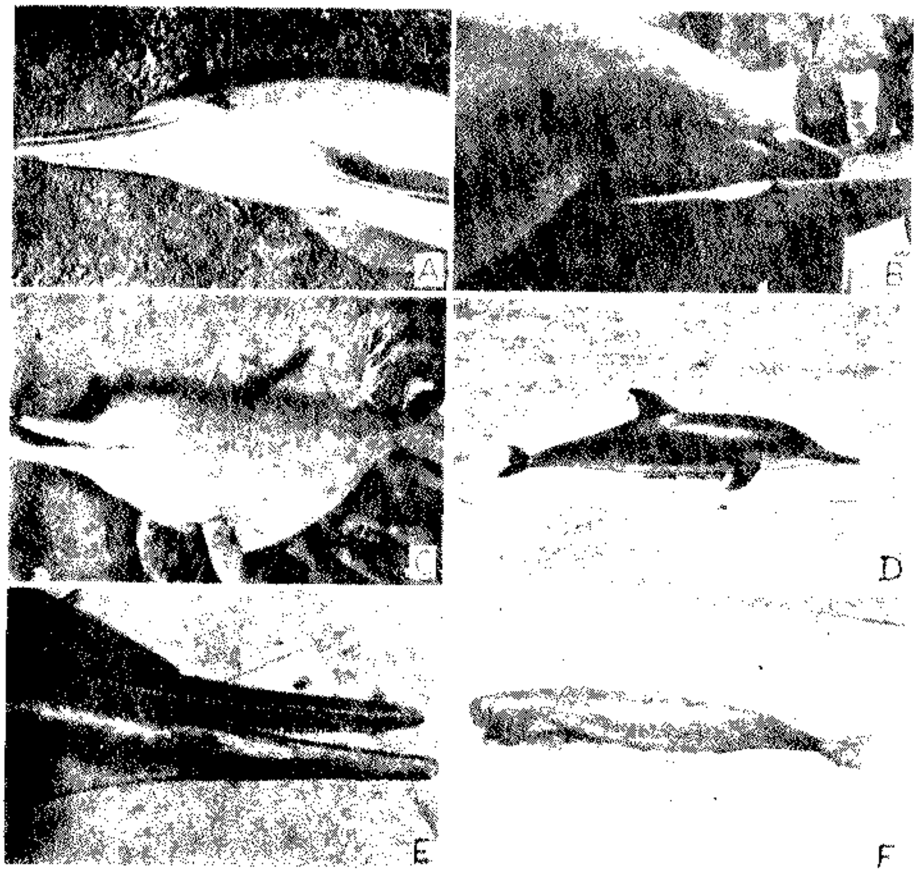

PLATE I. A. *Delphinus delphis tropicalis* with the characteristic flipper to lower jaw band, length 1480 mm, female, off Calicut ; B. *Tursiops aduncus*, length 3250 mm, female, off Calicut ; C. *Sousa chinensis*, length 2620, male, off Calicut ; D. *Stenella longirostris*, length 1759 mm, female, off Calicut ; E. Head of *D. delphis tropicalis* showing the detition, and F. *Neophocaena phocaenoides*, length 1386 mm, male, off Calicut.

R. S. LAL MOHAN PLATE II

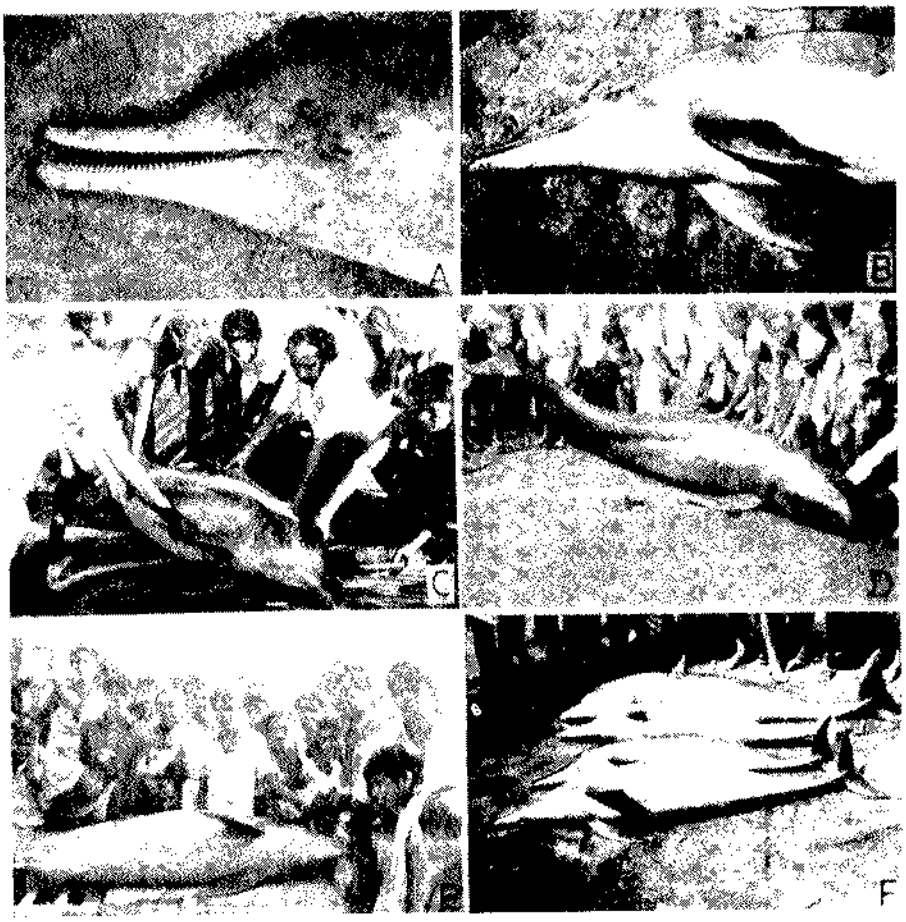

PLATE II. A. Head of *Sousa chinensis*, length 2620 mm ; B. *Stenella longirostris*, with the flipper to eye band, length 1750 mm ; C. *Sousa chinensis*, landed alive on 13-1-1981, length 2310 mm ; D. *Pseudorca crassidens*, length 4375 mm female, 12-2-1977 off Calicut ; E. *T. aduncus* in the Calicut fish market ; and F. By catch of dolphins in the Calicut fish market.

by examining external morphology. The length groups were classified in 250 mm intervals.

OBSERVATIONS

1. *Seasonal variation in occurrence*

The peak season of the occurrence of dolphins in the nets was from October to February. This period accounted for 92% of the dolphins landed. However, there were individual variations between the species in its seasonal occurrence.

Stenella longirostris

October to March contributed 97% of the total catch of this species. Variation between the years was also noticed. During the year 1978 all the landings of the species were reported from September to January whereas in 1979 this species was observed only during February. But in 1980 all the catches were from November to January.

Gill nets were not operated during June to August due the rough condition of the sea.

Tursiops aduncus

The peak season for this species was from November to January contributing about 73% of the landings. However, during 1978, the landings for the period September to January was 90% whereas October to January accounted for all the dolphins during the year 1979. But in 1980 this species was observed only in September.

Delphinus delphis tropicalis

During the period of observation only 14 numbers were examined. 57.2% of them were landed during September and November. However, during first 8 months of year only 28.6% of the landings occurred.

Sousa chinensis

This species is also not very common in the dolphin catches. 11 specimens were only observed in the catch. The period October to December contributed 63.6% of the dolphins landed.

2. *Variation in the by-catch between years*

Variation in the occurrence of dolphins ranged from 12 to 53. Lowest number of dolphins were observed in 1979 and the highest in 1980.

Stenella longirostris

Occurrence of this species varied from 5 numbers in 1979 to 38 in 1977. The average number landed for the 5 year period was observed to be 18.4 (Table 1).

Tursiops aduncus

This species also showed marked variation in its occurrence between years. Though only 2 dolphins were landed during 1977, the number landed in 1980 was 34. The average number landed for a year based on the 5 year data was 11.4 (Table 1).

Delphinus delphis tropicalis

During the course of the study only 14 dolphins of this species were reported. Though 6 dolphins were recorded during 1980 it was not landed during the year 1979.

Sousa chinensis

This species was also not very common in the catches. Though the species was not caught in 1976, the highest number of 5 specimens were observed in 1977. The number of specimens landed during 1978 to 1980 ranged from 1 to 3. The average number landed during an year was 2.2.

Besides the above species 8 numbers of finless propoise *Neophocaena phocaenoides* (Plate IF)

TABLE 1. *Sex ratio of* Stenella longirostris *off Calicut coast in relation to the total length*

Length groups (mm)		Jan. M	Jan. F	Feb. M	Feb. F	Mar. M	Mar. F	April M	April F	Aug. M	Aug. F	Sep. M	Sep. F	Oct. M	Oct. F	Nov. M	Nov. F	Dec. M	Dec. F	Total M	Total F	Ratio
750-990	..	2	1	—	—	—	—	—	—	—	—	—	—	1	1	1	—	1	—	5	2	1 : 0.4
1000-1249	..	1	1	—	—	—	—	—	1	—	1		—	3	—	2	3	—	—	6	6	1 : 1.0
1250-1499	..	—	1	—	—	—	—	—	—	—	—	—	—	2	1	5	5	1	2	8	9	1 : 1.1
1500-1749	..	—	1	—	—	2	1	—	—	—	—	—	—	6	6	2	4	1	2	11	14	1 : 1.4
1750-1999	..	—	—	—	—	—	—	—	—	—	1	—	—	5	7	1	1	1	1	7	10	1 : 1.4
2000-2249	..	—	—	1	1	—	1	—	—	—	—	—	—	—	2	1	1	1	—	3	5	1 : 1.6
2250-2499	..	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	1	—	2	2	1 : 1.0
2500-2749	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	1	1	1 : 1.0
Total	..	4	4	1	2	2	2	—	1	—	2	—	—	17	17	12	15	7	6	43	49	1 : 1.1
Ratio	..	1 : 1		1 : 2		1 : 1		0 : 1		0 : 1		—		1 : 1		1 : 1.2		1 : 0.8				

TABLE 2. *Sex ratio of* Tursiops aduncus *off Calicut coast in relation to total length*

Length groups (mm)		Jan. M	Jan. F	Feb. M	Feb. F	Mar. M	Mar. F	April M	April F	Sept. M	Sept. F	Oct. M	Oct. F	Nov. M	Nov. F	Dec. M	Dec. F	Total M	Total F	Ratio M F
1000-1249	..	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	—	2	0 : 2.0
1250-1499	..	—	—	—	1	—	—	—	—	—	—	—	—	—	1	1	2	1	4	1 : 4.0
1500-1749	..	—	2	—	—	—	—	—	—	—	—	2	—	—	2	—	1	2	5	1 : 2.5
1750-1999	..	—	—	—	1	—	—	—	—	—	—	—	—	1	—	1	2	2	3	1 : 1.5
2000-2249	..	1	1	2	—	1	—	—	—	—	1	2	1	2	1	1	3	9	7	1 : 0.8
2250-2499	..	—	4	—	—	—	—	—	—	—	—	—	—	1	2	—	2	1	8	1 : 8.0
2500-2749	..	1	—	—	—	—	—	1	—	—	—	1	—	—	2	3	2	6	4	1 : 0.6
2750-2999	..	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	1 : 0
3000-3249	..	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
3250-3449	..	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	0 : 1.0
Total	..	4	7	2	3	1	—	1	—	—	1	5	2	4	8	6	13	23	34	1 : 1.4
Ratio	..	1 : 1.7		1 : 1.5		1 : 1		1 : 0		0 : 1		1 : 0.4		1 : 2		1 : 2.1		1 : 1.4		

TABLE 3. *Sex ratio of* Delphinus delphis tropicalis *off Calicut coast*

Length groups (mm)		Jan. M	Jan. F	Feb. M	Feb. F	Mar. M	Mar. F	April M	April F	Sept. M	Sept. F	Oct. M	Oct. F	Nov. M	Nov. F	Dec. M	Dec. F	Total M	Total F	Ratio M F
1000-1249	..	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	1	0 : 1
1250-1499	..	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	1	0 : 1
1500-1749	..	—	—	—	—	—	—	—	—	1	1	—	—	—	1	—	1	1	3	1 : 3
1750-1999	..	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	1	—	1 : 0
2000-2249	..	—	—	—	—	—	—	—	1	—	1	—	—	2	1	—	—	2	3	1 : 1.25
2250-2499	..	—	1	—	—	—	—	1	—	—	—	—	—	—	—	—	—	1	1	1 : 1
Total	..	—	1	—	—	—	1	1	1	2	2	—	1	2	2	—	1	5	9	
Ratio	..	0 : 1		—	—	0 : 1		1 : 1		1 : 1		0 : 1		1 : 1		0 : 1		1 : 1.8		

measuring 1800 mm to 1920 mm and a *Pseudorca crassiders* (Plate IF) measuring 4200 mm were also observed in 1976 and 1978 respectively.

3. *Relative abundance of species*

Stenella longirostris formed 52.9% of the catch followed by *Tursiops aduncus* which contributed 32.7%. The other two species *Delphinus delphis tropicalis* and *Sousa chinensis* accounted for 8.1% and 6.3% respectively.

Monthly variation

The peak season for *S. longirostris* was October during which 36.9% of the landing was observed. 29.5% of the catch was landed in November. December and January shared 14.1% and 8.7%. Dolphins were not observed during the months of May to July due to the suspension of fishing activities because of rough sea condition.

December was observed to be the peak month for the *Tursiops aduncus* with 33.2% of the landings followed by Novembr with 21.0%. October and January shared 12.3% and 19.3% respectively. Dolphin catch was not observed during the months of May to August.

More or less a similar trend was observed in *Delphinus delphis tropicalis*. In this species September and November contributed 28.6% each. 14.4% of the catch was observed during April.

The occurrence of *Sousa chinensis* was observed to be more during the month of December with 27.2% of the catch though the months of January, March, October and November shared 18.2% of the catch.

4. *Size composition*

Stenella longirostris

The total length of the species ranged between 930 to 2520 mm. The smallest and the largest length groups contributed only 7.6% and 2.1% of the landings. The dolphins of length range 1500-1749 mm formed the model group with 27.2% of the catch.

Tursiops aduncus

The length range of the species was from 1010-3400 mm. The smallest and the largest groups contributed 3.5% and 1.7% of the catch respectively. The model length group was formed by 2000-2249 mm dolphins which accounted for 28.0% of the catch.

Delphinus delphis tropicalis

The length range of this species occurring in the gill nets varied between 1050 to 2415 mm. The smallest length group formed 7.1% and the largest group 14%. The model group was formed by the dolphins measuring 2000-2249 mm which formed 35.8%.

5. *Sex ratio*

S. longirostris

Sex ratio of this species was found to be 1.0 : 1.1 for the period of observation. The ratio was more or less same for January, March, October and December. Deviation from this pattern was observed during the months of February, April and August. But the landings during these months were less.

When the sex ratio was analysed based on length groups, a male dominance was observed in the 750-990 mm lengths where the ratio was 1 : 0.4 while female dominance was seen more pronounced in the length groups 1500-1749 mm, 1750-1990 mm and 2000-1249 mm. The ratio was equal in the 1000-2249 mm, 2250-2499 mm and 2500-2749 mm groups (Table 1).

Tursiops aduncus

The total male and female ratio was found to be 1 : 1.4 with more females. The ratio was about 1 : 2 during November and December. However, a male dominance with ratio of 1 : 0.4 was observed in October.

TABLE 4. *Sex ratio of* Sousa chinensis *off Calicut Coast in relation to total length*

Length groups (mm)	Jan. M	Jan. F	Feb. M	Feb. F	Mar. M	Mar. F	Oct. M	Oct. F	Nov. M	Nov. F	Dec. M	Dec. F	Total M	Total F	Ratio M F
1750-1999	—	—	—	—	—	—	1	—	1	—	—	—	2	—	1 : 0
2000-2249	—	—	—	—	—	1	—	—	—	1	1	—	1	2	1 : 2
2250-2499	—	1	—	—	—	—	—	—	—	—	—	—	—	1	0 : 1
2500-2749	—	1	—	—	1	—	—	—	—	—	1	1	2	2	1 : 1
2750-2999	—	—	—	—	—	—	—	—	—	—	—	—	—	—	— —
3250-3449	—	—	—	—	—	—	1	—	—	—	—	—	1	—	1 : 0
Total	—	2	—	—	1	1	2	—	1	1	2	1	6	5	
Ratio	0 : 2		—	—	1 : 1		2 : 0		1 : 1		1 : 0.5		1 : 0.8		

TABLE 5. *Number of Dolphins caught in the gill net off Calicut coast from* 1976-'80

Name of the Species	Years 1976	1977	1978	1979	1980	Total	%
Stenella longirostris	28	38	10	5	11	92	52.9
Tursiops aduncus	5	2	12	4	34	57	32.7
Delphinus delphis tropicalis	2	5	1	—	6	14	8.1
Sousa chinensis	—	5	1	3	2	11	6.3
Total	35	50	24	12	53	174	
Percentage	20.1	28.7	13.8	6.8	30.6		

A dominance of females was seen in the younger age groups ranging from 1000-1999 mm and in 2250-2499 mm. However, in the model length group 2000-2249, the sex ratio was 1 : 0.8. But in the larger length groups a dominance of male was found (Table 2).

Delphinus delphis tropicalis

The sex ratio was found to be 1 : 1.8 with a dominance of females. This trend was continued during the months of January, March, October and December. The 1 : 1 ratio was observed during the months of April, September and November. The dominance of females was observed almost in all the length groups except 2250-2499 mm group (Table 3).

Sousa chinensis

Sex ratio of this species was found to be 1 : 0.8 with a dominance of males. During the month of January males were not observed while females were not observed in October. Male and female ratio was equal during the months of March and November.

DISCUSSION

We have practically no information on the magnitude of the by-catch of dolphins along the Indian coast. The analysis of the dolphins caught along the Calicut coast indicates that they get entangled in the gill nets mostly during the colder part of the year from September to

February. The peak occurrence of the dolphins *S. longirostris* and *Delphinus delphis tropicalis* was during October whereas *Tursiops aduncus* and *Sousa chinensis* were landed during the month of December. No landing was observed during the monsoon months of June, July and August as gill nets were not operated during this period due to rough weather. The number of dolphins entangled annually varied from 12 to 53. In the present study the overall males to females ratio of *Stenella longirostris* was 1.0 : 1.1 and for *Tursiops aduncus* 1 : 1.4. The ratio for *Delphinus delphis tropicalis* showed a female dominance. However, such variations may be due to the limited number of specimens examined.

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A BRIEF REVIEW OF AGEING TECHNIQUES FOR TOOTHED CETACEANS WITHIN THE CONTEXT OF MARINE PARKS

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ABSTRACT

As in other mammals, age determination in odontocetes (or toothed whales) is based on the counting of growth layers which are found in hard tissue (dentine, cement, bone). Likely sources of material in marine parks are identified. A brief review of current methods of preparation of samples for age determination is given. Suggestions as to how marine parks can co-operate in age determination studies are made.

INTRODUCTION

IN 1978 an International Conference and Workshop on Determining Age of Odontocete Cetaceans was held. The Report of the Workshop and associated papers were published in 1980 (Perrin and Myrick, eds, 1980) and I make no apology for drawing heavily upon that volume in this review. It remains the most comprehensive treatment of the subject to date, and is an essential reference volume for anyone interested in the topic.

The sub-order Odontoceti comprises one species of great whale, the sperm whale (*Physeter macrocephalus*) and its smaller relatives, the dwarf and pygmy sperm whales (*Kogia* spp.) all of the family Physeteridae, the bottlenosed and beaked whales (Ziphiidae), the river dolphins (Platanistidae), the true dolphins (Delphinidae), the rough-toothed and humpbacked dolphins (Stenidae), the porpoises (Phocoenidae) and the white whale and narwhl (Monodontidae) As the name suggests, the major characteristic of odontocetes is that they posess teeth (although these are not always erupted) and it is their teeth which are most commonly used in age determination.

In brief, the principle of age determination in marine mammals is similar to that for other animals i.e. that annual/seasonal layers are formed in certain hard tissues (e.g. teeth, bone, shells) and that these can be counted (Grue and Jensen, 1979). Plate I shows a section of a generalised cetacean tooth. If a tooth is bisected longitudinally then alternating translucent and opaque layers can be seen within the dentine. A pair of these comprises a Growth Layer Group (GLG). It is believed, and for some species it has been shown, that these are formed regularly (Best, 1976). In the case of the sperm whale, for example, there is substantial evidence that one GLG is formed per year (Gambell, 1977). Although these layers in the teeth of marine mammals were noted as early as the mid-19th century (e.g. Owen 1840-45 ; Eschricht, 1845), the significance of these in terms of age determination was not recognised until over a century later with the work of Scheffer (1950) and Laws (1952). Similar layers have since been found in the cementum

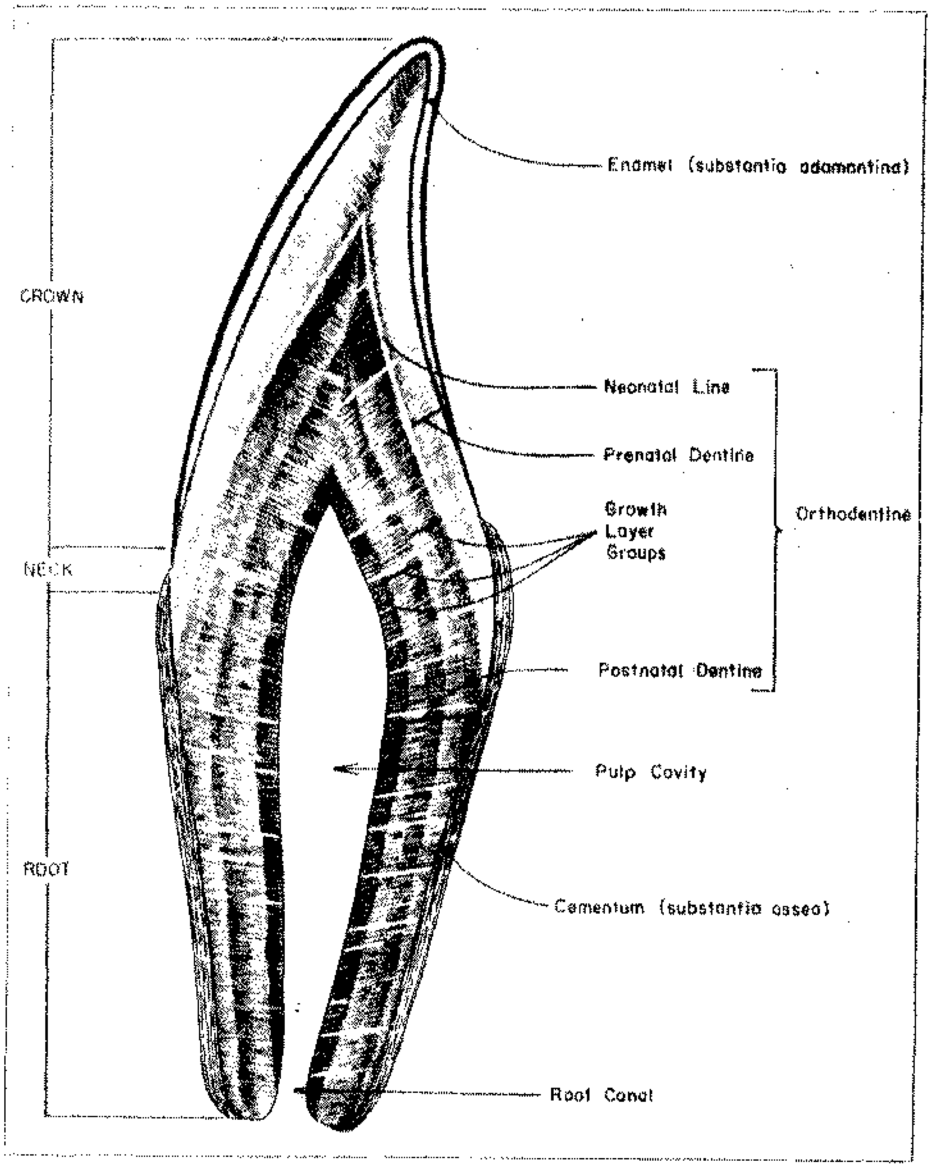


PLATE I. Generalised Cetacean tooth [from Perrin and Myrick (Eds.) 1980*] showing key terms and structures.

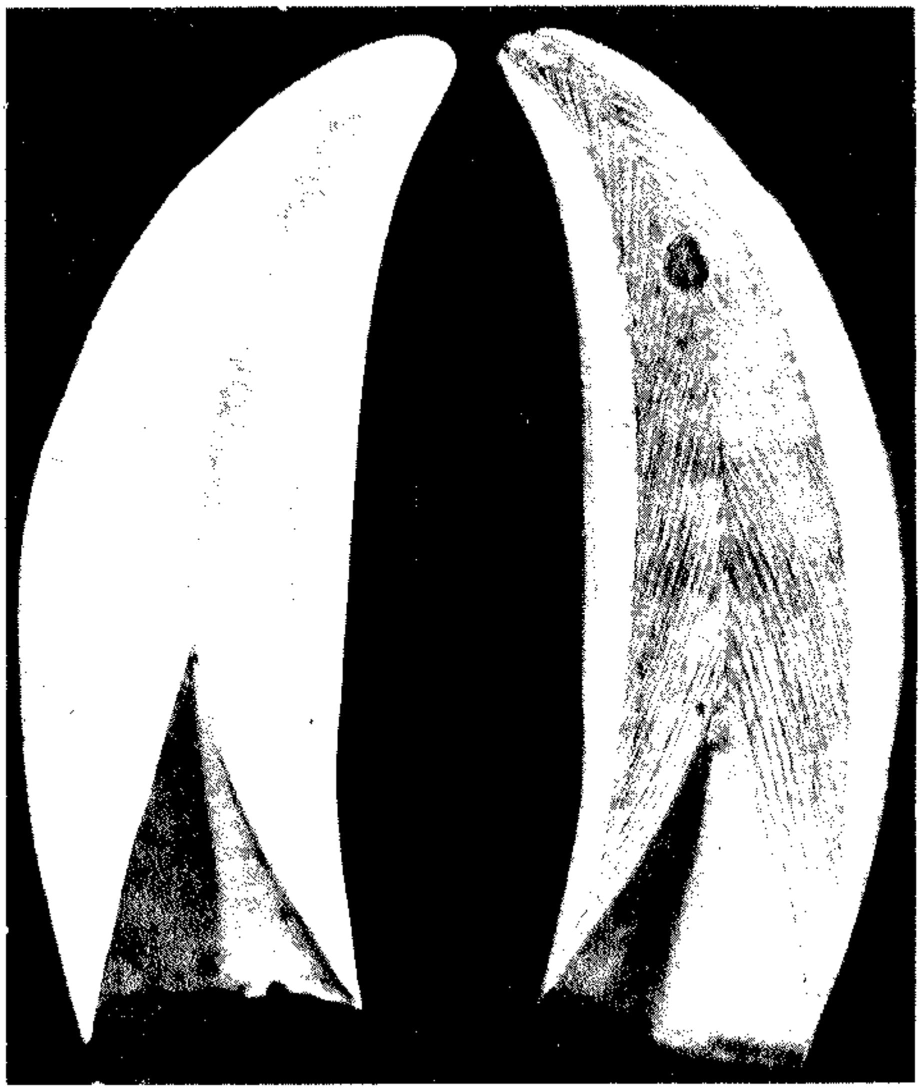
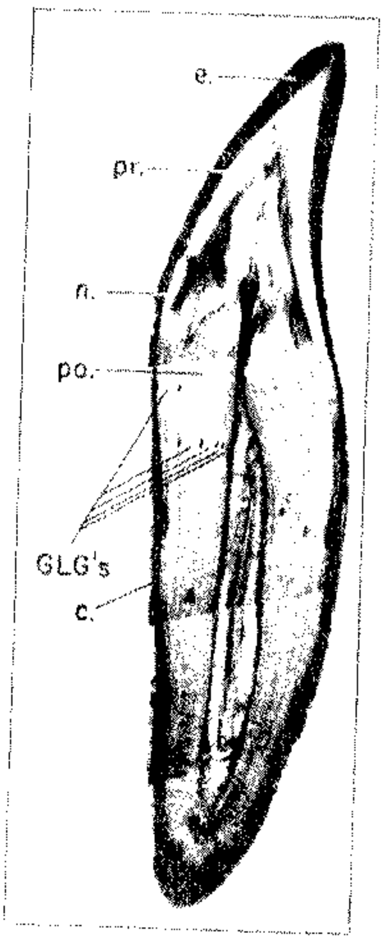


PLATE II. Example of untreated (left) and etched (right) sperm whale teeth. Note the ridges and valleys on the etched tooth which have been accentuated by rubbing with a pencil.



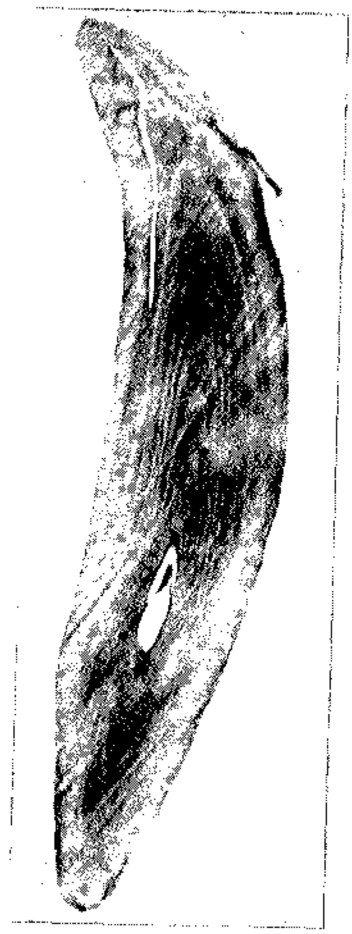


PLATE III. A. (Left) 100 μm thick (untreated) section of a tooth of *Stenella attenuata*, C = Cementum, e = enamel n = neonatal line, Po = postnatal dentine, Pr = prenatal dentine. B. (Right) Decalcified stained (Ehrlich's Haematoxylin) 20 μm sections of *Cephalorhynchus commersonii* teeth, the animal has 8 + 1 GLGs. Nl = Neonatal line (Photo : Courtesy of C. Lockyer).

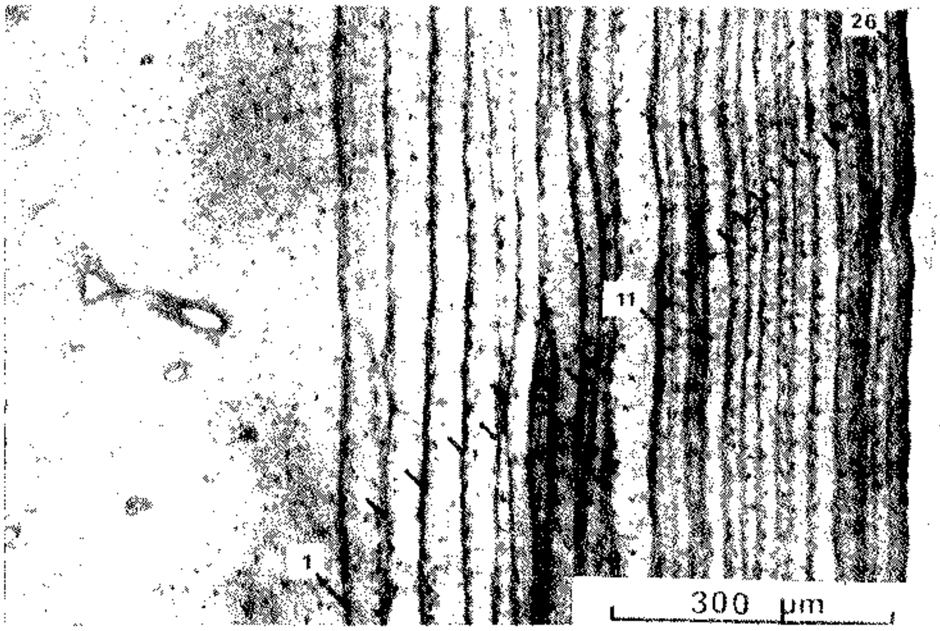


PLATE IV. *Decalcified stained* (Ehrlich's haematoxylin) 15 µm section of mandibular bone from a female *Delphinus delphis* showing 26 GLGs. (Photo: Courtesy of A. Collet and V. de Buffrénil.)

and in bone. The various techniques which are described later have been developed to accentuate the growth layers and make them easier to read (i.e. count). Several reviews of the history of age determination techniques have been written e.g. Klevezal' and Kleinenberg (1967), Klevezal' (1980), Scheffer and Myrick (1980).

The importantance of age determination studies in the estimation of life history parameters makes them central to the management of cetacean populations. There is even some limited evidence (Klevezal' and Myrick, 1984), at least for *Stenella*, that teeth may not only provide a record of the age of an individual but also in the case of females, provide an indication of its reproductive history.

This paper is intended to give a brief review of current techniques used to determine the ages of toothed cetaceans within the context of the present symposium. In particular, I hope it will provide a general introduction of the topic to people who may be practically involved in marine parks and perhaps stimulate some interest in such studies (if it does not already exist) in marine parks.

While absolving them from responsibility for any sins of commission or omission in this paper, I would like to thank Anne Collet of the Centre National d'Étude des Mammifères Marins in France, and Christina Lockyer of the Sea Mammal Research Unit in England, for useful suggestions and advice.

Materials and Collection

Likely sources of material in marine parks

The most likely source of material for age-determination (and indeed any study requiring tissue) in marine parks, is of course from stranded animals. The importance of obtaining as much associated information as possible from such animals cannot be over-emphasised, although the amount of data which can be collected clearly depends on the degree of decomposition of the animal. A comprehensive list of data to be collected under ideal conditions is given in Mitchell (ed., 1975, p. 978 ff.) although it is unlikely that such conditions will be met. Table 1 summarises the information most likely to be useful in conjunction with age-determination material, but should not be viewed as limiting.

TABLE 1. *Minimum data to be recorded or material collected from stranded or incidentally captured odontocetes (condition of specimen permitting) for use in conjunction with ageing studies*

A. Data to be recorded

Date and location of specimen.

Species (also take photographs or make sketches).

Length (from tip of snout to apex of notch between flukes measured in a straight line parallel to the body axis).

Number of teeth : upper left, upper right, lower left, lower right (note which teeth are erupted).

Position of teeth selected for ageing.

Females : lactating (milk in mammary glands) or pregnant (foetus present).

weight of left ovary, weight of right ovary (fresh or preserved in formalin, note which)

Males : weight of left testis, weight of right testis (fresh or preserved in formalin, note which) length, width and depth of each testis—(note if epididymis present ; note if sperm present)

B. Materials to be collected (in addition to ageing material described in the text)

Females : both ovaries, preserve in 10% formalin, note which is left and right.

Males : either one or preferably both testes, including epidydimis, where possible, or samples taken at midlength (including core and peripheral samples) preserve in 10% formalin.

Another potential source of material is animals killed incidentally in fishing operations, if the later are allowed in the park. Data required from these animals are the same as for stranded animals above.

A third possible source of material, which is treated more fully in Myrick (1980a) is the experimental capture of animals, which for example, can be measured, marked, have a tooth removed and then immediately released.

Most of the information in the following sections is based on or summarised from Perrin and Myrick (eds, 1980).

Collecting and storing material

A. *Teeth*

Most odontocetes are homodont (posess teeth all of the same kind). Unlike many terrestrial mammals they do not possess deciduous or milk teeth. Thus all of the teeth should provide the same record of true age. The most important factors, therefore in selecting teeth for ageing are that they are as little worn (so that all layers are present) and as straight (to make bisecting or sectioning easier, see below) as possible. In general, for dolphins and porpoises, teeth at the centre of the lower tooth row have been chosen (e.g see Fig. 1). The most commonly sampled tooth from sperm whales, if it is not worn, is the mandibular. If mandibular teeth are worn, however, straight, unerupted maxillary teeth should be chosen. In narwhals unerupted tusks are usually chosen. Where possible it is wise to collect more than one tooth from each specimen. It is not unknown for accident to occur during preparation, and, for those species which have not been extensively studied, it allows for some experimentation with techniques.

B. *Bone*

The ageing of odontocetes using growth layers in bones was not recommended by the 1978 Workshop as a routine method of ageing odontocetes, partly due to difficulties in interpretation for inexperienced readers (Perrin and Myrick, eds, 1980). However, particularly for those species where age determination using teeth has been poorly studied or found to be difficult (see Table 2), I would recommend that where possible, a sample of bone be also collected. For example, Hay (1980) and de Buffrenil and Collect (1983) found that counting layers in bone was preferable for ageing older specimens of narwhal (*Monodon monoceros*) common dolphin (*Delphinus delphis*), respectively, where the pulp cavity of the teeth closes quite early in life, preventing further accumulation of readable dentinal layers. The area usually sampled is the inner wall of the mandible (Kleinenberg and Klevezal', 1962). Fig. 1 shows the location of the teeth and bone samples taken by de Buffrenil and Collect (1983). Hay (1980) had taken more anterior samples (between the mental foramina).

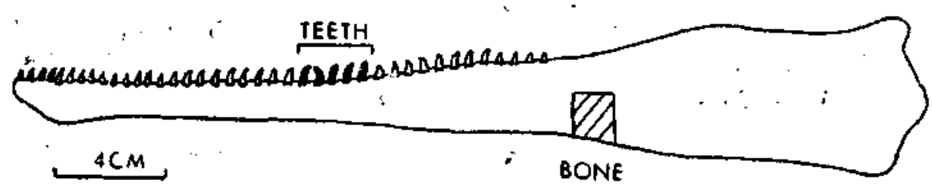


FIG. 1. Left mandible of *Delphinus delphis* showing where bone samples (shaded) and teeth (black) were taken (after de Buffrenil and Collet, 1983).

TABLE 2. *Summary of 'best' techniques for treating teeth for age determination for some odontocete species* (Source : Perrin & Myrick, 1980, unless otherwise noted)

Group/species	'Best' technique if known	dentine or cement
Beaked whales		
Hyperoodon ampullatus	Untreated, ground thin sections	dentine
*H. planifrons**	Untreated, ground thin sections	cement
*Ziphius cavirostris**	Etched half teeth	dentine
Beradius bairdii	Etched half teeth/	cement
	Decalcified, stained sections (Kasuya, 1977)	cement
*Mesoplodon spp.**	Etched half teeth (males)	cement
	Decalcified, stained sections (females)	cement
Sperm whales		
Physeter macrocephalus	Etched half teeth	dentine
Monodonts		
*Monodon monoceros**	No single method, see Hay (1980) for discussion	
Delphinapterus leucas	Untreated, ground thin sections	dentine
Large delphinids		
Orcinus orca	Etched half teeth (Christensen, 1982)[1]	dentine
Globicephala melaena	Etched half teeth (Lockyer, pers. comm.)[2]	dentine
G. macrorhynchus	Decalcified, stained sections (Kasuya and Matsui, 1984)	both
*Pseudorca crassidens**	Etched half teeth (Pierce and Kajimura, 1980)	dentine
*Grampus griseus**	—	—
Dolphins		
General	Decalcified, stained sections[3]	both
Tursiops truncatus	Etched half teeth	dentine
Porpoises		
Phocoena phocoena	Ground half teeth	dentine
*P. dalli**	Decalcified, stained	cement
Others*	—	—

[1] In Perrin and Myrick (eds, 1980) however, from a sample of 18-23 teeth (the exact number is unclear) the workshop had noted that results from acid etching were 'very poor' and that preparation of decalcified cementum was more promising. Christensen (1982) examined over 100 teeth.

[2] Sergeant (1962) and Perrin and Myrick (eds, 1980) reported that the 'best' technique for this species was to examine cemental layers in ground thin transverse sections. They examined North Atlantic specimens, Lockyer examined specimens from South America.

[3] Other techniques have also been reported as successful for individual species, e.g. Pierce and Kajimura (1981) used etched half teeth for *Delphinus delphis, Lagenorhunchus obliquidens* and *Lissodelphis borealis* ; de Buffrenil and Collet (1983) used untreated thin sections for *D. delphis* up to about 10 years of age.

* poorly studied.

Preparation Techniques

The following section is not intended as a workshop manual but rather as a general guide to the equipment needed and techniques used in age determination studies (see Discussion).

A. Teeth

Boyde (in Perrin and Myrick, eds, 1980) found that prolonged boiling, which has been one of the most commonly used methods of cleaning teeth in the past, denatures and gelatinises collagen from dentine and cement. This can damage the cemental layers and the pulp edge. Cleaning in an enzymatic preparation (e.g. of trypsin) is therefore recommended.

Once clean teeth have been obtained, various techniques have been used to make visible or enhance growth layers for counting. Choice of technique depends on various factors ranging from the size of tooth and availability of equipment to inherent species differences in teeth and personal preferences of individual scientists. Table 2 summarises some of the techniques successfully used for a selection of species or groups. Where practical, use of a variety of techniques is to be encouraged, particularly for the many little-studied species for which the most efficient technique has not yet been discovered.

The initial step is either to longitudinally bisect the tooth or to obtain longitudinal thin sections.

Preparation and treatment of half teeth

Half teeth can be prepared either by grinding or sawing. The former is more often used for smaller teeth. Commercial grinder/polishers are available. Either band saws or diamond saws can be used for bisecting teeth, the size of the blade depending on the size of teeth to be cut. One of the major practical difficulties is holding the tooth in the correct orientation during cutting. Individual researchers have developed a number of methods to solve this problem e.g. mounting teeth on a wooden block using dental wax, mounting in clear plastic resin, development of special vices and clamps.

Generally, some form of etching is required to render growth layers more visible. However, Stuart and Morejohn (1980) found that a film of water on the surface of a half ground, polished tooth facilitated reading of layers sufficiently for *Phocoena phocoena*, when using a binocular dissecting microscope and reflected light.

If etching is required, the teeth need to be polished, for example using fine wet and dry sandpaper. Several demineralising agents have been used for etching teeth from different species, and experimentation with both reagents and treatment times is necessary for the poorly studied species. The most commonly used reagent is formic acid (either 5% or 10% solutions). Nitric acid and hydrochloric acids have a tendency to cause dental tissue to crack or separate (Pierce and Kajimura, 1980). Etching times can vary from 2 hours for beaked and pilot whales to 30 hours for sperm whales.

After etching, the tooth must be rinsed thoroughly and left to dry for several hours. The result of etching is that the layers are thrown into a surface relief of valleys and ridges Plate II) These can be further accentuated by rubbing the surface with a pencil, crayon or jeweller's rouge and viewing with reflected light. Although sperm whale teeth can be read with the naked eye, some degree of magnification is needed for smaller teeth.

The acid etching of half teeth is the simplest preparation technique for age determination. Where it is not successful however, either untreated sections (often unnecessarily termed 'undecalcified, unstained sections' in the literature !) or decalcified, stained sections must be obtained.

Preparation of untreated sections (PLATE III A) (Left)

Small teeth can be ground directly to thin sections using whetstones or sandpaper and then polished. Other methods include the use of microtomes, diamond saws followed by grinding or tandem-bladed diamond saws. Various mounting methods are used, commonly on perspex slides using glycerine or synthetic resins. Final grinding and polishing is often carried out after the section has been mounted. Section widths suitable for reading vary from 30μm (*e.g. Pontoporei blainvillei,* Kasuya *in* Perrin and Myrick eds, 1980) to 200μm (*e.g. Delphinus delphis,* de Buffrenil and Collet, 1984). Sections should be examined using a microscope and transmitted light. A compound microscope with polarised light or phase contrast facilities may be useful for some specimens (Myrick, 1980b).

Preparation of decalcified, stained sections

PLATE III B (Right)

There are two methods of obtaining decalcified sections (which are usually between 12-15μm thick for reading cemental layers and less than 30μm for dentinal layers) : one is to decalcify the whole tooth and then section it on a freezing microtome ; the other is to section the tooth as described above and then decalcify the section. Formic acid (either 5% or 10%) is usually used as the decalcifying agent in the latter method, the exposure time varying with the species and the thickness. The former method is usually used for small teeth and the most commonly used reagent is fresh nitric acid (5%). There is a considerable body of literature concerning the preparation of decalcified sections (*e.g.* Brain, 1966 ; Wallington, 1972). Either Mayer's or Ehrlich's haemotoxylin is generally used for staining. Discussion of appropriate mounting and staining techniques for decalcified sections can be found in standard histological text books. The sections are read with microscopes using transmitted light. An example of such a section is shown in Plate III B (Right).

Bone (Plate IV)

Preparation of bone for age determination is similar to that for teeth. Either thin, untreated sections are examined (*e.g.* Hay, 1980) or samples of bone 1-2 cm thick are decalcified, sectioned and stained with haemotoxylin (*e.g.* Klevezal' and Kleinenberg, 1967 ; de Buffrenil and Collet, 1983).

DISCUSSION

To conclude this review I would like to examine the potential use of marine parks for age determination studies. One problem is that there are probably as many different 'species' of marine parks as there are of dolphins—some covering vast areas of Ocean (for example the 'Indian Ocean Sanctuary' established by the International Whaling Commission), others covering only a small local coastal area ; some with a large staff of wardens and scientists, others left largely to run themselves. I do not attempt here to distinguish between them. The application of any ideas below to specific parks is a matter for those familiar with the characteristics of those parks.

The likely availability of material has been discussed earlier. In several areas of the world (*e.g.* UK, USA, Australia), national or regional 'strandings networks' have been established, whereby the public are encouraged (using various techniques, such as posters, newspaper advertisements, lectures) to report any cetacean strandings to a central institution (*e.g.* in the UK to the British Museum of Natural History) and if possible to provide some basic data. Scientists or technicians then visit the stranding to collect the type of information and material outlined in Table 1. Similar systems could be usefully adopted in marine parks, drawing on the experience of currently operating networks. (Appendix 1 lists a number of individuals/institutions who could provide advice on establishing such networks and training personnel in the collection of samples).

Incidental captures of cetaceans in fishing operations pose a more difficult problem depending on the number of animals involved and the size of the fishery. For example where numbers are small it may be possible to encourage fishermen to collect required material; where numbers are large it might be possible to arrange for a technician to be allowed on a vessel on some fishing trips. Clearly, practical approaches need to be developed for specific local situations.

The question of experimental aquisition of material is dealt with later.

Having obtained the necessary samples, the question remains as to how these can most efficiently be examined and analysed. Before attempting to answer this question there are two aspects to consider. In the short review of preparation techniques it can be seen that not only is some degree of capital expenditure needed, but also, for example with respect to the cutting/sectioning equipment, some modification of commercially available equipment is required to cope with specific problems. The preparation of stained sections generally follows standard histological techniques.

To turn to the actual reading of prepared material, experience is a vital factor. This is not the place to describe in detail the problems of 'accesory layers, double laminae' etc. but it should be recognised that reading is rarely as simple as counting beautifully contrasting GLGs. The necessary subjective skill in counting layers has been the subject of much discussion (*e.g.* Mikhalev, 1982). Donovan *et al.*, (1982) examined a series of 50 sperm whale teeth read by six experts and the results indicated significant differences between some readers. It is thus important that new readers work for some time with experienced readers.

To return then to the question of how best to treat material collected in marine parks, the answer depends on the nature of the park itself. There are a number of institutions around the world who are experienced in ageing techniques for marine mammals. In general the number of samples to be expected from small marine parks will probably not justify the establishment of a facility to treat ageing material and the most efficient solution would be to co-operate with one of the established institutions who may be prepared to analyse any submitted material and incorporate it into their study programmes. Alternatively, there may be a local institution which already has the potential to treat such data; as we have noted, the histological techniques used are standard. In such cases it may be possible to arrange for someone from the institution to visit and work for a time in an 'experienced' institution to gain the necessary skills peculiar to odontocete studies, so that the material can in future be locally analysed. A list of some of the institutions which possess the necessary expertise is given in Appendix II. These institutions can usually provide help/advice with the analysis of associated reproductive material where this is also collected.

Particularly with respect to the little studied species (usually those for which only a few stranded specimens are avilable), reliable strandings networks within marine parks can play a useful role in providing further samples.

A final area in which marine parks could play an important role is in the provision of facilities and encouragement for research programmes concerning age determination. A brief look at Table 2 reveals a large number of little-studied species. A number of fundamental questions remain unanswered with respect to the age determination of odontocetes. For many species we have little direct evidence that layers are deposited regularly, even when they have been found easy to count (*e.g.* see Lockyer *et al.*, 1981). There remain many physiological questions with respect to the mechanisms and causes of layering. Local groups of odontocetes within marine parks could form useful study populations. Myrick (1980b) has described several programmes which could be undertaken to provide valuable information on unanswered questions *e.g.* animals could be captured, marked with visible markers and(or injected with a substance (*e.g.* tetracycline) which time-marks hard tissue, have a tooth removed and then returned to the sea. Subsequent capture of known animals could provide valuable information on the layering process.

Appendix I

Some Individuals/Institutions involved in Strandings Networks

Australia National Parks and Wildlife Service, P. O. Box 636, Canberra City, ACT 2601, Australia.

Musée Oceanographique, Centre National D'Étude des Mammiféres Marins, Port des Minimes, 17000 La Rochelle, France.

Mr. M. W. Cawthorn, Ministry of Agriculture and Fisheries, Fisheries Research Division P. O. Box 297, Wellington, New Zealand.

Mr. A. Raga, Departmento de Zoologia Facultad des Sciencias Biologicas, Dr. Moline 50, Burgascot, Valencia, Spain.

Mr. M. Sheldrick, Department of Zoology, British Museum (Natural History), Cromwell Road, London, SW7 5BD, UK.

Dr. J. Mead, Division of Mammals, NH Stop 180, National Museum of Natural History, Smithsonian Institution, Washington D.C. 20560, USA.

Appendix II

Some Institutions Involved in Odontocete Ageing Studies

Department of Zoology, School of Biological Sciences, James Cook University of North Queensland, Townsville, Queensland 4811, Australia.

Arctic Biological Station, 555 St. Pierre Blvd., Ste. Anne-de-Bellevue, Quebec, Canada, H9X 3R4.

Centre National d'Étude des Mammiféres Marins, MNHM, Laboratorire d'Anatomie comparée, 55 rue de Buffon, 75005 Paris, France.

Far Seas Fisheries Research Laboratory, 5-7-1 Orido, Shimizu 424, Japan.

Institute of Development Biology, Academy of Sciences of the USSR, 26 Vavilov St., 117334 Moscow, USSR.

Sea Mammal Research Unit, c/o British Antarctic Survey, Madingley Road, Cambridge, CB3 OBT, UK.

Southwest Fisheries Center, P.O. Box 271, La Jolla, California 92038, USA.

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OSTEOLOGY OF DOLPHINS *DELPHINUS DELPHIS TROPICALIS, STENELLA LONGIROSTRIS, TURSIOPS ADUNCUS* AND *SOUSA CHINENSIS* FROM SOUTH-WEST COAST OF INDIA

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ABSTRACT

Osteology of four dolphins *Delphinus delphis tropicalis* van Bree, *Stenella longirostris* Gray, *Tursiops aduncus* Ehrenberg and *Sousa chinensis* Osbeck are studied from the south-west coast of India. The measurements of the skulls are compared with the information available from other parts of the world.

INTRODUCTION

OUR information on the osteology of the dolphins occurring along Indian coast is far from satisfactory. Cuvier (1829) described the skull of *Delphinus dissumieri* Blanford from Malabar coast. The osteology of *Tursiops aduncus* Ehrenberg was recently studied by Ross (1977). There is no information on the skull of *Stenella longirostris* Gray and *Sousa chinensis* from India though their external morphology has been described (Blanford, 1891). In the present study, the osteology of these four species are described.

I am thankful to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute, Cochin for his encouragement and guidance throughout the study.

MATERIAL AND METHODS

The skulls were prepared by boiling the heads of dolphins caught in the gill net as by catch from the Calicut Coast. After removing the flesh, the skull was sun dried with sprinkling boric acid powder for about a week. The skull was then coated with french polish, adding a few grams of arsenic powder. The teeth were removed and treated with Hydrogen per oxide solution and fixed in the alveolus with eraldite gum. Measurements were taken after Perrin (1975)

OBSERVATION

Delphinus delphis tropicalis van Bree

Rostrum of the species is narrow and acute forming 66.2 to 70.0% of the condylobasal length. The number of teeth on the upper jaw ranged from 134 to 138. The rostral length Zygomatic width ratio varied from 2.1 to 2.2. The Zygomatic width measured 30.8 to 32.5% of the condylobasal length. The ventral surface of each maxilla on the palate is deeply grooved in the posterior two third of the rostrum. The vomer forms a ridge ventrally. The craniun is small (Fig. 1 a, b). The maximum width of premaxilla ranged from 13.6 to 13.7% of CBL (Table 1).

Stenella longirostris Gray

The rostrum of the species is not acute (Plate I A, B and Fig. 2 a, b) and measured

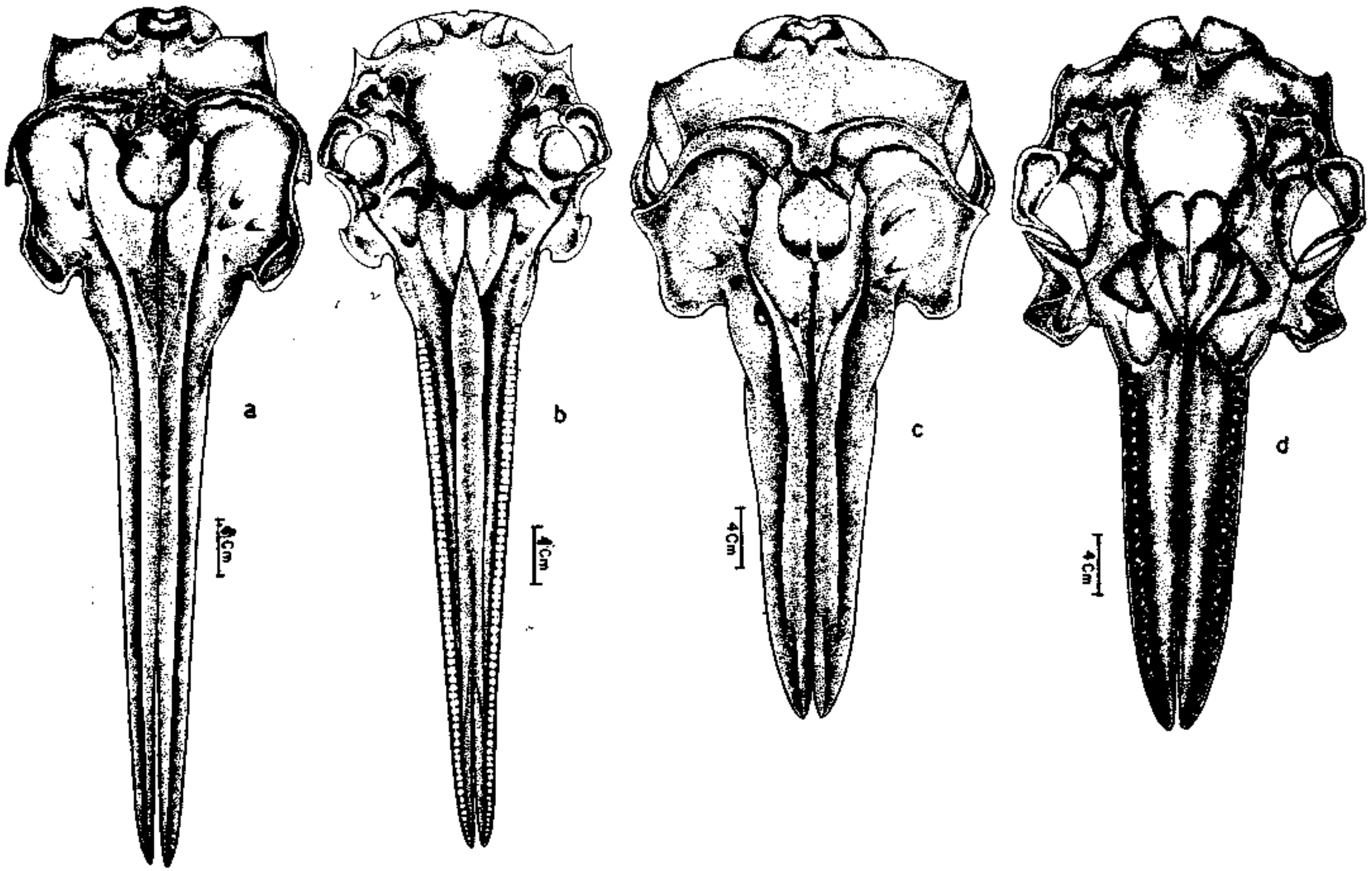

FIG. 1. Skulls of dolphins : a. Dorsal view of *Delphinus delphis tropicalis*, b. Ventral view of same, c. dorsal view of *Tursiops aduncus* and d. Ventral view of same.

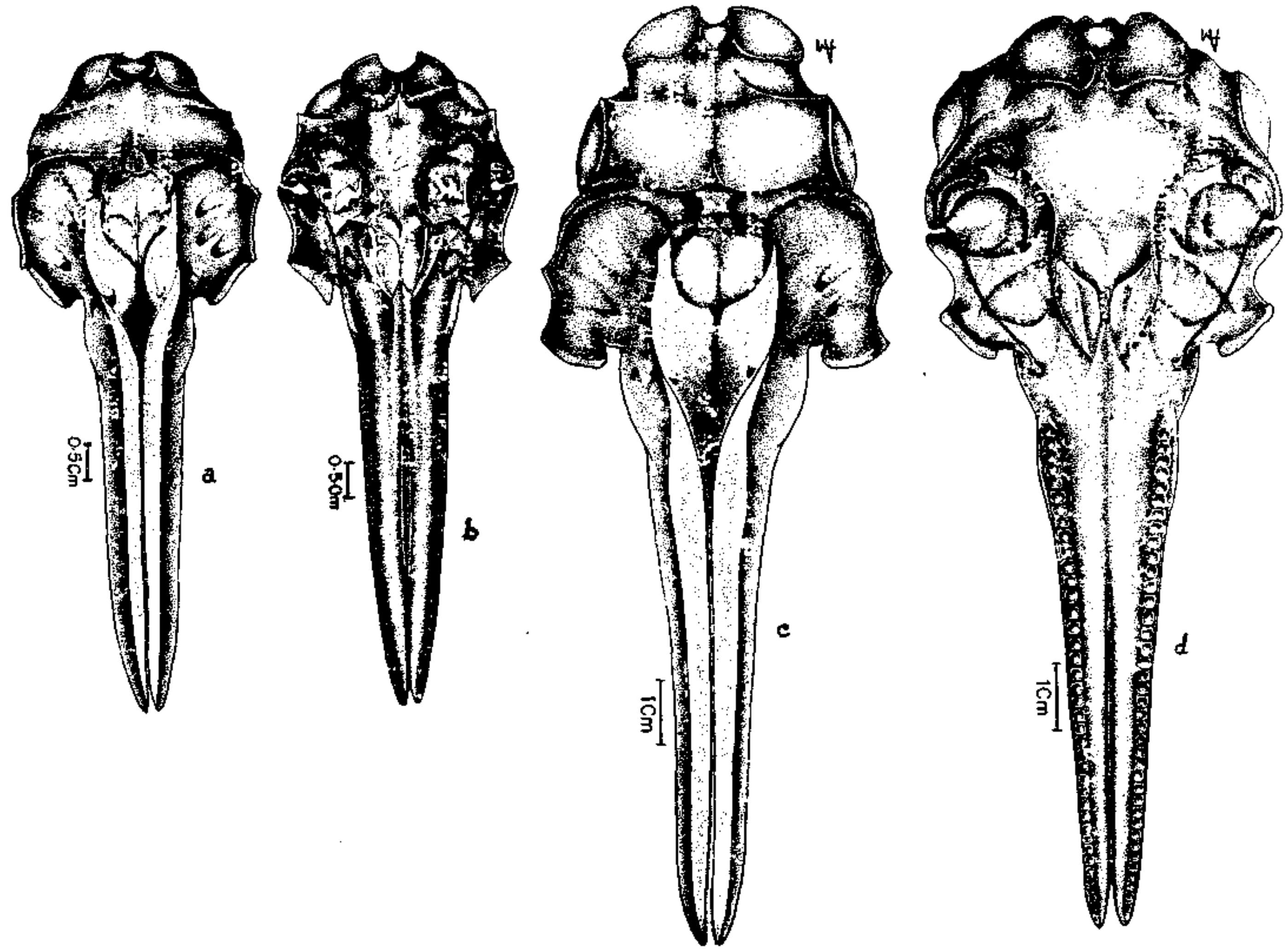

FIG. 2. Skulls of dolphins, a and b. Dorsal and Ventral views of the skull of *Stenella longirostris*; and c and d. Dorsal and ventral views of the skull of *Tursiops aduncus*.

64.5 to 67.5% of the condylobasal length. Number of teeth varied from 107 to 108 in upper jaw. The rostral-Zygomatic ratio was 1.7 to 1.8. The palate was not grooved ventrally. The greatest length of pterygiod measured from 12.9 to 14.2% of the condylobasal length. The length of tooth row was 55.2% to 59.7% of CBL. The length of mandibles ranged from 84.2% to 83.3% of CBL (Table 2).

Tursiops aduncus Ehrenberg

The rostral length was 60.6 to 62.5% of the CBL. The skull was also much heavier and the bones are solid and firm (Fig. 1 c, d). The number of alveolus on the upper jaw ranged between 27 to 28. The rostral-Zygomatic ratio was 1.3. The length of tooth row in the upper jaw was 1.2 to rostral length. Teeth strong measuring 26 mm (Table 3).

Sousa chinensis Osbeck

The rostrum is long measuring 63.3 to 64.1% of the condylobasal length. It is slender and laterally compressed; the premaxillae are arched dorsally along its length. The frontal bones are exposed near the vertex of the cranium between the posterior margin of the premaxillae and the transverse supraoccipital crest. The pterygiod hamuli are narrow (Plate I c, d and Fig. 2 c, d). The rostral-Zygomatic ratio is 1.6 to 1.7. The length of teeth row on upper jaw 55.1 to 56.0% of CBL. The number of alveolus on the upper and lower jaws range from 73-76 and 69-72 respectively. Teeth in the middle of the jaws measured 20 mm (Table 4).

Discussion

The need for more information on the osteology of the dolphins from the Indian coast has been expressed by many workers. (Banks and Brownell, 1969; Perrin, 1975 and Mitchell, 1975). This information is vital as the knowledge of the geographical variation is important in determining the species based on the collection from its whole range of distribution.

The osteology of the ***Delphinus delphis tropicalis*** has been recently studied by van Bree (1971) clearing some of the confusion that existed in the nomenclature of the species and relegating the species *Delphinus dussumieri* Blanford and *Delphinus longirostris* Cuvier as junior synonyms. The importance of the extreme acute nature of the rostrum and more number of teeth were considered to be of taxonomic significance. Banks and Brownell (1969) while studying the common dolphin of Eastern pacific suggested that the ratio of Zygomatic width to rostrum length was important enough to differentiate between *D. delphis* Linnaeus and *D. bairdii* Dall. However, this was refuted by van Bree and Purves (1972) who explained that dolphins with short rostrum were found in colder waters and that with longer rostrum in warmer waters. They attributed the elongation of the rostrum to lower surface to volume ratio. However, they conceed that it may be the beginning of speciation. If the attenuation of the rostrum is temperature related, it should be seen in other species of dolphins also. Perrin (1975) while examining the spotted and spinner dolphins in the eastern tropical Pacific found that coastal population was with longer rostrum and the off-shore population with short rostrum. The degree of attenuation in relation to the skull is important. Considering this aspect, the *Delphinus* species occurring along the south-west coast of India with long attenuated rostrum, more number of teeth and higher rostral-Zygomatic ratio was given subspecific status (Mohan, 1983). The rostral-Zygomatic width ratio in *D. tropicalis* of south Africa was 1.8-2.03 (Ross, in press) whereas in the dolphins off Calicut coast it ranged from 2.14 to 2.15.

The ratio of condylobasal length to rostrum of *Stenella longirostris* of Calicut coast ranged

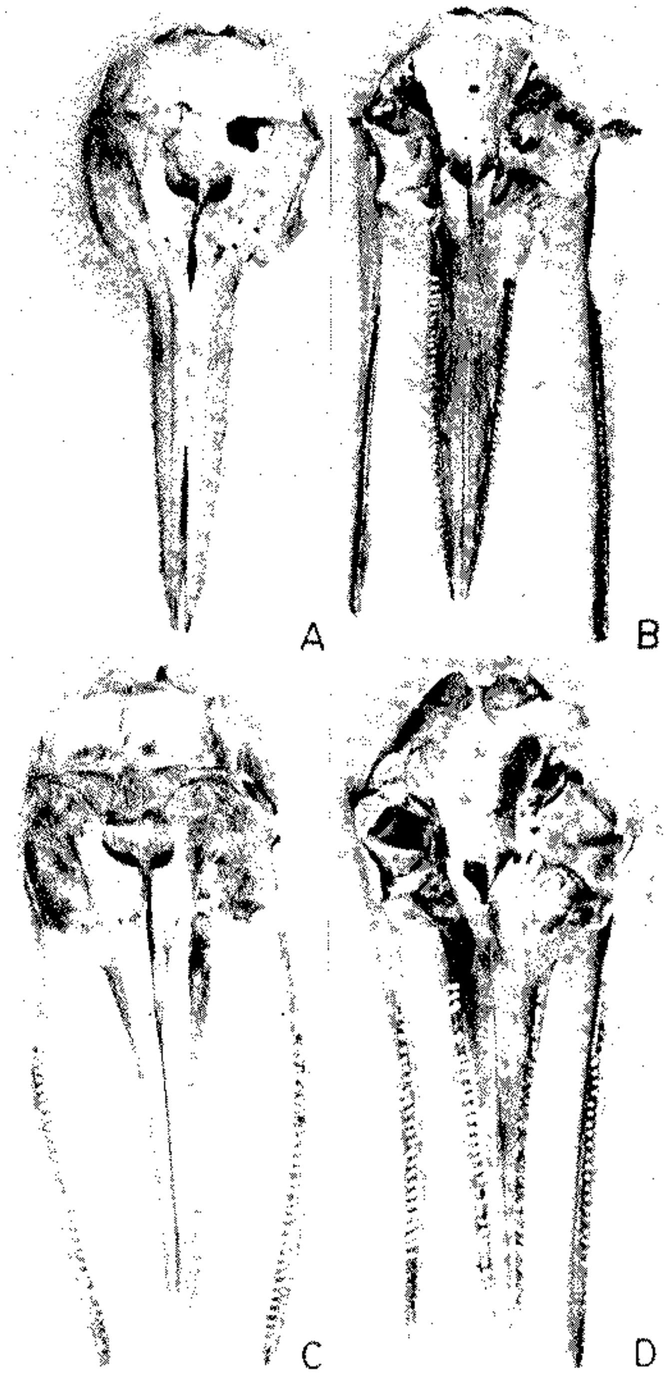

PLATE I. Skulls of dolphins. A. dorsal view of *Stenella longirostris*, B. Ventral view of same; C. dorsal view of *Sousa chinensis* and D. Ventral view of same.

TABLE 1. *Measurements of the skull of* Delphinus delphis tropicalis *Mohan from Off Calicut coast*

	(mm)		(%)	(%)
	1	2	range	$\bar{x}$
Condylobasal length ..	438	585		
Rostrum ..	290	410	66.2-70.1	68.1
Rostrum basal width ..	75	100	17.1	17.1
Breadth across Pre-orbital ..	128	178	29.2-30.0	29.6
Zygomatic width ..	135	190	30.8-32.5	31.6
Width of Brain case (across parietals) ..	130	153	26.1-29.6	27.8
Greatest length of Pterygoid ..	62	80	14.1-13.6	13.8
Greatest postorbital width ..	136	182	31.0-31.1	31.0
Maximum width of pre-maxilla ..	60	80	13.6-13.7	13.6
Length of post-temporal fossa ..	57	82	13.0-14.0	13.5
Length of tooth row (right) ..	230	365	52.5-62.4	57.4
Number of alveolus (upper jaw) ..	68-67	69+69	68-69/67-69	68.5/68.0
Length of mandible ..	375	512	85.6-87.5	86.5
Length of lower tooth row ..	235	340	53.6-58.1	55.8
Number of alveolus (lower jaw) ..	65+65	64+64	64-65/64-65	64.5/64.5
Teeth length ..	12	14	12-14	2.5

TABLE 2. *Measurements of the skull of* Stenella longirostris *Gray from Off Calicut coast*

	(mm)			(%)	(%)
	1	2	3	range	$\bar{x}$
Condylobasal length ..	385	351	380		
Rostrum length ..	260	230	245	64.5-67.5	66.7
Rostrum basal width ..	70	65	68	17.9-18.5	18.2
Breadth across Pre-orbital ..	127	120	127	33.0-34.2	33.4
Zygomatic width ..	138	132	135	35.5-35.8	36.3
Width of Brain case (across parietals) ..	132	120	130	34.1-34.2	34.1
Greatest length of Pterygoid ..	50	50	54	12.9-14.2	13.8
Greatest post-orbital width ..	139	135	138	31.0-38.5	34.6
Maximum width of pre-maxilla ..	55	52	55	14.3-14.8	14.5
Length of post-temporal fossa ..	47	58	46	12.1-16.5	13.6
Length of tooth row (right) ..	230	200	210	55.2-59.7	57.3
Number of alveolus (upper jaw) ..	56+54	53+54	49+49	49-56/49-54	52.6-52.3
Length of mandible ..	340	300	320	88.3-84.2	86.0
Length of lower tooth row ..	227	190	210	54.1-59.0	56.1
Number of alveolus (lower jaw) ..	50+51	50+50	49+49	49-50/49-51	49.6-50.0
Teeth length (30th) ..	11	11	11	2.3-2.7	2.7
		30th			
Sex ..	M	M	F		

TABLE 3. *Measurements of the skull of the dolphin* Tursiops aduncus *Ehrenberg off Calicut coast*

		(mm)		(%)	(%)
	1	2	3	range	$\bar{x}$
Condylobasal length ..	432	435	495		
Rostrum length ..	270	265	300	60.6-62.5	61.3
Rostrum basal width ..	95	95	105	21.2-22.0	21.6
Breedth across Pre-orbital ..	185	175	190	38.4-42.8	40.4
Zygomatic width ..	205	200	230	45.9-47.4	46.5
Width of Brain case (across parietals) ..	165	165	185	37.4-38.2	37.8
Greatest length of Pterygoid ..	58	50	66	11.5-13.3	12.6
Greatest post-orbital width ..	185	—	—	—	42.8
Maximum width of pre-maxilla ..	77	74	83	16.7-17.8	17.1
Length of post-temporal fossa ..	91	87	95	19.1-20.1	20.0
Length of tooth row (right) ..	223	220	250	50.5-51.6	50.8
Number of alveolus (upper jaw) ..	28+28	27+27	27+27	27-28	27.3
Length of mandible ..	385	370	410	82.8-89.1	85.6
Length of lower tooth row ..	222	220	255	50.4-51.5	51.1
Number of alveolus (lower jaw) ..	28, 26	26, 26	28, 28	26-28	27.3
Teeth length (14th) ..	26	26	26	26	26
		14th			
Sex ..	F	F	M		

TABLE 4. *Measurements of the skull of the hump back dolphin* Sousa chinensis *Osbeck from off Calicut*

		(mm)	(%)	(%)
	1	2	range	$\bar{x}$
Condylobasal length ..	557	575		
Rostrum ..	357	364	63.3-64.1	63.7
Rostrum basal width ..	108	115	19.4-20.0	19.7
Breadth across Pre-orbital ..	192	195	33.9	33.9
Zygomatic width ..	210	220	37.7-38.2	37.9
Width of Brain case (across parietals) ..	185	180	31.3-38.2	32.2
Greatest length of pterygoid ..	74	70	12.1-13.2	12.6
Greatest post-orbital width ..	195	195	33.9-35.0	34.4
Maximum width of pre-maxilla ..	80	84	14.3-14.6	14.4
Length of post-temporal fossa ..	110	110	14.7-15.3	15.5
Length of teeth row (upper right) ..	312	317	55.1-56.0	55.5
Number of alveolus (upper jaw) ..	38, 38	36, 37	36-38/37-38	37.0/37.5
Length of mandible ..	465	481	83.6-88.5	83.5
Length of lower teeth row ..	295	312	52.9-53.9	53.4
Number of alveolus (lower jaw) ..	34+35	36+36	34-36/35-36	35.0/35.5
Teeth length ..	20	20	3.3-3.6	3.4
	16th			

between 1.48 to 1.55 and it is more or less same in the species from Costa Rica, Eastern Pacific and Hawaii with values 1.53 to 1.57 (Perrin, 1975). Similarly the rostrum-Zygomatic ratio was also found to vary between 1.74 to 1.88 in the specimen from Calicut whereas the values ranged from 1.67 to 1.84 in the samples from Costa Rica, Eastern Pacific and Hawaiian waters. However, lower values were obtained in the Calicut specimens for the width of brain case (across parietal) to condylobasal length. In the Calicut samples it ranged between 2.91 to 2.92 whereas it was observed to vary between 3.0 to 3.3 in the Costa Rican, Eastern Pacific and Hawaiian samples. The number of teeth in the Indian form ranged between 98 to 110 in upper jaw, whereas, in the Costa Rican waters it was found to vary between 101 to 117 showing a high degree of closeness. (Perrin, 1975).

In the *Tursiops aduncus* occurring in India, the CBL rostrum ratio was 1.5 whereas in the South African bottle-nose dolphins the value was found to be 1.7 (Ross, 1977). The width of the brain case-CBL ratio was for 2.9 *T. aduncus* from the Indian Sea and 2.7 for the South African waters, showing a great degree of closeness. The same trend is reflected in the dentition as well. The Indian specimens have 54-56 teeth in upper jaw and 52-56 teeth in lower jaw, while the South African specimens have 48-53 teeth in the upper jaw and 46-56 in the lower jaw.

The ratio of condylobasal length to rostrum of *S. chinensis* was found to be 1.56 to 1.57 in the Indian form whereas the above ratio in the South African hump-backs varied between 1.56 to 1.63. The number of teeth in the dolphin from both places also did not show much variation. The Calicut hump-back dolphin has 76 or 77 teeth in upper jaw and 69 to 72 in lower jaw, whereas in South African dolphins the teeth ranged from 67 to 82 in the upper jaw and 62 to 76 in the lower jaw.

Though many species of the genus *Sousa* were described based mainly on the colour variation, a closer examination of their osteology may show that *S. plumbea* Cuvier, *S. lentiginosa* Gray, and *S. borneensis* Lydekker and *S. teuszi* Kukanthal are conspecific.

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LONG TERM BEHAVIOURAL STUDIES OF THE SOUTHERN RIGHT WHALE (*EUBALAENA AUSTRALIS*)

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ABSTRACT

Since 1970 we have studied southern right whales on their wintering grounds in protected waters near the coast of Peninsula Valdes, Argentina. We have repeatedly surveyed these wintering grounds from the air and from shore and have identified over 580 individual right whales from aerial photographs of natural markings on their heads. Many individuals return to the area each year, but most mature females come back only in years when they give birth, usually every third year. The mothers with young calves are usually strung along the coast about 1 km apart in a roughly consistent order, in water about 5 m deep. There is no evidence for a permanent pair bond or for paternal investment in caring for young. Observed mating behaviour includes groups of males which cooperate in order to copulate with females. Right whales are found at Peninsula Valdes in three separate areas that have three different functions—one area is predominantly occupied by mothers and calves, a second predominantly by males, and a third by all categories of whales including subadults and mating groups.

INTRODUCTION

RIGHT whales (genus *Eubalaena*) occupy two broad bands of ocean encircling the world between 20 and 60 degrees latitude in northern and southern hemispheres. The number of species in the genus *Eubalaena* is unclear, but most authors consider that there are two species, *Eubalaena glacialis* in the northern hemisphere and *Eubalaena australis* in the southern hemisphere. This paper concerns the southern right whale which we have studied during the winter and spring in the waters surrounding Peninsula Valdes, Argentina since 1970.

Most major recent advances in behaviour studies of free-ranging populations of large mammals seem to come from research in which two conditions were fulfilled : first, it was possible to recognize individuals, and second, it was possible to extend the study over several years.

We looked for a practical way to identify individual right whales in Argentina and soon discovered that an excellent natural marker existed in the pattern of callosities—patches of raised, thickened epidermis on their heads (Plate I). The callosities are exposed every time a whale surfaces to blow. Their number, position, and shape is unique to each whale and is unchanged from birth and almost certainly remains unchanged throughout the life of the whale (Payne *et al.*, 1983).

To make a long-term study at Peninsula Valdes feasible, we built a permanent field station in the southeast corner of Golfo San Jose overlooking an area frequented by right whales in winter and spring. We have occupied this station since 1972 and collected data from this area every year since 1970, mostly between the months of August and mid-November.

We gratefully acknowledge the help of many friends during all phases of research described herein. The following made especially large contributions : J. Bird, O. Brazier, H. Callejas, K. Chu, N. Cisson, C. Clark, J. Clark, L. Cowperthwaite,

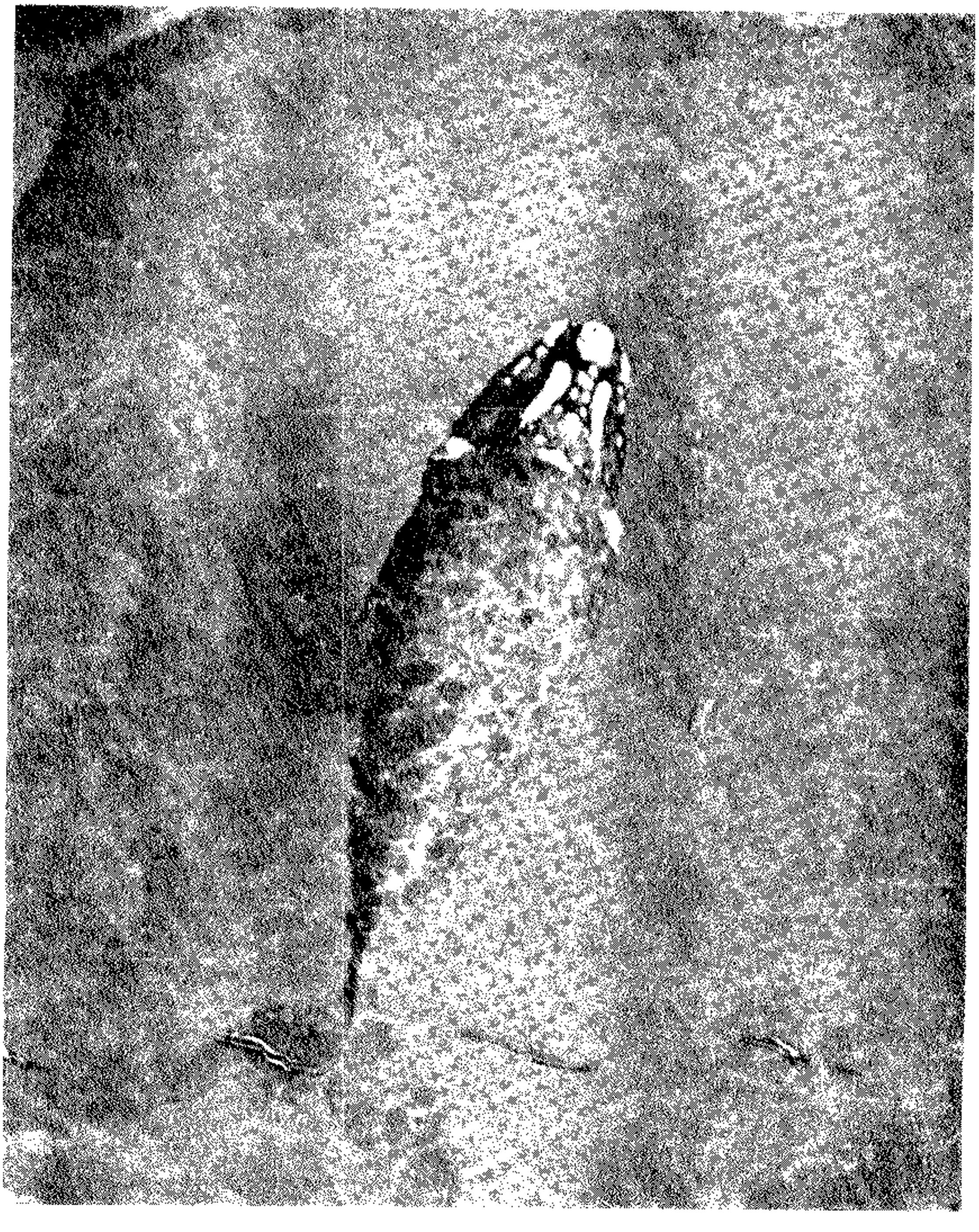

PLATE I. Aerial photograph of a southern right whale showing a typical callosity pattern.

R. Christensen, P. DeNormandia, E. Dorsey, C. Gould, J. Gould, N. Griffis, S. Guinee, L. Karnovsky, L. Struhsaker-Leland, K. Payne, J. Perkins, V. Rowhtree, V. Solo, P. Thomas, H. Whitehead, and B. and M. Wursig. This research was supported by grants and contracts from the Marine Mammal Commission (Contract No. MM6AC017), the National Geographic Society, the New York Zoological Society and the World Wildlife Fund.

Data Base

We made frequent air flights during which we took photographs of the heads of right whales to identify individuals. We also made observations from cliffs, from boats, and occasionally from underwater. The study is in its 14th year and we plan to continue it indefinitely. Most data reported here were taken during the first 12 field seasons. Our most complete data were collected in 1973. The data base is extensive and includes, for example, over 40,000 still photographs. We have identified over 580 individual animals, and we have been able to determine the sex of many of them from anatomical and/or behavioural evidence.

The coastline of Peninsula Valdes which we surveyed repeatedly is 495 km long (Fig. 1).

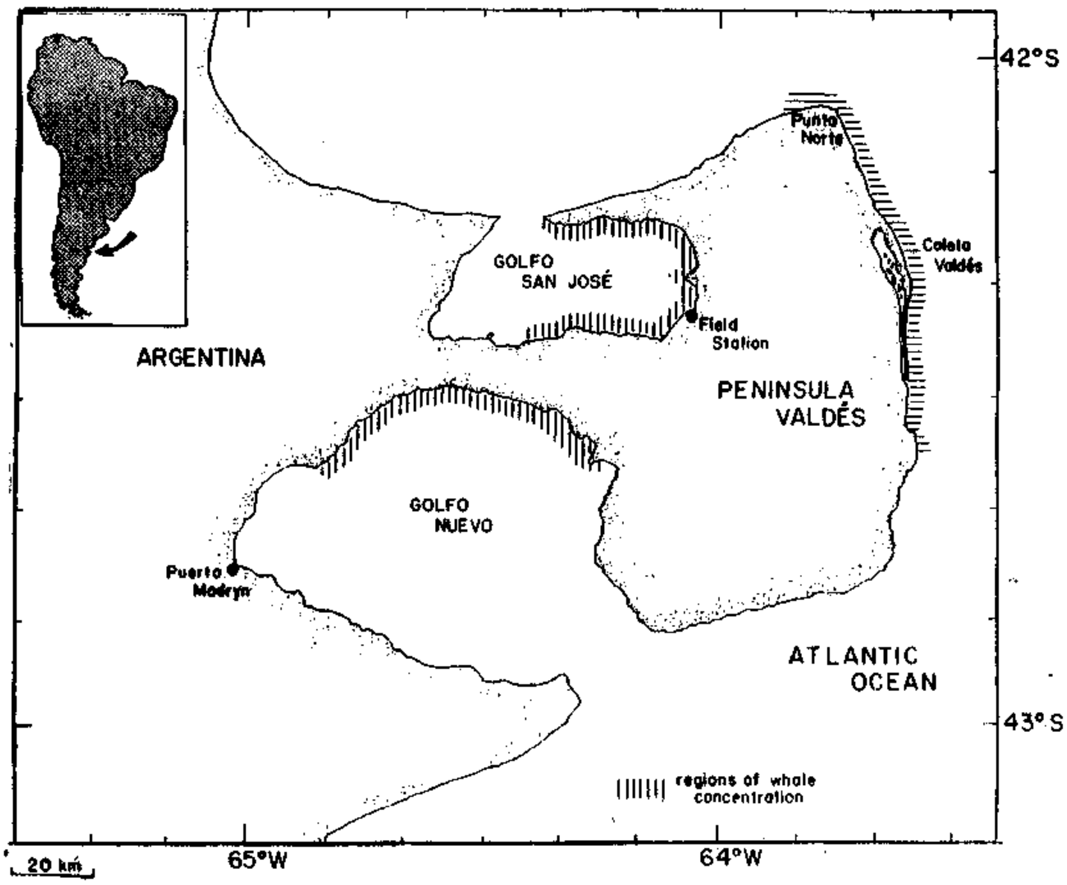

FIG. 1. Map of Peninsula Valdes, Argentina showing principle areas frequented by right whales and the field station established for this study (Taken from AAAS selected symposium series book Communication and Behaviour of Whales, R. Payne (ed.) Copyright 1983 by the American Association for the Advancement of Science).

We divided it into 5 sections: Golfo San Jose, the northern outer coast, the eastern outer coast, the southern outer coast, and Golfo Nuevo. Of these five sections, three were areas where whales were frequently encountered. We refer to them as assembly areas. Within these three assembly areas were stretches of coast along which right whales regularly congregated and which we designated as 'regions of concentrations', marked by hatching in Fig. 1. A few flights across the two large bays and many observations from shore led us to the conclusion that the great majority of the right whales wintering at Peninsula Valdes are concentrated near the coast.

can be used as a ruler with which to measure the whale. We also measured whales by noting the ratio of head length to body length, an age-dependent variable, and by using whales of known length as rulers with which to measure whales of unknown length lying parallel to them. In these ways, we could distinguish subadults from adults, and in a few cases, even calculate growth rates of free-swimming right whales. Details of these techniques are given in Whitehead and Payne, 1981.

When whales can be seen from shore, it is possible to track their movements with useful accuracy out to a distance of five or more kilometres by means of a surveyor's theodolite.

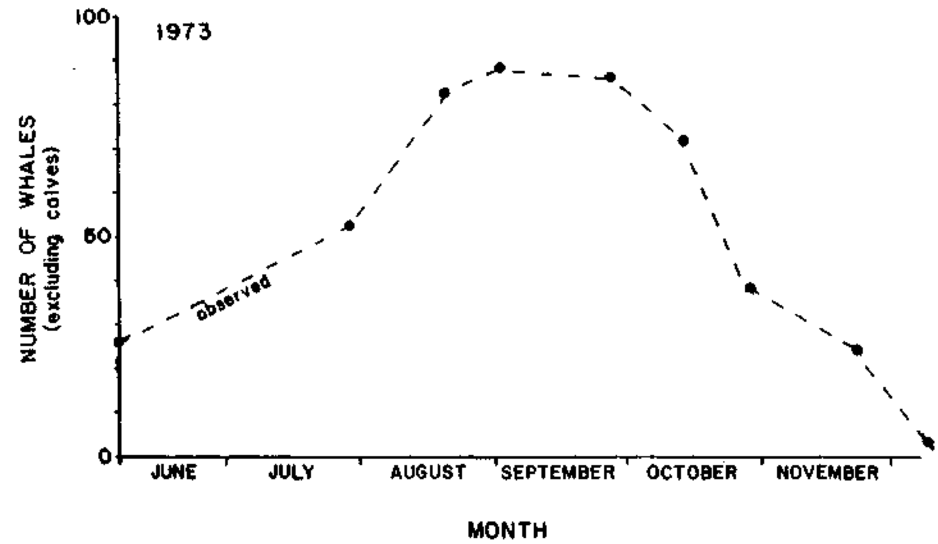

FIG. 2. Buildup and decline of right whales at Peninsula Valdes during 1973. Dots indicate the number of whales seen in each of nine flights along the coastline.

We had to develop several new techniques in order to study these whales. We sought to measure length of the whales because it provides a clue to age. To do this, we developed several techniques based on aerial photographs. For example, we took aerial photographs of whales next to a boat which was carrying a white disc one metre in diameter. In the resulting photographs of disc and whale, the longest apparent diameter of the disc

Bearings to the whale are taken in the vertical and horizontal plane. The vertical bearing is used to compute the distance to the whale. That distance applied along the horizontal bearing gives the map position of the whale.

The year 1973, in which we had the broadest coverage, can serve here to show how the population at Valdes builds and declines within the year. Figure 2 shows the number of whales seen in each of nine flights along the coastline. The dashed curve is the one that concerns us here. It shows that the population builds slowly, remains at a high value for about eight weeks, and then declines more rapidly than it built up, suggesting that at the end of the long winter of semi-starvation whales depart relatively rapidly for their summer feeding grounds.

Structure of the Herds at Peninsula Valdes

The term 'herd' has many usages. It is used here to describe a very local grouping: all whales seen in and near a single region of concentration at Peninsula Valdes. The whales in a given region move together as a loosely knit group while staying roughly clustered about a focal group. Local land forms, like headlands and bays delineate the different herds. In all three assembly areas, the herd was usually found in the same general area, although in Golfo Nuevo it was a much smaller herd and usually more spread out. Our usual experience was to fly for many kilometres without seeing whales and then to come upon a lone individual or pair. This signalled a buildup in the next 10-30 km to a central group of whales, usually more than 10. Having passed the densest concentration, the numbers fell off in much the same way that they had increased.

We have made 6 complete surveys along the entire coast of Golfo San Jose and 19 surveys along the entire eastern outer coast. In 23 of these 25 complete surveys, the herd was clustered together regardless of where we found it.

The overall mean herd width for all of Peninsula Valdes was about 37 km. The mean herd width for females with claves was 22 km. Females with calves were often located near the center of the herd, suggesting that they are its focus. However, it appears to be all females, not just lactating females, which are the focus of the herd.

In both Golfo San Jose and the eastern outer coast, there is a significant positive correlation between numbers of whales and density (Fig. 3). It is apparent that the whales are not spreading out as their numbers increase, which they might do if they were maintaining territories, but rather, they incorporate additions to their group by crowding more tightly into a relatively small area. (We have failed to find any lines of evidence for territoriality in this species.) It is obvious that, at this season at least, whales are attracted to each other very strongly.

In order to study the distribution of the herds in space, we counted the number of whales seen in every consecutive 5 km segment of coastline. We plotted the mean herd shape for Golfo San Jose by taking the distribution plots for each flight and sliding them so as to line up the 5 km strip with the greatest number of whales. We then calculated the mean number of whales seen in each of the 5 km segments flanking the densest segment. The result (Fig. 4a) is a sharp, symmetrical curve representing the mean shape of the herd in Golfo San Jose.

The herd does not stay fixed in space but moves back and forth along the coast. Figure 4b is a plot of where along the perimeter of Golfo San Jose the peak concentration of the herd fell during our flights. One sees that, while moving back and forth along a 40 km stretch of coast, the herd is keeping mostly to one end of its range.

We compared the shape of the herd at Golfo San Jose with its shape along the eastern outer coast by dividing the number of whales in each 5 km segment by the number of flights which entered that segment. The result is shown in Fig. 5. It is apparent that the Golfo San Jose herd (Fig. 5a) tends to be more

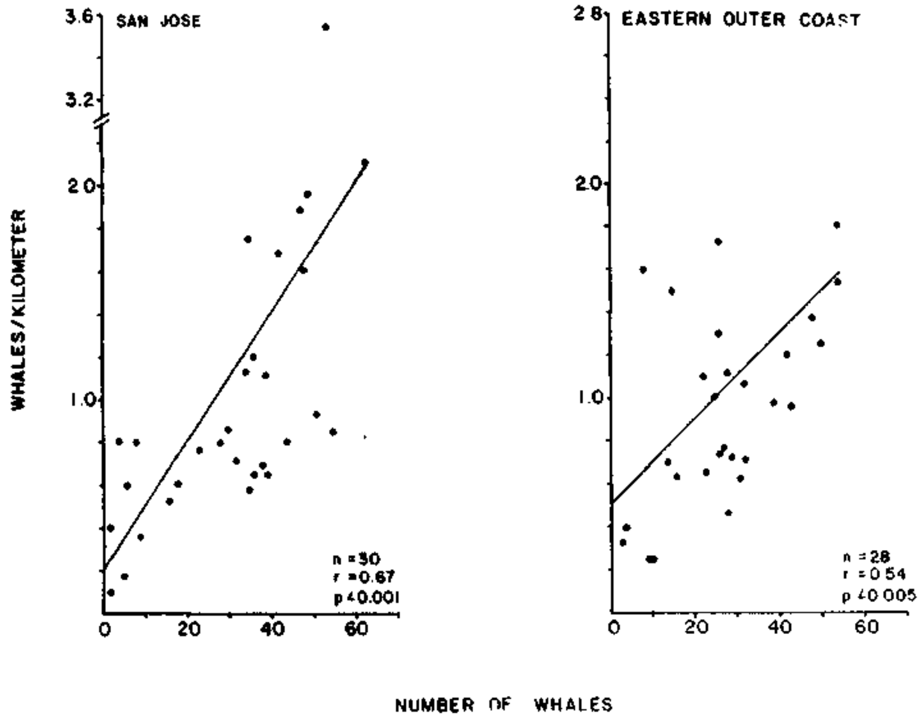

FIG. 3. The correlation between the number of whales observed and their density, in Golfo San Jose and along the eastern outer Coast. n = the number of herd distribution flights. In both areas there is a significant positive correlation.

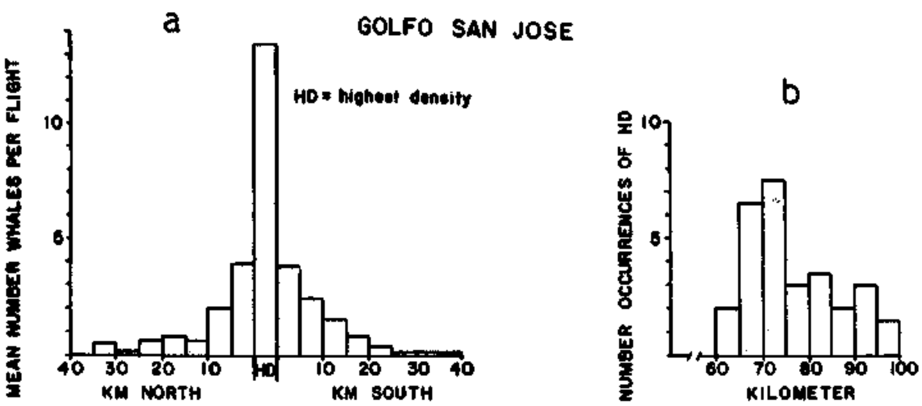

FIG. 4. Spatial distribution of the Golfo San Jose herd : a. The mean distribution of whales observed around the densest five segment of coast and b. The variation in location of the densest segment of the herd. Both a and b are derived from herd distribution flights.

sharply concentrated and that the eastern outer coast herd, (Fig. 5b) is more spread out. In spite of the denser center of the herd at San Jose, whales are spread over a wider area in that assembly area than they are along the eastern outer coast.

simply a consequence of the distribution of average water depths in our study area we calculated the distribution of mean depths (Fig. 7). By comparing Figures 6 and 7, it is apparent that we are justified in concluding whales are selecting specific depths.

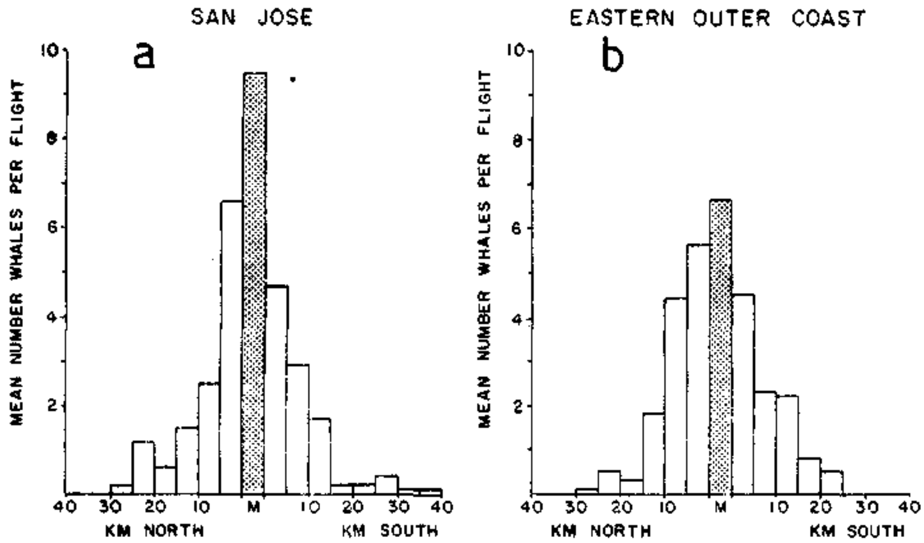

FIG. 5. The distribution of the herd around its mean position, Golfo San Jose is the eastern outer coast. Data are from herd distribution flights.

DEPTH PREFERENCE

To look at depth preferences, we used the surveyor's theodolite from three prominent cliff lookouts to locate the positions of all whales within the study area. We made censuses on 18 calm days in 1973 and 1974 and calculated 857 whale positions. The positions were all mapped on a detailed chart of the bay, and their depths were corrected for the tide height at the time the whale was observed. In Figure 6 the number of whales is plotted for each half metre interval of depth. The striking preference for shallow water, and particularly for a depth of 5 metres, is apparent. It suggests that there may be important selective pressures on right whales for remaining in 5 metres of water.

In order to be sure that the result was not

The strong preference of right whales for a depth of 5 m caused us to start referring to the 5 m depth contour as the 'whale road'. We feel that different age/sex categories may gain different advantages from shallow water, but that the whole species could benefit from its strong preference for the whale road as a means of meeting each other. Unlike rorquals, whose low, loud voices can travel in deep ocean for hundreds of kilometres under some circumstances before being lost in background noise (Payne and Webb, 1971), the right whale vocalizations are at significantly higher frequencies and are made in shallow water. Thus they do not appear to be well suited to long range communication. As a result, it seems likely that right whales need to have a meeting place, and the whale road both within and

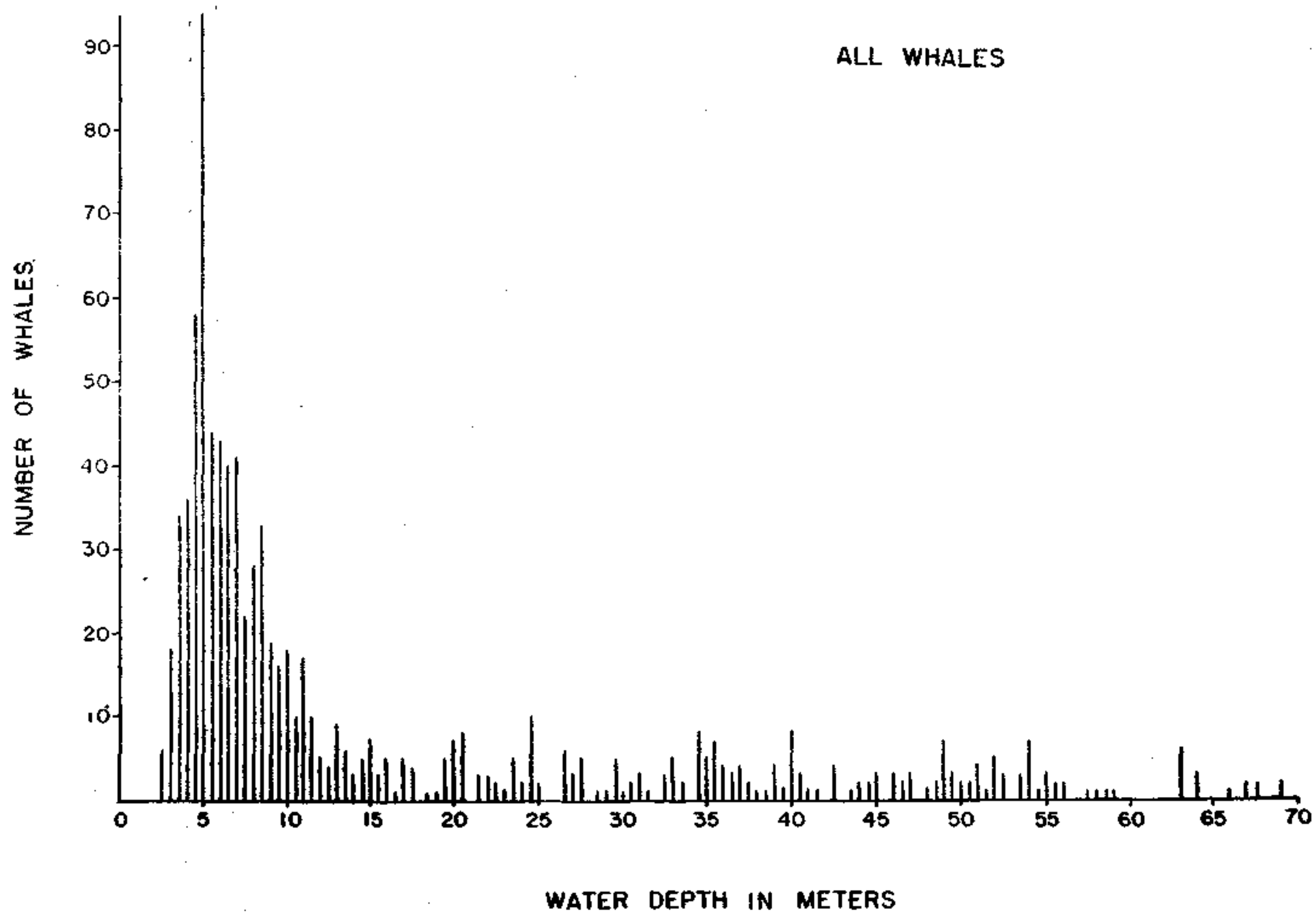

FIG. 6. Depth preference of all whales near the Cliff observation site in Golfo San Jose.

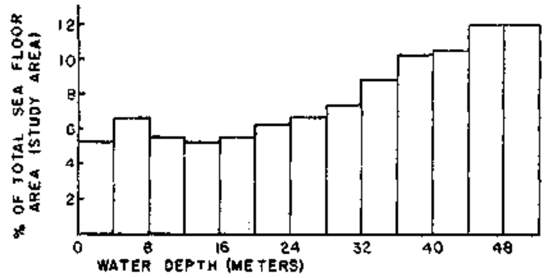

FIG. 7. Distribution of water depths during an average tidal cycle within the study area of Golfo San Jose cliff observation site. This is the same area for which the depth preferences of whales are given in Fig. 6 and 8.

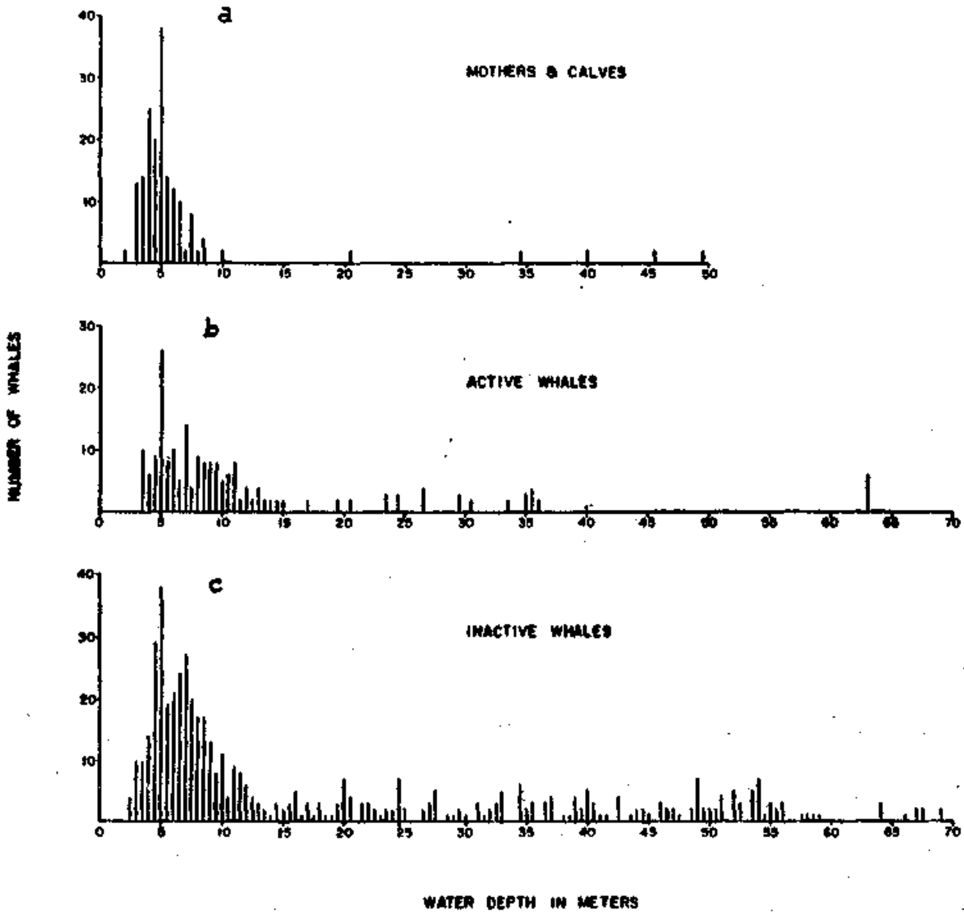

FIG. 8. Depth preferences of whales in Golfo San Jose ; a. Mothers and calves. These whales show the most marked preference for shallow water ; b. Active whales ; defined as whales obviously moving or creating white water. These whales are mostly in mating groups and c. Inactive whales. The great majority of deep water sightings were of inactive whales.

between assembly areas may provide a region for rendezvous.

During most cliff surveys there was a second observer watching through a telescope to determine for each whale or group of whales the type of behaviour. This behaviour was put into one of five categories: active groups (obviously moving or white water present), breaching, lobtailing, flippering, and inactive animals (not moving). Our division into age/sex categories was limited to two groups, females with calves and all other whales. The results are given in Figure 8, which again presents the number of whales by depth. They show that females with calves (Fig. 8a) are almost never seen in water over 10 m deep. Most activity, takes place within water less than 15 m deep (Fig. 8b). Most activity that we observed was group activity and the great majority of groups whose behaviour could be determined were obviously involved in mating behaviour, which will be discussed later. Figure 8c shows that most whales which were found in water deeper than 15 m were inactive. Because of the local restrictions on flying over water, we know very little about these deep water individuals.

Different Uses of the Regions of Concentration

One of the most unexpected results that we found at Peninsula Valdes was that the three different regions of concentration (Golfo Nuevo, Golfo San Jose, and the eastern outer Coast) have different functions. We have been studying the usage of the three different areas ever since 1971 when we first noticed that the three regions had different ratios of females with calves to mating groups. The three regions of concentration are occupied for different lengths of time by different proportions of the various age/sex categories.

To explore these differences, we looked at all identified 'residents' in each area, that is, whales seen two or more times in that area in one year. We calculated the proportion of the known age/sex categories in all identified residents for each area. Figure 9 presents the results. The age/sex categories that we used were: known males, females with calves, females without calves, and subadults. Because males are considerably harder to sex than females, we do not know the absolute sex ratios at Peninsula Valdes and these figures can only be used for comparisons between areas.

The area in which the proportion of females with calves is the greatest among identified residents is the eastern outer coast, suggesting that this is principally a calf rearing area. We have seen eight unaccompanied females along that coast who were accompanied by calves later in the same year, so we suspect it is also a calving region.

The area in which the porportion of males to other known categories is largest is Golfo Nuevo, suggesting that it is principally a bachelor male area. In the last four years, however, a herd of females with calves has moved into Golfo Nuevo and taken up residence. We seem to be witnessing the founding of a calving/nursery area within a bachelor male area.

Golfo San Jose appears to contain good samples of all categories, including the largest ratio, as well as the largest number, of subadults. It thus appears to be an important area in which subadults can undergo their development. It is also a major mating area, as indicated by the high ratios of males and of females without calves and by the high incidence of mating activity observed there during census flights. We have classified it as a 'general' area.

The above results are confirmed by our data on the mean periods of residency for differing age/sex categories in the different

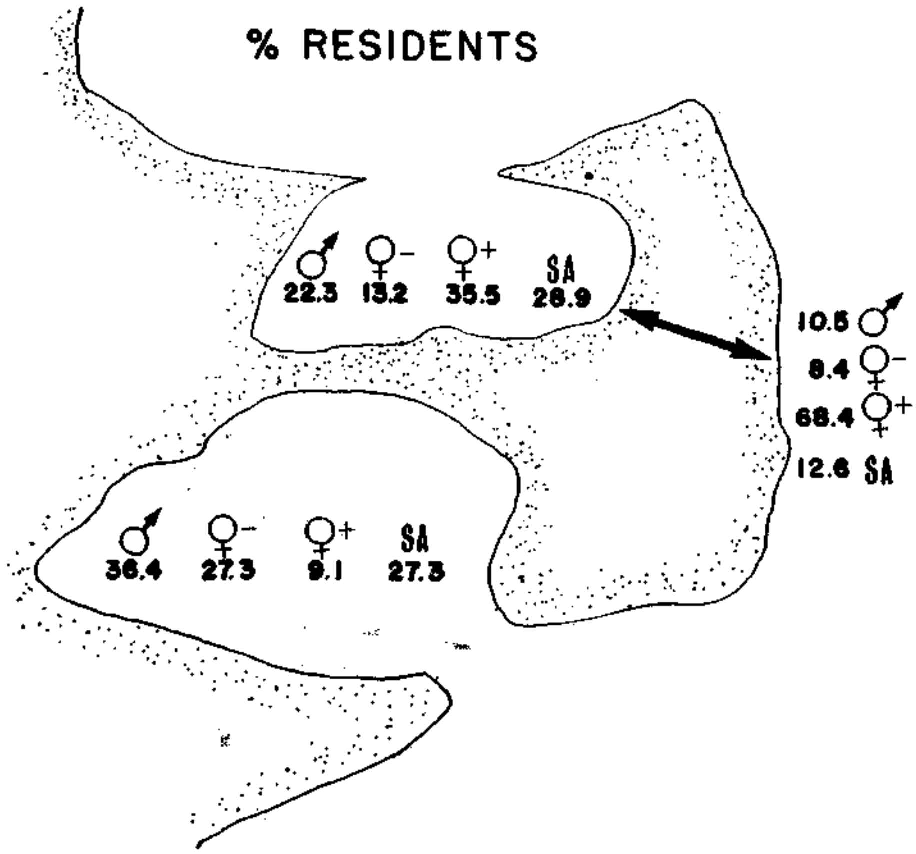

FIG. 9. Proportions of known age/sex categories of all identified residents for each area. ♂ = known males, ♀- = known females without calves; ♀+ = females with calves, SA = subadults.

regions of concentration, shown in Table 1. It is the females with calves that have the longest residency times both in Golo San Jose and along the eastern outer coast. Yet these very same individuals in their non-calf years have the shortest residency times of all known age/sex categories in these two areas. The residence times of subadults seem to be more nearly related to the residences of females with calves than to any other age/sex category. We have noted a correspondence between these two age/sex classes in many other areas. Table 2 shows that at the age of 3 or 4 years, subadult males appear to move out of the bays in which they spent their first winters and into Golfo Nuevo, presumably to join the other adult males there. The same does not seem to be true of subadult females, which continue to reside in their calf area.

One might expect that females would bear calves in the same area where they were born and spent their subadult year. In recent years, however, females that have grown up in Golfo San Jose have gone to the eastern outer coast to raise their calves. This suggests that the eastern outer coast is the most favoured calving area.

We also investigated the question of which area individual adult females prefer in their calving and non-calving years. We found that the eastern outer coast is the preferred

TABLE 1. *Residence times by age/sex category in the three assembly areas at Peninsula Valdes. The flight dates are the same in Golfo San Jose and along the eastern Outer Coast, but different in Golfo Nuevo. Therefore direct comparisons are possible only between Golfo San Jose and the eastern Outer Coast.*

Assembly area		Males*	Females in non-calf years	Females in calf years	Subadults	All known age/sex categories	
Golfo San Jose	$\bar{x}$	29.5	28.1	38.1	35.8	34.0	Balanced Flights
	sd	16.17	15.68	20.39	23.38	20.28	
	n	27	16	43	35	121	
Eastern Outer Coast	$\bar{x}$	36.8	42.3	48.3	30.3	44.33	
	sd	37.59	18.95	24.90	22.26	26.16	
	n	10	8	65	12	95	
Golfo Nuevo	$\bar{x}$	37.0	24.0	27.0	70.0	41.6	Principle Flights
	sd	34.80	9.85	—	5.20	27.63	
	n	4	3	1	3	11	

TABLE 2. *Locations of all 11 right whales of absolute known age (first seen in their year of birth) and known sex that were seen at Peninsula Valdes. SJ = Golfo San Jose; EOC = Eastern Outer Coast; GN = Golfo Nuevo. nd = no data collected at Peninsula Valdes in that year. Calves of both sexes tend to be in Golfo San Jose the first three years. In the next years female sub-adults tend to remain there, while male sub-adults move to Golfo Nuevo.*

Females I.D.	Age in Years 0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8
13-71	EOC	EOC				EOC		EOC
83-71	SJ	SJ			SJ	SJ		
340-74	SJ		SJ			nd	nd	nd
290-75	SJ	SJ		EOC	nd	nd	nd	nd
403-75	SJ	SJ		EOC	nd	nd	nd	nd
88-76	SJ				nd	nd	nd	nd
Males I.D.								
99-71	EOC	EOC		EOC				
153-72	EOC		EOC		GN			nd
154-72	SJ	SJ	SJ	SJ	GN		GN	nd
105-74	SJ	EOC	SJ + GN			nd	nd	nd
99-76	SJ		SJ	nd	nd	nd	nd	nd

location in calving years and that Golfo San Jose is the preferred area in non-calf years. It appears that individual females are switching from one area to another depending on whether they have a calf that year. This again supports our finding that different areas at Peninsula Valdes have different functions.

CALVING INTERVAL

By keeping track of the years in which we saw recognizable females with and without calves, we were able to determine the calving interval. The data for all females who had more than one calf are shown in Fig. 10.

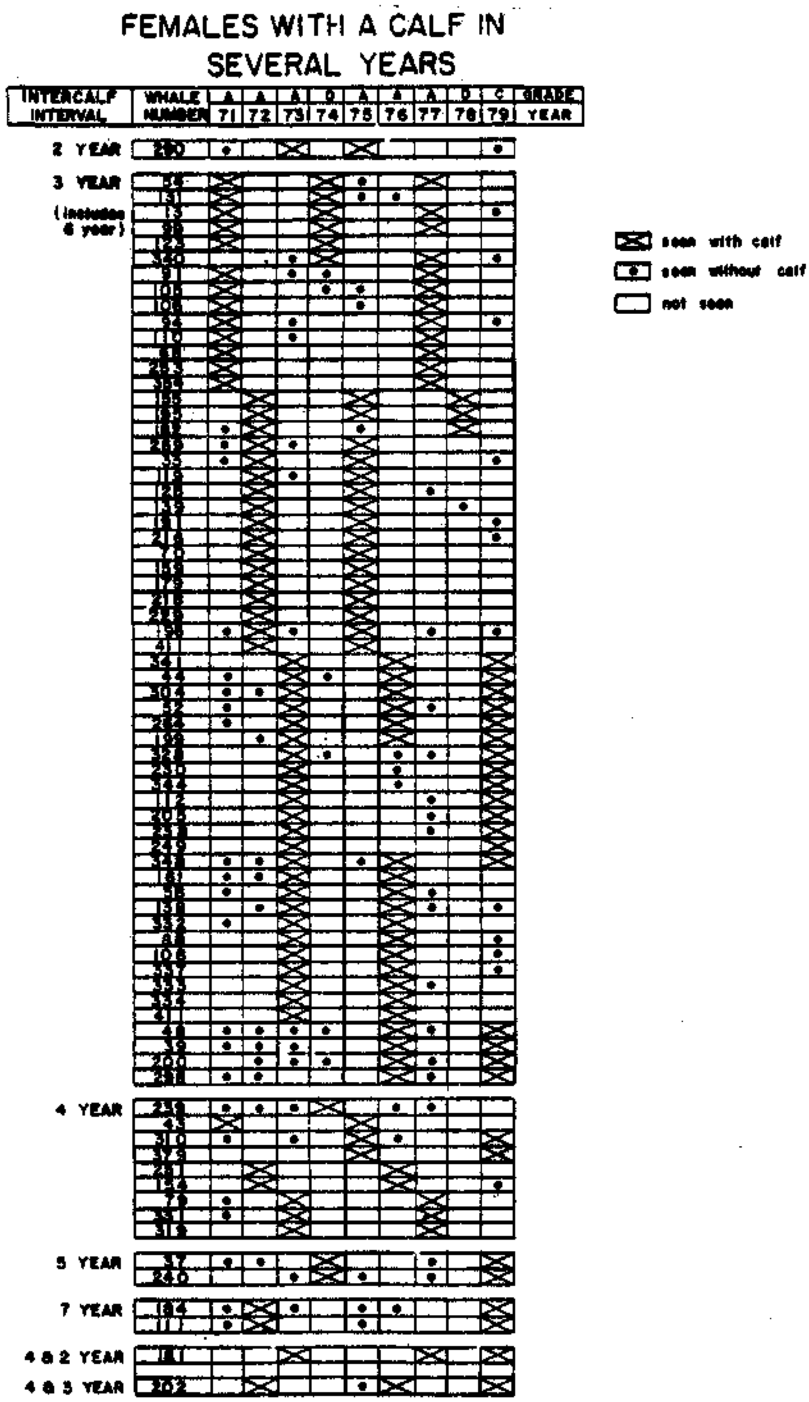

FIG. 10. Sightings of female right whales with a calf in two or more years at Peninsula Valdes, 1971 through 1979. The whales are ordered according to length of intercalf interval and to the year in which we first observed them with a calf. The years are graded A-D according to the member of representative flights made. Note the strong preponderances of three-year calving intervals and the division of the population into three major calf-year classes.

Each line is an individual female ; each column is a year. Years marked with an X are years in which the female was seen with a calf; years with a dot are years in which the female was seen without a calf; and years with neither a dot nor an X—the blank spaces—are years when that whale was not seen. At the top of this chart, each year is given a grade from A to D to indicate the relative amount of data collected in that year. A failure to see a given individual in the years with low grades (1974, 1977 and 1979) means less than a failure to see her in years with an A grade.

We found calving intervals from 2 to 7 years. We have grouped the six year intervals with the three year intervals in this chart. It is clear that the interval that is much the most common is the three year interval.

A striking pattern in these data is the very low rate at which females appear at Peninsula Valdes in the years in between their calves (note all the blank years in between the years with X's). This has interesting consequences for the composition of the herds at Valdes. There appear to be three different adult female herds using the calving areas, so that it takes three years for a complete cycle of occupancy.

But there is an even more surprising aspect to the schedule of reappearances of females. Although the commonest group behaviour we see in these waters is mating (including numerous direct observations of intromission), these matings seem not to be the ones which result in pregnancy, since the females do not return to Valdes waters in the year they conceive (the year prior to parturition) by all evidence. Figure 10 shows that in only 3 out of 91 cases was a female seen at Valdes in the year prior to giving birth to a second or third calf. This means that the vast majority of pregenancies must be occurring in some place besides Peninsula Valdes—even though mating is so very common at Valdes.

This is an enigma that awaits explanation.

Mating Behaviour

As mentioned earlier, the principal group activity visible in the bay is courtship and mating. Normally one sees several males attempting to mate with a female at the same time. Under such circumstances, males are competing with each other in groups of from 2 to 7 individuals. The behaviour of most males in mating groups are similar. They surround the female on both sides and beneath her while she lies belly up at the surface holding her breath. The males move quickly when the female rolls over to breathe, presenting a chance for alignment with her, and they sometimes shove each other aside, but that is the general limit of apparent aggression between them. Often males continue for hours to pursue the same females, and perhaps even for days. From our observations from the air, where we can see better what is going on, we have seen a male mate with a female and each of them mate with a second partner in the course of an afternoon.

The behaviour of groups of males towards females in mating groups leaves the impression of gang rape, an impression which is strengthened by the rare but apparently deliberate attacks on a female by a particular male in a mating group. We have seen three such attacks in which the attacking animal gouged the female by raking its callosities along her back (callosities are used for fighting in right whales, Payne and Dorsey, 1983). Since so much of the mating by right whales appears to be forced, the advantage to individual males of joining a group seems obvious enough. When alone, an uncooperative female can keep her back to a lone male indefinitely. In a group, a male will become one of three males (stationed below and to either side of a belly up female), and although his chances are one in three of mating with her, there is a new chance to do so every time she rolls over to breathe.

Males seem to cooperate with each other at times when courting females. It is otherwise hard to explain why males so frequently try to push females underwater. We have never seen this strategy result in a successful mating for the male who did it, but it sometimes puts the female within reach of another member of the group. Figure 11 shows a sketch from a photograph of a female and two males (one with an erect penis). The male with a white blaze on his back has overriden the female's head thus pushing her slightly underwater. The other male is trying to mate with her even though her belly is still in the air. Such efforts can be successful if the female is slightly submerged owing to the fact that the male right whale is able to move his penis independently of his lower body in a series of sweeping, searching motions. If his penis touches the female's genital slit, penetration is immediate in spite of the awkward body postures of both individuals.

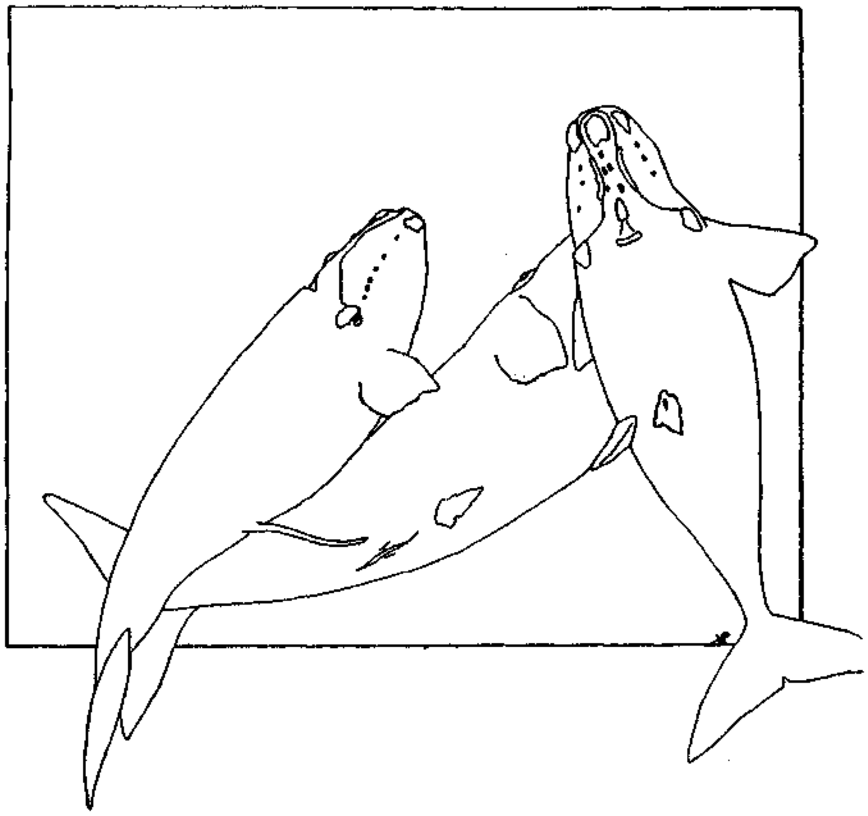

FIG. 11. Sketch from a photograph of apparent cooperation between males is a mating trial. The penis of one male is directed toward the genital site of the female who is trying to avoid him by belly up (a small ventral blaze is visible). The second male (who has a white dorsal blaze) is apparently aiding the mating attempt by pushing the female lower in the water. Notice that he is submerging the females in such a way as to leave open access to her genital slit for the second male.

It is interesting in this regard to find the same combinations of individuals 'collaborating' in mating groups on more than one occasion. For instance, a group of at least 3 males with at least 2 females was together in two locations 37 days and 295 km apart.

The fact that males stay together and that members of male groups appear to cooperate in pushing a female under water suggests that they are practicing reciprocal altruism.

In proposing his model for reciprocal altruism, Trivers (1971) pointed out that when several conditions apply, the chances for a benefit from altruistic behaviuor are improved. Among these conditions are: (1) when the lifetimes of individuals are long, maximizing the chance that individuals will encounter many altruistic situations, (2) when the chances are high that individuals will interact repeatedly with the same set of neighbours, (3) when the benefit of mutual dependence is greatest during times when a small number of individuals are together, and (4) when there are not strong dominance hierarchies. All of these conditions seem to be fulfilled in right whales.

There is a chance that what we are witnessing in bands of males is not just reciprocal altruism, but also kin selection—i.e., the whales in mating gangs may be closely related. Now, the total promiscuity of right whales makes it seem extremely unlikely that either males or females could know who sired a given calf. This means that males cannot join their father's mating groups because the son cannot identify the father or vice versa. There exist male relatives who should be able to recognize each other, however: brothers. We have good evidence that subadults follow their mothers around whenever they are present in the area. Thus brothers could very well get to know each other and later become members of the same mating groups.

We have strong evidence that bonds sometimes form between subadults and calves. We have seen on at least ten occasions subadults who spent hours in the vicinity of a female with a calf, sometimes initiating play with the calf, circling slowly ahead of or behind it, even embracing it in a posture similar to the mating posture. The reaction of the calf was one of obvious excitement and attraction to the subadult. The most interesting aspect of this behaviour is the unusual reaction of the calf's mother to the subadult. Mothers almost invariably interrupt play between their own calf and another calf, yet they tolerate play between their calves and some subadults. The fact that females are feeding their calves during a long period when the females are themselves starving seems reason enough for them to keep their calf's metabolism as low as possible by interrupting play. The fact that they allow their calf to play with some subadults suggests the importance of those subadults in the calf's life.

Further work will be needed to test the hypothesis that reciprocal altruism is of importance in the mating systems of right whales, but the background information which we now have on the relationships between the individuals in this long term study should make it possible to do so—another example of the value of long term studies even when applied to one of the most difficult of large mammal subjects.

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ENDANGERED CETACEANS IN ENDANGERED ECOSYSTEMS : THE EXAMPLE OF THE NORTHWESTERN MEDITERRANEAN

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ABSTRACT

The N. W. Mediterranean is undergoing telluric and anthropic metallic contamination, added to the general pollution of petroleum compounds, organochlorines, and so on. 7 metals (Fe, Ti, Cr, Cd, V, Pb, Hg) are assayed in different levels of three trophic networks : planktophagous, teuthophagous, ichtyophagous. 700 data from marine invertebrates or vertebrates are given here, and indicate that all demersal or intertidal or oceanic tested species present various amounts of these metals. In some organs of cetaceans processes of bioaccumulation are shown : liver, cartilage, bone ; in another ones, on the contrary, excretory processes are in evidence, like in the skin or the lung. A third process, intermediate between the two other, is a mineral way of storing the contaminants in mesenteric calculi.

INTRODUCTION

THE Ligurian Sea, The North Tyrrhenian Sea, and the Gulf of Lion, between 40°N and the European coasts, are affected by European industries and their discharges into the rivers or the open sea: petroleum compounds, pesticides, and various heavy metals. We decided to search for some of the latter, mainly brought by the largest rivers of this area. Studies realized by governmental Agencies indicate two kinds of metallic pollutants, (1) soluble compounds, and (2) hydroxydes and nonsoluble mineral salts mixed up in the suspended matters: iron hydroxyde, TiO_2, Al_2O_3 ; these muds bear an important quantity of metals adsorbed onto the particles. Rainwaters drive to the sea some inorganic substances arising from the mines such as those of cinnabra from Italy, Spain, of manganese from Pianosa island, of iron from Elba, and silver bearing lead or asbestos from Corsica. Discharges from the industries are estimated, for example in the Rhone, as, by day: iron, 46 tons, with a maximum of 220 tons——; lead, 1 ton——; copper, 1 ton——; cadmium, 1.6 tons——; zinc, 3 tons——; mercury, 0.1 ton (Table 1). It is necessary to summarise the contributions of the 9 greatest rivers which enter the Northwestern Mediterranean. The Tiber brings waters containing 0.05 to 0.1 ppm of mercury, 10^{-3} of chrome, 10^{-4} of arsenic, 0.01 of cobalt, 0.1 of zinc, 0.05 of lead *etc.* (Battiston and Moauro, 1973). The riverine inputs for the whole Western Mediterranean are estimated by UNEP (1978) at an average of: Pb, 2600 Tons/year; Zn : 14000 tons/year; Cr : 1900 ; Hg : 90.

Effluents from the industrial plants of Barcelona, Marseilles, Genova, and from the leather industry of Tuscania, are to be added and can be estimated as average daily total input of 500 tons of iron (UNEP 1984).

Furthermore, the input of metals through atmospheric way was unknown up to iron, but only suspected. Arnold *et al.*, (1982) gave a convincing demonstration of metal bearing by winds. The Ligurian Gulf and the Algero-provencal Basin are submitted to climatic changes resulting in a cyclonic circulation of air masses. From the South, winds bring minerals with the particles ripped away from Saharian or Maghrebian rocks; from the East, they bring metals, particularly mercury, Cd and Se from volcanic emissions of Vesuvio and Stromboli; from the North they bear the industrial smokes coming from the Rhur and the Rhinelands. These smokes contain marked tetraethylic lead characteristic of human activities, which allowed Chesselet and coll. to identify the air masses sampled in the central area of the Mediterranean (Arnold *et al.*, 1982; Buat-Menard 1983). Recent data published in ICSEM/IOC/UNEP workshops on marine pollution of Mediterranean in 1980, '82 and '84, show that the atmospheric charge is quickly integrated into the geochemical cycles, thence to the bottom and the sediments. Since 1972, I have been investigating whether the main metals brought in the ecosystem pass into the animals and how, and the pathways for elimination or storage (bioaccumulation). As says Gaskin (1982), pollution is a mundial phenomenon, but the Mediterranean and the Baltic Sea have the first place, according to the metal contents of animals.

This work needed an important financial effort that was not supported neither by the Universities, not C.N.R.S., but by the Laboratoire de Surveillance des Nuisances, CEA Pierrelatte (30%), CNEXO (15%), Municipality of Bastia (10%), and private resources. I wish to express my gratitude to all those responsible from the above-mentioned laboratories and to the private sponsors. I thank my friends from the Universities of Paris VI, Lille and Genova for their technical help.

Material and Methods

We sampled at random among various species of the trophic network interesting to man and/or cetaceans. The latter are considered here as mammals at the end of the food chain, and at the same trophic place as humans. Seven metals were analyzed: iron, titanium, chromium, cadmium, vanadium, lead and mercury. These metals, and aluminium not analyzed here, are the most representative of the metallic input in this ecosystem. Due to the financial limitations, we were not able to obtain statistical series and analyses were made only once in every animal or organ assayed.

Samples came from both neritic and oceanic areas, and even from intertidal zone. Benthic or pelagic organisms were caught or fished (some were bought in the markets); a swarm of euphausids, *Meganyctiphanes norvegica*, was stranded on the Southeastern coast of Corsica and sampled there. On the other hand, cetaceans were not sampled at random but only the carcases of dead stranded whales and dolphins permitted the sampling of organs.

Every sample involves histological work in order to understand anatomical and functional structures, and to localize calculi or granules which seem to be unusual. These granules, when localized were tested with RX-spectrography on a Castaing's microprobe. Furthermore, some samples were congealed, then analyzed always by the same Laboratory agreed by the French Ministry of Environment, the Laboratorie de Surveillance des Nuisance of the Commissariat á l'Energie Atomique, Pierrelatte, in charge of Dr. Chalabreysse.

The analytical techniques utilized are: for mercury, atomic absorption without flame; for iron, atomic absorption with acetylen oxydation: titanium, chromium, vanadium, cadmium, calcination, atomic absorption without flame; lead, atomic absorption after mineralization by acid way.

Among 180 histological preparations of organs made, 40 were assayed with microprobe. 100 analyses were made on zooplankton or nekton samples, regularly caught on a transect Nice-Calvi, or around Corsica, with the O. S. 'Korotneff'. 600 analyses were made on fishes or marine invertebrates, coming from :

— trawling during the mission of the Laboratorio Central di Idrobioligia of Roma (Dr. Matta), June 1973 ;

— trawling during the May 1973 mission of Pr. Sara, University of Genova, from which samples were taken by R. Auteri in order to study the repercussion of the discharges of 'red muds' from the Montedison factory (TiO_2) : samples from the discharge zone and adjacent areas ;

— samples from the markets of Bastia and Ajaccio, or from fishing off the Cape Corse.

TABLE 1. *Average contents of various ions in the water of Rhone, and total amounts dumped by day (according to an average flow of 1000 m³ per day)*

ions	Average content in 4 years (1971-74), mg 1—1	Average content in 1974	Amount dumped per day (tons), averaged	Maximal amount in a day in 1974 (tons)
Fe ..	0,46	0,65	46	220
Pb ..	0,01	0,01	1	5,15
Cr ..	0,01	0,01	1	5,15
Cd ..	?	?	1,6	2,3
Cu ..	0,01	0,01	1	2,06
Zn ..	0,03	0,03	3	6,18
As ..	?	?	?	1
Mn ..	0,07	0,05	7	16,5
Na ..	13,9	11,9	1390	1600
K ..	4,8	2,0	480	400
Ca ..	76,8	79,6	7680	8800
Mg ..	6,2	6,2	620	860
Cl— ..	25	244	2500	30206
SO_4— ..	61	64	6100	10000
NO_3— ..	40	34	400	660
NO_2— ..	0,12	0,09	12	20

The results of 1350 analyses of cetacean organs are available, but are not recorded here because of the lack of space.

These samples were made between 1973 and 1976. All results were summarized in a thesis (Viale, 1977, multigr.). They were accepted for publication in a book edited by F. Ramade, which failed due to the lack of financial support.

It appeared to me necessary to make some new measures of the content of contaminants in a new series of sampled animals of the same species. But without having any subsidy, as well from a local or a national or international level, this project had to be dropped. Therefore, the first series of results is published here ; they are summarized in Tables 2 to 6 and their reading needs abundant comments.

RESULTS AND COMMENTS

We shall consider separately three trophic networks, respectively those of planktophagous, of teuthophagous and of ichtyo-teuthophagous cetaceans.

A. *Metal bioaccumulation in planktophagous trophic networks :*

Table 2 shows metallic contents of zooplankton and euphausiid samples, following International Agency for Atomic Energy, Monaco (pers. comm.). The differences between the amount of metals in *Meganyctiphanes* with and without their stomachs show the digestive input of contaminants. Please note that the results are here in ppb of dry weight, while all other Tables give the results in ppm of wet weight. It can be inferred from these data that the mean daily input of *Balaenoptera physalus*, when consuming one ton of *Meganyctiphanes* by day, is : Fe, 30 g ; Zn, 16 g ; Cu, 13 g ; Cr. (III + VI), 1.2 g ; Cd, 0.2 ; Pb, 0.1. We examined a stomach content of a 18 m long *B. phsyalus*, essentially constitued

TABLE 2. *Metal contents in zooplankton and in* Meganyctiphanes norvegica *from the Ligurian Sea (µg/g of dry weight)*

(ZPK : zooplankton from a 130 µ plankton net ; Mn : *Meganyctiphanes*, entire ; Mn' : *idem*, without stomach. From A.I.E.A., pers. comm.)

Station		Material	Fe	Zn	Pb	Cr	Cd	Mn	Cu
Monaco	1	ZPK	892	246	110,00	12,5	1,69	2,03	16,2
	2	ZPK	567	443	38,60	4,71	2,27	6,01	20,7
		Mn	86	79	5,01	5,47	1,43	1,79	58,6
	3	ZPK	317	358	86,70	8,3	7,36	3,01	15,1
		Mn	86	66	4,61	6,0	1,50	1,13	65,6
	4	ZPK	502	508	56,70	6,3	2,60	3,17	12,3
		Mn	295	112	8,11	6,6	1,97	3,80	70,4
		Mn'	233	95	5,48	6,64	1,92	2,72	62,9
	5	ZPK	373	596	37,30	5,80	2,96	5,73	19,7
		Mn	143	90	8,68	6,00	0,80	1,53	62,1
		Mn'	95	79	7,91	5,98	0,78	1,08	62,9
Cape Corse	6	ZPK	1025	395	25,30	6,0	2,45	6,17	15,5
		Mn	86	80	4,17	10,6	0,93	1,65	71,1
		Mn'	72	72	3,50	8,91	0,87	0,44	70,6

with *Meganyctiphanes norvegica* and showing small red masses of complexed iron and titanium (as described by Charlot, 1963), associated with chromium, like the masses found in the contaminated integument of the same whale (Viale *et al.*, 1973). In bathypelagic shrimps, eating on *Meganyctiphanes*, as *Aristeus*, *Parapenaeus* and *Aristeomorpha*, sampled in the ' red muds ' area, the associated Fe, Ti, Cr appear in the hepatopancreas. Furthermore, added to the contaminants in the tissues are quantities of various metals trapped by the floculated hydroxydes, and glued with them to the pleopoda and ovigerian silks, or to all the tegumental silks and gills. An input of the absorbed metals is possible by pinocytosis way (Viale 1977 ; Bezard *et al.*, 1984).

B. *Metal bioaccumulation in teuthophagous trophic networks :*

The above referred shrimp species are 10 to 22 cm long, and are consumed by pelagic squids, and even by benthic ones because these shrimps migrate between 700 m deep (where we caught them) in the morning, up to the surface at dawn. When the entire animals can be examined in transversal 7µ thick slices, it is possible to detect in the digestive tract, with microprobe what contaminants are transported by the food, and what are those which pass into the organs through the digestive epithelium (see Table 3). For example, the digestive tract of *Pycnodonta cochlearis* (a little oyster living on the bottom and sampled at the same time as *Aristeus*, *Aristeomorpha* and so on, given in Table 2, shows the presence of Fe, Ti, Cr, with often Ba, and always greater amount, Ca. The amoebocytes, characteristic of the Lamellibranchs, scattered in all their tissues, have a macrophagous role and contain always iron and phosphorus. On the gills, yellow masses rich in iron occur ; this metal is equally found inside the digestive epithelium, giving reddish masses. Winter (1972) showed that particulate iron can be phagocyted by the liver of mussels, and can be also excreted as excretory pellets

TABLE 3. *Microprobe detecting of various elements in organisms from the throwing zone of 'red muds'*

(Trawling in the Bathyal zone, B; in the Neritic zone, N; Intertidal zone, on the rocks in Ajaccio and 8 km North, from Bastia (Corsica), I.
Elements present, +; very abundant, ++.)

Species	origin	tissue	Fe	Ti	Cr	V	Al	Si	S	P	Ca	Ba	others
Etmopterus spinax													
(fish)	B	vitellus									+		
Galeus melanostomus													
(fish) male, 29 cm	B	muscle	++	+			+	+	+		++		Mn
		kidney								+	+		
female, 39 cm	B	liver	+	++			+	+	+	+	++		Zn
		kidney	+						+	+	+		
Coelorhynchus sp.													
(fish)	B	skin	+	+			+	+		+	++		Mn
		liver	+							+			
		macrophagous cells of liver	+							+	+		
		kidney					+	+	+	+	++		
Sepiola rondeleti													
(Cephalopod)	B	gill	++	+			+	+		+	+		
		skin	+	+			+						
		melanoph.	+	+									
		gonad	+				+	+	+	+	++		
Pycnodonta cochlearis													
(Lamellibranch)	B	amoebocytes	+								+		
		gill	++										
		intestin. epithel.	++										
		stomach content	+	+			+	+		+	++	+	
Aristaeus antennatus													
(shrimp)	B	hepatopancreas	+	+	+		+		+	+	+	+	
		gonad	+										
Plesionika martia													
(shrimp)		egg wall	+	+	+								
		embryo			+				+	+	+		
Aristeomorpha foliacea													
(shrimp)	B	hepatopancreas	++	+									

TABLE 3—(*Continued*)

Species	origin	tissue	Fe	Ti	Cr	V	Al	Si	S	P	Ca	Ba	other
Parapenaeus sp. (shrimp)	B	hepatopancreas	+	+									
Dentex vulgaris (fish)	N	macroph. of liver	+		+	+					+		
Octopus vulgaris (Cephalopod)	N	liver	+	+			+	++	+	+	+		
Gobius sp. (fish)	I	macroph. of liver	+	+			+	+					
		stomach content	+	++			+	+					
Paracentrotus lividus (Echinoderm)	I	ovarious	++										
		peribuccal membrane	++										
Actinia equina (Coelenterate)	I	stomach content	++	++									
Gibbula varia (Gasteropod)	I	stomach content	++	++									
id.	I (Ajaccio)	stomach content	++	+									Mn
Trochocochlaea sp. (Gasteropod)	I	stomach content	++	++			+	+					Mg
Patella coerulea (Gasteropod)	I	stomach content	++	++			+	+					
Pisania sp. (Gasteropod)	I	stomach content	++	+	+		+						Mn
Ligia mediterranea (Isopod)	I	stomach content	++	++			+	+					
Clibanarius sp. (Pagurid)	I	stomach content	++	+									Mn
Meganyctiphanes norvegica (Euphausiid)	plankton	entire	+	++					+	+	+	+	Mg

into the digestive tract. So endocytosis and exocytosis, processes are to be considered in pollutant transfer.

The Cephalopods sampled here are bathypelagic, or pelagic, or neritic. *Sepiola rondeleti* (Table 3), a deep water species, shows by microprobe examination some iron red masses on the gills, but also iron inside the gills, proving that the macrophagous cells can phagocyte iron from floculated masses glued on the gill surface. Another macrophagous cells, the melanophores of the integument, present the association Fe-Ti which was found in many samples, such as in the integument of cetacea (Viale *et al.*, 1973). The same metals are found in the liver of *Sepiola* and inside granules located in an unidentified glandula. In the specimens sampled off Pianosa island, where mines of manganese exist, the metal is found in the liver and in the above-mentioned glandula, but we cannot demonstrate that it is the true manganese from Pianosa. Manganese is often present in the Ligurian or Tyrrhenian samples (Tables 2 and 3), namely in 3 fishes from the bathyal zone, in *Pisania* and *Gibbula* (Gasteropods) and in *Clibanarius* (Pagurid) from the intertidal zone. 6 samples of *Octopus vulgaris* from the neritic zone were analyzed (Table 4); one of them, assayed with the microprobe, contained the association Fe-Ti in the liver (Table 3); other four were analyzed and contained Fe, Ti, Cr in both tentacles and viscera, and even in the nervous tissues. Hg, Cd and Pb are present in all organs of all cephalopods sampled here. In a bottom species, *Eledone moschata*, the amounts of the tested metals are higher, except for Hg and Ba, which are equal. This feature is due to the enrichment of pollutants in the bottom waters by way of sedimentation and exchanges or release through the interphase water-sediment.

One of the two *Loligo vulgaris* studied here (Table 4) was taken in the stomach of an incidentally captured dolphin: *Tursiops truncatus*; only its muscle was analyzed. The other was bought at the market of Bastia and analyzed with viscera. Ti, Pb and Hg are found in the flesh—the same flesh eaten by cetaceans and man. Mediterranean people are fond of squids and sepia flesh. A specimen of *Sepia officinalis* analyzed contained amounts of Fe, Ti, Cr and Hg. We cannot analyze human samples, but we did with samples of cetaceans stranded on the Corsican coasts. We had the opportunity to study one spermwhale (*Physeter macrocephalus*) and one *Ziphius cavirostris*, two species eating mainly cephalopods. The spermwhale was a 9 or 10 years old specimen beached dead on the Tyrrhenian Corsican coast. It contained large amounts of Fe in all the organs assayed (18 to 204 ppm of wet weight), Hg (0.6 to 4 ppm) and Pb (up to 10 ppm in the blubber). In the *Ziphius*, lead is important: up to 8.5 ppm in the rete mirabilis and 6 ppm in the melon. Ti attains 2.3 ppm in the lungs of pregnant female, while its foetus contains 3.45 ppm, more than its mother (Viale, 1980); this remark gives the evidence that Ti pass through the placental barrier from the mother to the embryo. This foetus taken *in utero* contains amounts of Hg varying from 1.60 to 5.25 ppm, but its mother had accumulated 440 ppm of Hg in its liver, constituting granules of mercuric selenid (Martoja and Viale 1977). We found more than 600 ppm of mercury in the liver of a *Grampus griseus*, species feeding principally on squids (see discussion).

Among all the cetaceans sampled in this work, those feeding on squids are the most contaminated with Hg, Pb, Fe and Ti, probably because they constitute the fifth trophic level of the food chain: phytoplankton, zooplankton, *Meganyctiphanes*, cephalopods, cetaceans. The average content of Cd in *Meganyctiphanes* is 1.26 ppb of dry weight, or 0.00025 ppm of wet weight; in squids, it is 0.002 and 0.06 and in other cephalopods, 0.01 to 0.1 (and up to

TABLE 4. *Metal content in Cephalopods from the area studied (ppm of fresh weight).—is non-analyzed*

Specimens	Organs	Fe	Ti	Cr	V	Cd	Pb	Ba	Al	Hg
Octopus vulgaris (found dead in the harbour of Bastia, Jan. 1973)	tentacle	—	8,45	—	—	—	—	—	84,53	—
Octopus vulgaris (captured in the harbour of Bastia, Nov. 1973)	tentacle	7,07	0,74	0,40	0,05	0,23	0,65	0,37	—	—
Octopus vulgaris	tentacle	11,70	0,35	0,11	0,10	0,08	0,31	0,21	—	0,10
(Cape Corse, Dec. 74	viscera	11,65	0,10	0,20	0,24	0,14	0,42	0,11	—	0,04
58 cm, 1, 1 kg)	brain	1,45	0,05	0,24	0,04	0,07	0,18	< 0,1	—	0,15
Octopus vulgaris (Cape Corse, Sept. 74)	tentacle	10,15	0,10	0,09	0,25	0,10	0,42	0,23	—	0,05
Octopus vulgaris (Cape Corse, Sept. 74)	tentacle	7,70	0,10	0,11	0,19	0,10	0,39	0,16	—	0,10
Eledone moschata (bathyal z., Nov. 74)	entire	56,5	0,87	0,84	0,72	2,08	0,77	0,19	—	0,10
Loligo vulgaris (market of Bastia; Feb. 1974; 10 cm)	entire	2,20	0,05	0,17	0,03	0,06	0,44	< 0,1	—	0,06
Loligo vulgaris (stomach of *Tursiops*, Oct. 1975; 25 cm)	muscle	0,50	2,40	0,10	0,18	0,002	0,47	—	—	1,3
Sepia officinalis (market of Bastia)	entire	18	0,75	1,15	0,10	0,011	0,19	—	—	0,38

2 ppm in *Eledone moschata*, a bottom species). Now the muscle, the kidney and the lung of the a 25 years old *Tursiops truncatus* which had eaten one of the analyzed *Loligo* contained only 0.06 ppm of Cd, which suggests that there was no accumulation of Cd in this dolphin, although old, but Cd is eliminated at the same rate that other metabolites from its food, and incorporated also at the same rate in its flesh.

On the contrary, bioaccumulation is probable in the bones and the lungs for Ti (Table 6), relating with the abundance of macrophagous cells. (Viale 1981)

C. *Metal bioaccumulation in ichtyophagous trophic networks :*

Among the fishes analyzed here (Tables 3 and 5), some (*Sardina, Trachurus, Boops*) feed on phyto and zooplankton; *Pelamys* feeds on euphausids and shrimps; others Bach as *Mullus, Trigla, Gobius, Julis* feed on demersal Crustaceans and algae; *Dentex, Scorpaena, Serranus* feed on crustaceans and fishes; *Xiphias, Squatina* and *Conger* live on large fishes. For the latter three, only pieces of organs were analyzed, generally muscles.

TABLE 5. *Metal content of fishes of the area studied, and a bird*

(Ca : ‰ ; other : ppm of fresh weight, Dosages made by the Laboratoire de Surveillance des Nuisances of the C.E.A., Center of Pierrelatte)

Species	Organs	Ca	Ba	Fe	Cr	Cd	Pb	Ti	V	Hg
Market of Bastia.										
Raja sp.	liver	0,08	—0,10	89,60	0,07	0,08	0,04	0,11	0,08	0,91
Trachurus trachurus	viscera + head	11,02	15,60	8,14	0,06	0,66	0,70	0,61	0,62	0,37
										0,36
Mugil cephalus (1)	viscera	0,54	—0,10	135,65	0,23	0,10	0,06	0,18	0,10	0,07
	head	10,80	3,09	47,80	0,05	0,40	1,97	0,55	0,56	0,04
(2)	viscera	0,35	—0,10	101,50	0,21	0,06	0,08	0,49	0,11	0,04
	head	21,70	1,73	45,55	0,08	0,59	1,51	1,14	0,83	0,02
Scorpaena scrofa		3,38	0,92	64,60	0,07	0,45	0,64	0,26	0,27	0,13
Pelamys sarda		71	17,20	85,00	0,61	0,66	3,44	4,60	3,15	0,22
Serranus ca rilla	muscle (average)			1,66					0,09	
(15 individuals ×2)	variation in 6 months :			to 3,11					to 1,25	
Scorpaena scorfa	muscle			1,50					0,07	
(15 individuals ×2)	(*id.*)			to 1,82					to 1,0	
Crenilabrus sp.	muscle			1,57					1,26	
(15 individuals ×2)	(id.)			to 4,14					to 1,47	
Dentex vulgaris	muscle			32	0,12	1,69	0,25	0,55	0,11	2,1
Mullus barbatus	muscle			79	0,4	0,1	0,03	1,40	0,21	0,14
Boops boops		4,31	2,12	10,00	0,03	0,11	0,52	0,14	0,10	0,10
Sardina sardina		3,23	0,40	16,05	0,02	0,06	0,44	0,13	0,49	0,15
Conger vulgaris	head	18,50	5,18	22,20	0,07	0,41	2,37	1,28	0,77	0,45
	tail	3,70	0,96	4,40	0,10	0,13	0,50	0,115	0,09	0,30
	skin	0,20	0,34	10,35	0,05	0,02	0,34	0,09	0,01	0,13
	fin	8,10	1,01	5,10	0,81	0,07	0,05	< 0,05	< 0,05	0,07
	kidney	0,19	< 0,10	99,20	0,05	0,004	0,19	< 0,05	0,11	0,10
Market of Ajaccio.										
Serranus sp.	muscle						0,42	0,51	0,40	
Fished off Bastia.										
Squatina and elus	muscle			4,2	0,05	0,04		0,08	0,02	0,07
	viscera			28,6	0,06	0,33		0•44	0,07	
	skeleton			11,5	0,08	0,17		0,28	0,40	
	skin + fins			31,6	0,11	0,13		1,60	0,19	0,51
Xiphias gladius	muscle						1,50	1,50		
Found dead, Cape Corse, 1973.										
Larus argentatus	viscera except alimentary canal			530	39,7	1,01		5,50	1,68	2,5
	alimentary canal			133	0,15	0,54		0,83	0,08	0,29
	bones			62,2	0,15	0,22		4,44	0,59	?
	xesh			101	0,51	0,28		0,56	0,10	0,70

TABLE 5—(*Continued*)

Species	Organ	Ca	Ba	Fe	Cr	Cd	Pb	Ti	V	Hg
Fished in Pietra, Corbara Corsica, 30th November 1974, 130 m deep.										
Rala sp.		1,62	0,68	2,40	0,01	0,12	0,63	0,105	0,10	0,16
Merluccius vulgaris		1,95	0,58	2,10	0,02	0,09	0,22	0,125	0,05	0,41
Trigla lyra		3,50	4,55	70,00	0,14	0,27	1,47	1,78	0,73	0,24
Limanda limanda		6,03	2,78	21,40	0,12	0,28	0,77	0,46	2,92	0,08
Fished South from Cape agro, 30th November 1975, 45 m deep.										
Mullus surmuletus		6,35	2,15	16,00	0,10	0,30	0,55	0,48	0,24	0,06
Serranus cabria		8,50	0,94	23,60	0,09	0,20	0,47	0,61	0,07	0,07
Trigla lyra		8,74	3,17	19,00	0,13	0,34	0,15	<0,05	0,15	0,10
L. limanda, youngs		9,00	0,95	9,50	0,26	0,04	0,47	0,38	<0,01	0,09
Market of Bastia, 6th December 1974.										
Mullus surmuletus		4,96	1,36	5,45	0,04	0,18	0,95	0,25	0,13	0,18
Trigla lyra		5,65	2,07	16,90	0,06	0,20	1,03	0,34	0,26	0,09
Serranus vulgaris		7,81	2,22	15,55	0,07	0,31	1,16	0,43	0,57	0,14
Motella fusca		14,32	2,31	9,40	0,05	0,37	1,04	0,64	0,10	0,10
Julis vulgaris		6,80	1,86	18,00	0,05	0,34	1,07	0,40	0,56	0,09
Scorpaena scrofa		9,70	1,69	12,90	0,07	0,33	1,04	0,55	0,64	0,10
Serranus cabria		9,02	2,51	18,30	0,08	0,44	0,62	0,30	0,29	0,16
Gobius sp.		7,02	0,82	9,65	0,09	0,30	0,41	0,49	0,27	0,07
Padellus sp. (1)		4,62	1,23	8,70	0,01	0,12	0,46	0,26	0,09	0,085
(2)		6,08	1,83	7,90	0,04	0,24	1,38	0,28	1,03	0,35

The samples bought in the market at Bastia (6th Dec. 1974) are specially young specimens, all less than 50 g; they were analyzed *in toto*. It is very surprising to find in these young demersal fishes noticeable amounts of each contaminant studied here: Cd is present as 0.06 to 0.44 ppm; Pb as 0.44 to 1.38 ppm; Ba is noteworthy, well identified above in several species with microprobe; it is always associated with Ca. Ba reaches a level of 15.6 ppm in *Trachurus trachurus* and 17.2 ppm in a young *Pelamys sarda* (20 g); the latter contains, moreover, important amount of Pb (3.44 ppm) and Ti (4.60 ppm). Note that barium is responsible for myastheny in near particularly described in workers in barium mines and factories. The liver of *Raja* does not appear as a bioaccumulation organ, except for Hg. The comparison of the amounts of pollutants in viscera and in the head of a *Mugil cephalus* brings interesting information: Ba, Cd, Pb, Ti, V present in viscera are stored in the head of the fish, essentially made of bones and nervous tissues. The analysis of a selacian, *Squatina angelus*, indicate the tendency to store V and Ti in the cartilaginous skeleton, but not Cd; it was impossible to measure Pb and Hg amounts in this specimen, because of the quantity of tissue necessary for each analysis.

Another feature pointed out by these results is the importance of the metallic contamination on the benthic or benthopelagic species, e.g Pb and Ti more important in *Trigla*, *Pleuronectes*, *Mullus*, five to ten times higher than in other species of comparable size. It would be seen from Table 5 that Cr is not stored in any organ of very young fishes. In an example of *Pelamys*, particularly enriched in all the contaminants studied, the amount of Cr is not over 0.61 ppm. The origin of this Cr is the food, since this metal is always more abundant in the digestive tractus than in other organs.

In a large *Conger* it was possible to isolate the kidney (mesonephros); its analysis shows that it does not accumulate the Cd as do the kidneys of the Mammals: the metal appears to accumulate in the head 100 times more than in other organs, without knowing whether that accumulation principally occurs in the bones or the nervous tissue.

Three results from an experiment of the Departmental sanitary authorities in 1974 are to be commented now. Fe and V were analyzed in 15 specimens of *Serranus cabrilla* obtained from the market; the average content is respectively 1.66 and 0.9 ppm. The same measures 6 months later on 15 *Serranus* from the same market gave values of 3.11 and 1.25 ppm respectively. Unhappily the experiment was not pursued! For a *Crenilabrus*,

TABLE 6. *Metal contents of various organs of a* Tursiops truncatus *captured in a trawlnet in Bastia, Corsica, 25th November* 1975. (Male, < 25 years old. Contents are in ppm of wet weight; (+) are metals found with microprobe. Only three organs were assayed with microprobe).

Organ	Fe	Ti	Cr	Cd	V	Pb	Hg	Ca
dorsal skin ..	51	0,125	0,24	0,002	0,10	0,05	10,4	385
blubber : melon ..	52	0,20	0,40	0,004	0,16	0,08	7,3	—
diaphragm ..	160	0,08	0,23	0,002	0,09	0,05	20,0	—
liver ..	295 (+)	0,075(+)	0,23	0,025	0,135	0,20	293,0(+)	— (+)
rete admirab. ..	175	0,135	0,43	0,003	0,135	0,09	19,7	—
ventral muscle ..	171	0,085	0,27	0,001	0,065	0,035	9,0	—
lung ..	130 (+)	0,065(+)	0,51	0,003	0,55	0,025	8,95	— (+)
muscle ..	160	0,07	0,26	0,001	0,06	0,03	24,0	—
kidney ..	160 (+)	0,065	0,21	0,051	0,065	0,88	12,7	—
heart ..	125	0,095	0,18	0,003	0,095	0,04	16,8	—
pancreas ..	40	0,065	0,14	0,012	0,05	0,17	20,6	—
brain ..	25	0,065	0,13	0,002	0,05	0,025	7,85	—
ventral skin ..	20	0,125	0,24	0,001	0,10	0,08	6,1	125
ventral blubber ..	15	0,22	0,53	0,001	0,18	0,10	1,7	—
blood ..	600	0,10	0,67	0,009	0,20	0,05	6,25	—
stomach ..	60	0,67	0,62	0,002	0,055	0,13	8,0	325
dorsal blubber ..	25	0,20	0,65	0,002	0,16	0,185	4,4	—
rectum ..	65	0,415	0,18	0,121	0,40	0,11	8,5	—
glottis ..	440	0,92	1,27	0,003	0,16	0,995	11,0	—
hyoidal bone ..	65	4,79	0,59	0,003	0,17	0,685	—	—
testicles ..	55	0,045	0,14	0,005	0,045	0,04	6,6	—
penis ..	35	0,085	0,12	0,001	0,085	0,035	7,5	—
spleen ..	170	0,07	0,12	0,003	0,055	0,06	14,3	—
bladder ..	50	0,07	0,03	0,006	0,070	0,06	18,8	140

Other : Se in liver (+)

For Ca,—is no analyzed.

whose diet is more vegetarian than *Serranus*, the progression in six months is greater for Fe ; on the contrary, the increment of the vanadium content is 1.17 times more in *Crenilabrus* and 14 times more in the two species of carnivorous fishes.

What concerns the predators of fishes, only few species are considered in this study : *Xiphias* and *Conger*, a bird and some cetaceans. The bird, *Larus leucophaeus* (ex-*argentatus*), feeding on fishes but also on organic detritus, was found dead on the upper northern coast of Cape Corse. Table 5 indicates its abnormal bioaccumulation of Cr in the viscera excluding the digestive tract, *i.e.* liver, heart, lungs, kidneys, gonads with Cd and Hg well represented in both the flesh and the bones.

TABLE 7. *Estimations of the weights of organs and of the total amount of mercury in a* 3.30 m, 300 *kg* Tursiops truncatus

Organ	Weight (kg)	Mercury content (ppm) $\mu g/g$	Total amount of mercury (mg)
skin ..	4,8	8,20	39,36
blood ..	21,3	6,27	133,55
heart ..	1,8	16,8	3,02
liver ..	6,0	293	1932
lungs ..	3,0	8,95	26,85
kidney ..	3,3	12,7	41,91
spleen ..	0,1	14,3	1,43
pancreas ..	0,45	20,6	9,27
testicles ..	0,25	6,60	1,65
penis ..	0,5	7,50	3,75
bladder ..	0,25	18,8	4,70
diaphragm ..	4,8	20,0	96,00
rete mirabilis ..	1,9	19,7	37,43
vascular system ..	3,0	6,27	18,81
lymphatic system + lymph ..	3,1	6,27	19,42
brain + spinal marrow	2,5	7,85	19,62
stomach ..	3,0	8,00	24,00
intestine ..	18	8,50	68,00
mesentery ..	2,0	6,27	12,54
skeleton ..	50	11,0	550
muscles ..	130	15,5	2145
blubber ..	40	3,80	152
Total ..	< 300		5340,31 < 5,34 g

As for cetaceans, interesting data appear in the comparison between the contents of *Sardina sardina* and *Loligo vulgaris* sampled in the true stomach of a *Tursiops truncatus*, and the content in the cetacean. *Loligo* has been commented on earlier. Table 6 shows the content of 7 metals in 24 organs of this dolphin. There is evidence that the cetaceans have a high capability for eliminating great quantities of pollutants they consume every day, for in many cases the observed amounts are low. Especially, the Cd content is lower in all the organs than in the preys. The V has the same magnitude as in fishes, or is lower. On the contrary, the Fe is bioaccumulated in the cartilage (glottis), in bones, lungs, liver etc.

Hg is definitively fixed in calculi, *i.e.* deposits of tiny agglomerated granules of mercuric selenid, SeHg, located in the wall of the blood vessels. They are numerous in the liver, where they were seen for the first time (Martoja and Viale, 1977 ; Viale, 1981), and correspond to a detoxication of the methylmercury (see Discussion). They are also present in various well vascularized organs : kidneys, pancreas, while in muscle one third of the Hg content is methylated and 100% in the blubber, instead of 7.5% in the liver (Martoja and Viale, 1977). Table 7 gives the total amount of mercury by organs, estimated multiplying the content by the weight of organs following Gihr and Pilleri (1969 *a* and *b*), and the total content of the body, it is 5.35 g for this 300 kg, 3.30 m dolphin. The overall percentage of Hg is hence 17.8 ppm of wet weight, which would be lethal in the absence of any detoxication mechanism such as the storage of SeHg in granules.

Discussion

A. *Why is the ecosystem said to be endangered?*

According to the literature because no part of it is free from metal contamination, and the levels of observed bioaccumulation are higher than in other areas. In our results, *iron* appears in all samples, and always more concentrated, namely 2 to 11 times more concentrated than reported by Bryan (1976), Gaskin *et al.* (1973). Normally this metal is found in the liver of mammals at levels lower than 80 ppm of wet weight, and in the muscle at 15 to 41 ppm (Jaulme and Hamelle, 1971). It must be added that in our histological samples, iron is always detected by R X spectrography with Castaing's microprobe, whereas this technique only puts in light the important bindings of atoms; the diffusible substances such as iron in hemoglobin of the red blood cells are not detected by the microprobe, whereas chemical analyses measure as well as diffusible iron as insoluble, bioaccumulated one (see Table 6, where microprobe-detected iron is shown in the three organs assayed). These two techniques allow to distinguish an iron considered as normal, like that of the blood, and an abnormal iron, bioaccumulated and set aside in granules principally made of calcium phosphate or magnesium phosphate (Viale, to be published). Nevertheless, a problem remains: the blood contains 600 ppm of iron, that is an enormous content with respect to the normal state assessed by Jaulme and Hamelle (1971), *i. e.* 80 ppm in the true organ assuming the normal function of iron storage ('martial function'). Iron is also stored in cartilage of the dolphin.

Titanium, associated with iron and chromium, characteristic of the 'red muds' discarded as wastes from the TiO_2 plants of Tuscania and Catalunia, is present in the digestive tract of all the tested animals coming from the neritic and intertidal zones. It means that these metallic pollutants discharged in the open sea reach all the Corsican shelves, while this island is devoided of any industry and presents pollution-free rivers (Anon., 1973). The fishes sampled in the bathyal zone (—600 to —800 m) and all the bottom-living animals contain Fe and Ti, often associated as a red chemical complex (Charlot, 1963) which can be observed with light microscopy and sometimes visible to the naked eye in stomach contents.

Other metals: V, Cr, Cd, Hg, Pb, have high contents with respect to the data of Bryan (1976). Our own data put in light concentrative processes with the following ratios: Cr, teratogenic and embryotoxic, (Pagano 1984) 7 to 65 times more, V, 7 to 15, Hg, 11 to 20, Pb, 6 to 40, Cd, 2 to 17 times more, the concentrations given by Bryan being taken as references.

The *lead* brought by the rivers into the sea is relatively scarce (40 times less than Fe). Nevertheless, it is always well represented in the animals tested. This paradox had an explanation since the works of Baut-Menard 1983 which proved that the 90% input of Pb in the Mediterranean waters comes from human activities and originated from the industrial N. European areas.

The *cadmium* is practically absent in the wastes thrown out in the open sea, while the rivers and volcanic activities bring it copiously. The cadmium found in the animals is hence principally telluric, but linked to human activities giving also an atmospheric input. This enrichment of Cd endangers the ecosystem, because this metal has embryotoxic effects. (Pagano 1984).

In other words, synergic effects between two types of pollutants (organochlorines and metals; petroleum compounds and metals; Hg and acid for methylation of the metal, etc.) endanger also the ecosystem. Alzieu and Duguy (1978) showed the noteworthy amounts of organochlorines in Mediterranean cetaceans (*Stenella* *coeruleoalba*). Gaskin (1982) consider The Western Mediterranean as an area of heavy organochlorine pollution ; the highest levels are found here and in the Baltic Sea.

TABLE 8. *Number of strandings of dolphins on the French Mediterranean coasts between* 1971 *and* 1983 (*data from Duguy and Budker,* 1972 *and Duguy,* 1973 *to* 1984).

Year	*Delphinus delphis*	*Stenella coeruleoalba*	*Tursiops truncatus*	Total *Cetacea*
1971 ..	1	0	0	6
1972 ..	2	2	1	18
1973 ..	2	4	7	27
1974 ..	2	7	1	22
1975 ..	0	10	7	22
1976 ..	1	18	4	29
1977 ..	3	13	3	26
1978 ..	1	10	1	19
1979 ..	1	26	2	42
1980 ..	1	18	1	29
1981 ..	0	12	0	19
1982 ..	1	13	1	22
1983 ..	0	12	0	21

B. *Why are cetaceans considered endangered?*

Gaskin (1982) opines that Mediterranean populations of fin whale, common dolphin, bottlenosed dolphin, Cuvier's beaked whale, 'are potentially at risk' due to metallic contaminants (Fe, Ti, Hg) as well as organochlorine pollution.

Since 1972, modifications appeared in the cetacean populations (Viale, 1978 1980): *Delphinus delphis* became scarce in all the area North——from 42°N, and in opposition—— this species is found South from this latitude, but always in small herds and the overall population is depleted, as compared to what existed before the second world war. *Stenella coeruleoalba*, scarce before 1960, became the commonest dolphin of the area. But, when occupying the ecological niche left by *Delphinus delphis*, this species has had to pay a heavy toll : the number of carcases stranded on the Mediterranean French coasts is growing up since 1972, and represents now more than 60 % of the whole cetacean strandings (Table 8). I propounded that the spread of this new area, from adjacent areas, implies an endeavour of supernatality of the species (Viale, 1978). It is stated now that the mere supernatality cannot explain the increase of population density, which implies an immigration ; the methods of analyzing that population dynamics is explained by Frontier and Viale, (submitted).

Now two features are to be discussed here. First, the most part of the carcases are juveniles, and proofs of diseases can be seen on them : lung diseases (Viale, 1981), cardiopathies (Viale, submitted) and mesenteric calculi. Second, the predominance of males in the sex-ratio of stranded dead cetaceans. It is to evocate here the possibility of females of detoxifying themselves, at the expense of the embryos or calves, when gestating and lactating.

C. *Evidence of regulation processes in the ecosystem*

Strategies of the ecosystem can be seen at the levels of the population and of individuals. We just described a population phenomenon. Let us now examine some mechanisms at the level of the individual organism.

1—*Cutaneous excretion* was put in evidence for various cetaceans (Viale, 1977, 1979), allowing them to evacuate the excess of the mineral balance. It is physiological mechanism of the epidermis, where many cells scattered in all the surface of the body, but principally on the anterior part, exclude by pinocytosis a saturated solution of Na Cl and all other components of the sea water. This constitutes a possible way of excreting some pollutants. Furthermore, the skin is regularly exfoliated and this quick renewal of tissues may partially eliminate the absorbed contaminants. This mechanism puts again the contaminants in the environment, but not always under the same chemical form, *e.g.* for mercury (see below).

The same salt excretion concerns also the marine birds, which have a nasal salt excretive glandula.

2—*Demethylation of the methylmercury* in the cetaceans. This procedure was found in odontoceta, such as *Ziphius cavirostris*, *Delphinus delphis* and *Grampus griseus* (Martoja and Viale, 1977). Selenium is necessary to constitute mercuric selenid (Se Hg), a very stable compound that resists the chemical attacks of sulphuric and chlorhydric acids, and the mixture of the two. It is precipitated in tiny granules, progressively added one to another till forming calculi deposited in the interstitial spaces between the cells of the blood vessels walls (photographs in Viale, 1978). These calculi are above all in the liver, where selenium is also abundant ; they are responsible for the high level of mercury found in certain organs such as liver, lungs and kidneys. The methyl radical which confers toxicity to the mercury is got rid of in the atmosphere by the pulmonary way. The noteworthy point of this mechanism is the stability of the compound SeHg, which resists the protease enzymes, (not to be confused with metalloproteines). Therefore, it appears a sclerification of the tissues of the cetaceans up to their death ; when dead, and when cetaceans are eaten by squales, these little mercury stones finally reach the sediment under a stable, non biodegradable and non bioaccumulable form. The overall phenomenon is a process of detoxication of the marine environment.

3—*Integration of contaminants in other mineral calculi*

In the same way, calculi are put in evidence in mesentery (Viale, 1977, 1978). They are found only on some dead stranded individuals, generally young specimens, belonging to all the species of odontoceta living in our zone. These tiny stones are always made of phosphorus associated with calcium and magnesium, amorphous or crystallized. When big enough, they also contain iron, titanium, nickel, cobalt, identified with CAMEBAX RX spectrography (Viale, in preparation).

These mechanisms allow us to think that ecosystems show a certain resilience, and therefore is not endangered. Margalef (1984) thinks so, saying that the Mediterranean ecosystem is able to save itself ; we all need to believe the philosophical optimistic assertion of Margalef. But the economic managing of the Mediterranean marine resources risks to have to change when the ecosystem is modifying. Probably the marine ferrugineous bacteria such as *Leptothri* found by Ferrero (1974) around the area of wastes discharge, will have a good luck in the future. Humans have to prepare themselves for new utilization of new species for food !

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A REVIEW OF BRAZILIAN WHALING : ASPECTS OF BIOLOGY, EXPLOITATION AND UTILIZATION

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ABSTRACT

Data on whaling in Brazil from 1910 to 1984 are reviewed. Analysis of overall data shows that Brazil took 921 toothed whales and 20,472 baleen whales ; and of the latter 13,772 were minke whales, the only species allowed for commercial whaling. The minke whale catch, by comparison with the rest of the major whaling nations, USSR and Japan, constitutes only one tenth of the total quotas allowed for Antarctic stocks ; USSR and Japan took the highest shares. The sex ratio of minke whales for Brazil is 1 male : 2 females ; and usually the resting females predominate and foetuses were rarely recorded. These catch compositions are generally contrary to those taken in Antarctic where pregnant females and foetuses predominate. Nearly 94.0% of the males taken off Brazil are sexually mature at 7 m and the mean weight of testis is 1,433 g. Despite individual variation, most females reach sexual maturity at 8 m. These features are generally similar to those minke whales caught in the Southern Hemisphere. Aspects of exploitation and utilization are also briefly discussed.

INTRODUCTION

REVIEW : THE PAST AND THE PRESENT : EVOLUTIONARY INTERESTS : The whales are the largest among the living forms. In common with many other Eutherians, they probably derived from a common ancestral mammalian stock. Since the Eocine, about 40 million years ago, perhaps, because of their enormous size they became specialized into distinct fish-like mammals, and well adapted for fully aquatic life. Of the three suborders of the Cetacea, the Archaeoceti had already become extinct during the middle of the Miocene—long before man originated. The modern whales are assigned to two suborders : Odontoceti or toothed whales and Mysticeti or the baleen whales. So far, no missing links have been found to bridge the gap between the Archaeoceti and the modern whales. The three groups of whales probably evolved independently. Although the term 'whale' generally implies something of a large size, for taxonomic purposes, the smaller Cetaceans such as dolphins and porpoises are also conceived as whales. Some 76 living species of whales have been recognized (Watson *et al.*, 1981). They are world wide in distribution and found in all oceans and most of the major seas. From the available records, it is evident that at least seven species of whales have been taken on commercial scale from the Brazilian waters (Table 1).

Whales as Components of the Natural Ecosystem : Whales are an important living component of the marine ecosystem, and ever since man began to excert his dominance over them, their destiny has been modified considerably. The impact of man in destroying or conserving these living components will continuously create a state of imbalance in

TABLE 1. *Catches of whales off coast of Brazil: Costinha/Carbo Frio during—1910-1984*

Year		Species and (common names) *Physeter catodon* (Sperm)	*Balaenoptera musculus* (Blue)	*Balaenoptera edeni* (Bryde's)	*Balaenoptera borealis* (Sei)	*Balaenoptera physalus* (Fin)	*Balaenoptera acutorostrata* (Minke)	*Megaptera novae-angliae* (Humpback)	Total
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
1910	..	=	=	=	=	=	=	=	
1911	..							102	102
1912	..							342	342
1913	..							352	352
1914	..							317	317
1915	.. }								
1923	..	*	*	*	*	*	*	*	-
1924	..							62	62
1925	..							42	42
1926	..							32	32
1927	..							47	47
1928	..							40	40
1929	.. }								
1930	.. }								
1946	..	=	=	=	=	=	=	=	
1947	..				14			11	25
1948	..		01		10			21	32
1949	..				18		01	15	34
1950	..				98			24	122
1951	..				151			28	179
1952	..	01			153			09	163
1953	..	01			161			08	170
1954	..	01			183			18	202
1955	..	01			198			06	205
1956	..	03			196	01		14	214
1957	..	02			115				117
1958	..	04			118	01		05	128
1959	..	11			294		02	08	315
1960	..	01/28			500/250	/21		10/03	511/302
1961	..	05 97			504 453	10		11 02	520 562
1962	..	04/81	/01		272/338	/49		08/03	284/472
1963	..	07 35			253 93	04	02	10 02	272 134
1964	..	04			256		44		304
1965	..	13			149		68		230
1966	..	24			72		352		448
1967	..	20		06	49		488		563
1968	..	39		06	58		456		559
1969	..	75		06	56		617		754
1970	..	76		03	23		701		803
1971	..	55		02	18		900		975
1972	..	66		–	05	01	702		774
1973	..	75		01	06		650		732
1974	..	29		01	02		765		797
1975	..	54			03		1,039		1,096
1976	..	09			03		776		788
1977	..	25			05		1,000		1,030
1978	..	24					690		714
1979	..	27					739		766
1980	..	30					902		932
1981	..						749		749
1982	..						854		854
1983	..						625		625
1984	..						600		600
Total	=	686/241	01/01	25 †	3,715 228 / 1,134	03/84	13,722	1,542/10	19,922/1,470 21,392

} = First catch had no record.
}* Whaling was suspended & station closed.

† Bryde's & Sei were identified mostly as Sei.

the flow of energy of the complex natural ecosystem. As has been recenty suggested that Sei whales (Allen, 1981) and minke whales (FAO, 1981) in the Antarctic have increased as a consequence of the reduction in numbers of the other larger species of baleen whales. Added to the already depleted whale resources, the situation has been made worse, particularly when interacting species such as krills and baleen whales are exploited simultaneously by man in the Antarctic.

Traditions and Development of Brazilian Whaling Operations: Stone age man had been known to have hunted smaller whales for both food and oil. The earliest records of whaling on a regular basis on the Asiatic side of Bering strait go back to 500 B. C. (Bockstoce, 1973). The Eskimos of Alaska and Greenland had almost always depended on the whales and seals for their very survival. In Europe, evidence of large scale whaling enterprises by Flemish and Norwegians in the 19th century, followed by Biscayans through mediaeval centuaries, had been reported (Vaucaire, 1941). Japanese traditions of whaling and their increasing dependence on whaling industries have been claimed to exceed 1000 years (Yonezawa, 1980).

Except perhaps the incidental killing of the smaller whales by the indigenous Indians who settled along the coastal belt, Brazil seems to have inherited the whaling tradition during the colonial time of Portuguese in the XVII century (Ellis, 1958). By about this time, the American sperm-whale fleet also appeared to have taken a substantial share from the Brazilian waters. Perhaps, prompted by the abundance of whales and the ability to use these readily available living resources and sites, Brazil continues to be a whaling nation (Singarajah, 1980). However, it was not until 1910 that the Companhia de Pesca Norte do Brasil (COPESBRA) was founded at Costinha in the northeastern part of Brazil (Fig. 1). Following its success, another whaling operation was undertaken at Cabo Frio by Sociedade de Pesca Taiyo Limitada (SPTL) but, after a brief operation during 1960-1963, this was abandoned for a variety of reasons ; the chief among them were technical, particularly the distance between the whaling grounds and landing station, and high costs to operate.

Status of Whales and the International Whaling Commission (IWC)

As a consequence of the ruthless exploitation, added with commercial impetus, by different whaling nations over successive generations, particularly the larger species of whales had already been reduced to the verge of extinction. It was even feared that they would never recover if the population sizes fell below a certain level. It is often believed that to ensure successive mating of whales, the population of each stock need to be maintained at higher level. However, prior to World War II, the stocks of Blue, Fin and Humpback whales were already at their brink of disappearance as there was no effective control of the whale resources of the sea. There was an imperative need for the protection of whales. Whaling operations were, however, suspended for a while during war. Fortunately for the whales, a League of Nations, initially represented by: Argentina-Australia, Brazil, Canada, Chile, Denmark, France, Netherlands, New Zealand, Norway, Peru, South Africa, the United Kingdom, the United States and the USSR (IWC, 1946), met at Washington and the International Whaling Commission was constituted under the International Convention for the regulation of whaling and signed on 2nd of December 1946. The prime purpose and objectives of the IWC were :—

(1) 'to safeguard for the future generations the great natural resources represented by the whale stocks';

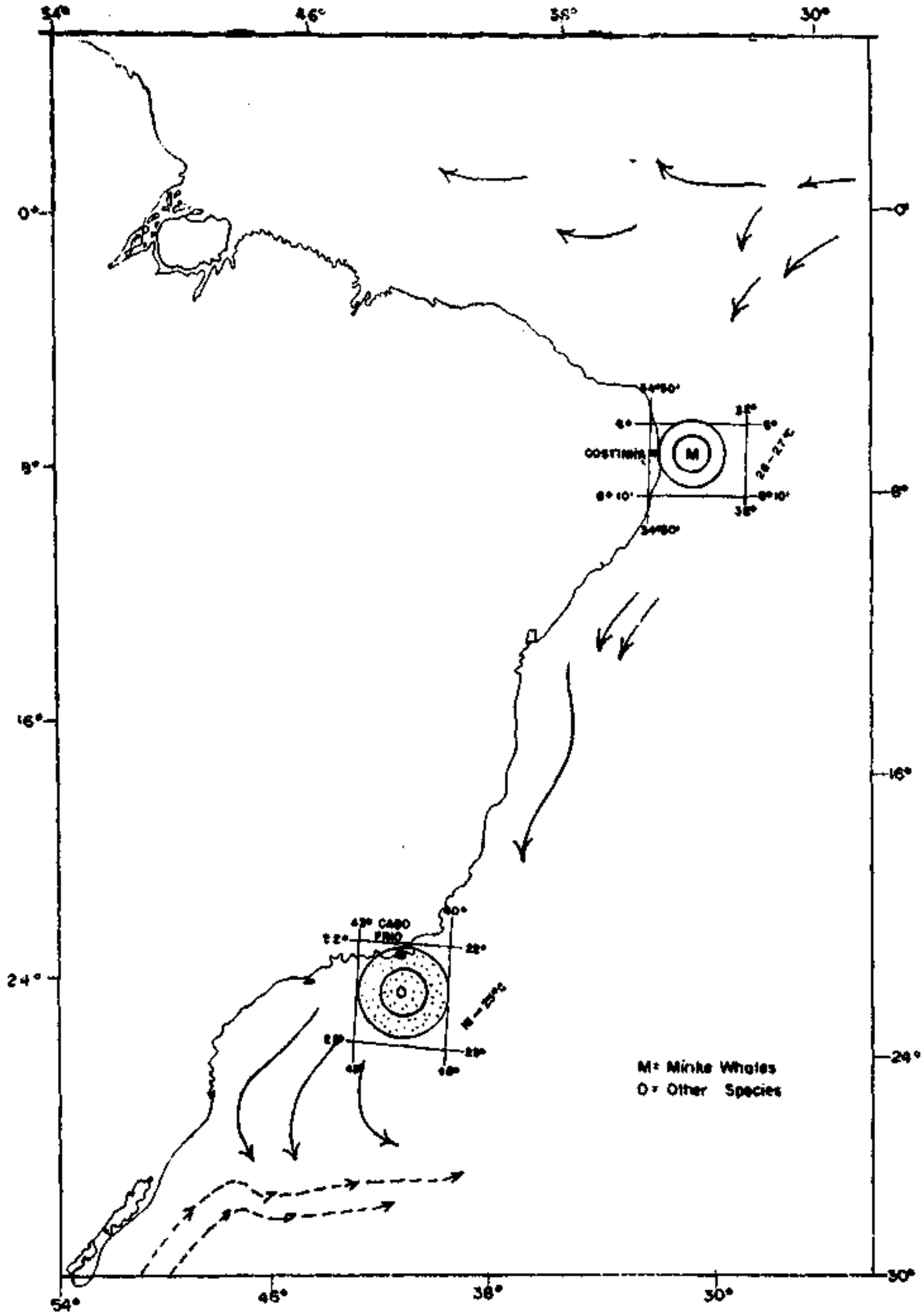

Fig. 1. Whaling grounds off Brazil ; the Circular areas represent concentrations of whales.

(2) 'to protect all species of whales from further overfishing';

(3) 'for the conservation, development and optimum utilization of the whale resources; and shall be based on scientific findings'.

(IWC, 1946). Obviously not all whaling nations were (and still are) members of the IWC. Nevertheless, despite a series of crisis, it has survived and grown now into a 40 member body (IWC, 1985) and has become most effective in limiting the exploitation of whales at scientifically acceptable levels.

Quota System

As a first step, though initiated in 1944, to regulate, IWC chose to limit whaling by quota systems based on 16,000 Blue whale units for all waters of Lat. 40°S. One Blue whale unit (BWU)=1 Blue=2 Fin=2.5 Humpback=6 Sei whales. Soon, it was realized that these unitary limits were far too high to ensure sustenance of whale stocks. The convention was now rightly concerned with the protection of overexploitation. Effective conservation measures were less acceptable to whaling member nations, particularly USSR and Japan who operate the Antarctic pelagic fleets; this is largely because of their investments on modern whaling could not be recovered and thought to be at stake and partly because of the wider difference of opinion rather than agreement among member nations. Norway and Denmark even left IWC for a while. Finally, since 1965, IWC has generally succeeded in persuading whaling nations to divide total allowable catch into national quotas. Although Brazil was one of the signatories of the IWC convention of 1946, she reluctantly left IWC in 1966 only to rejoin in 1970. Despite her very useful contributions, her present mood once again is one of gloom and despair. The quota for Brazil this year has been reduced to only 600 minke whales.

Exclusive Economic Zone and Rights of States to Resources: The Latinamerican countries have always favoured the creation of economic zones (ILM, 1970; 1972). The exclusive economic zone is 'an area beyond and adjacent to the territorial sea; shall not exceed 200 nautical miles from baselines from which the breadth of the territorial sea is measured' (Art. 57, UN Conf. 63, 1982). In this economic zone, a coastal state has 'sovereign rights for purpose of exploring and exploiting, conserving and managing the natural resources, whether living or nonliving'. Under such provisions, Brazil, with her area of 8,511,967 km^2 and a sea coast of about 7,410 km, has great advantages of developing her potential natural resources. However, due to less favourable topographical features of the continental shelf, the sea fishery is no longer expanding (Singarajah, 1984 b). Therefore, one of the strongest arguments for Brazil to continue whaling lies in the fact that whales are renewable resources and, being mobile and migratory over a range, found well within the economic zone and they constitute an integral part of natural resources of the Brazilian waters. Perhaps, in the context of the economic zone and within the objectives of IWC conventions, Brazil intends to continue to conserve, carry out research, and exploit this renewable marine resource on a rational basis without endangering the species.

Since whales are commonly regarded as endangered marine animals, this paper briefly discusses some of the basic aspects of biology, exploitation, and ulitization of whales resources in Brazil.

The author wishes to thank Dr. S. Suzuki, Vice-President of COPESBRA for his keen interest and enthusiastic support; Dr. G. Rabay of COPESBRA for his interest and for providing me with much of the IWC reports; Dr. M. Saito, the General Manager of Whaling Factory at Costinha for providing much of the factory data.

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Materials and Methods

Data on catch and sightings were collected from a number of sources, including BIWS and SUDEPE (Superintendência Do Desenvolvimento Da Pesca). Biological materials were obtained both from the factory and in the field. Whale observations were made by the author personally on board catcher boat, *Cabo Branco*. Data recordings and field methods for collections of samples and behavioural observations were described previously (Singarajah, 1980 ; 1984 a, c). Testes were measured to the nearest cm and grams. Histological analysis of testis samples was carried out and spermiogenesis was examined using a binocular microscope.

Results

Whaling Areas and Landing Stations :

The whaling areas off Brazil fall well within the 200 n. miles economic zone as defined by the UN (Conf. 62, 1980) and constitute a small part of the Area II (0°—60°W) management stock (IWC, 1981 ; 1982). Whaling operations from Costinha, in the northeast, are confined to about 15,000 n. miles[2] off the continental edge (see Singarajah, 1984 a) ; whilst from Cabo Frio, in the southeast of Brazil, covered some 42,000 n. miles[2], extending seaward a little further from the continental edge. Thus, the increase in distance had made the coastal whaling operations from Cabo Frio relatively more difficult and less economical.

Biological Parameters : Stock Identity :

Following the general decline of the larger species and the protective measures adopted by IWC, the commercial catching off Brazil, since 1964, is concentrated mainly on minke whales. Therefore, much of the discussions that follow here will deal with the Brazilian stock of minke whales since the data on other species are less reliable or incomplete. The minke whales coming to Brazilian waters are winter breeders and probably a substock of the Southern species, *Balaenoptera acutorostrata* (*bonaerensis*) as originally described (Burmeister, 1867).

Stock Characteristics of Brazilian Minke Whales:

Ohsumi *et al.*, (1970) described the stock characteristics of Antarctic minke whales. The only reports on morphologic characteristics of Brazilian minke whale stock (Williamson, 1975 ; Singarajah, 1984 a) clearly suggest that the two types closely agree in the following main features :

1. body form, length and colouration ;
2. flipper colouration, particularly in the absence of any white patch ;
3. morphometrics of ventral grooves and other related structures ;
4. baleen plates, colour patterns and asymmetry of baleen colour ;
5. length at sexually and physical maturity ;
6. seasonality of migration.

However, these unique and discriminatory features appear to be different from those minke whales taken from South African waters where Best (1984) recognized at least three types of flipper colouration and body lengths, including a ' diminutive type ' of minke whale.

Sex Ratio :

As previously reported (Singarajah, 1984 a), an analysis based on catch data covering the entire minke whaling period generally showed that the sex ratio for the Brazilian minke whale stock remained fairly constant at 1 male : 2 females. Since minke whales off Brazil are considered as a part of Antarctic stocks (IWC 1982 ; 1984), it would be very interesting to compare this ratio with those of Antarctic catches. Fig. 2 compares the sex composition of Brazilian catch for 1983 with those of the Antarctic catches of the corresponding season.

maturity criteria, *i.e.* females are generally considered to have reached sexual maturity when there is at least one corpus luteum or corpus albicans present in either of the ovaries ; and for males one testis of at least 0.4 Kg is present (Masaki, 1979 ; Ohsumi *et al.*, 1970),

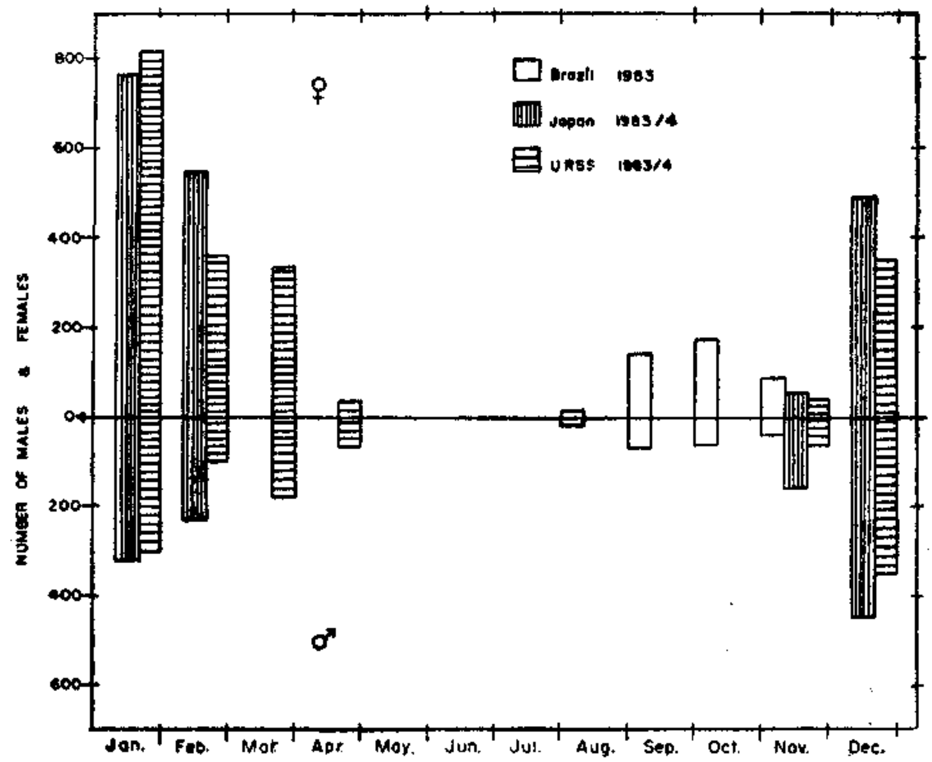

Fig. 2. Catch Composition of Antarctic minke whale stocks by sex and months

Length-Weight Linked Sexual Maturity and Reproductive State :

The onset of sexual maturity has been examined in minke whales by a number of authors (Masaki, 1979 ; Ohsumi *et al.*, 1970 ; Kato, 1982). Fig. 3 shows plots of frequency distribution of testis weight against length of the animal as an index of length-weight linked sexual maturity. As expected, an analysis based on 1982-1983 samples (N = 986) showed no significant difference between the left and right side testes. Using the length at sexual it was found that about 94.0% of males caught off Brazil are sexually mature at 7.0 m (22.98 ft) and this value is almost similar to the findings of Masaki (1979) who found that 23.3 ft to be the length for sexual maturity of males in Area II. However, the body lengths of matured males ranged from 7.0 to 9.2 m (mean 8.3 m), whilst the range of testis weight was 50 g-4600 g (mean 2433 g). Despite considerable individual variation, the plots further suggest a peak increase in weights of testes with the greatest numbers of testes falling within a narrow length spectrum of 7.0-8.5 m (Fig. 3). Immature males with testes less than 400 g were very few. These results are consistent with the estimates for the previous years (Singarajah, 1984 a). On the other hand, da Rocha (1980) estimated the length at maturity of females off Brazil to be 26.5 ft which is somewhat higher than the value of 26.1 ft estimated by Masaki for the females in Area II. Fig. 4 compares the sex ratio and lengths of all species of whales caught off Brazil.

Pregnant Females and Foetuses :

Only a few reliable records on pregnancy are available off Brazil. These data indicate that always the resting females dominated the catch and pregnant females were recorded only occasionally for the different species taken. However, the data on minke whales from 1963-1983 showed only three cases of foetuses (Singarajah, 1984 c). In addition, this year (31-08-1984) a further foetus was found with the following details ; male, length 0.95 m ;

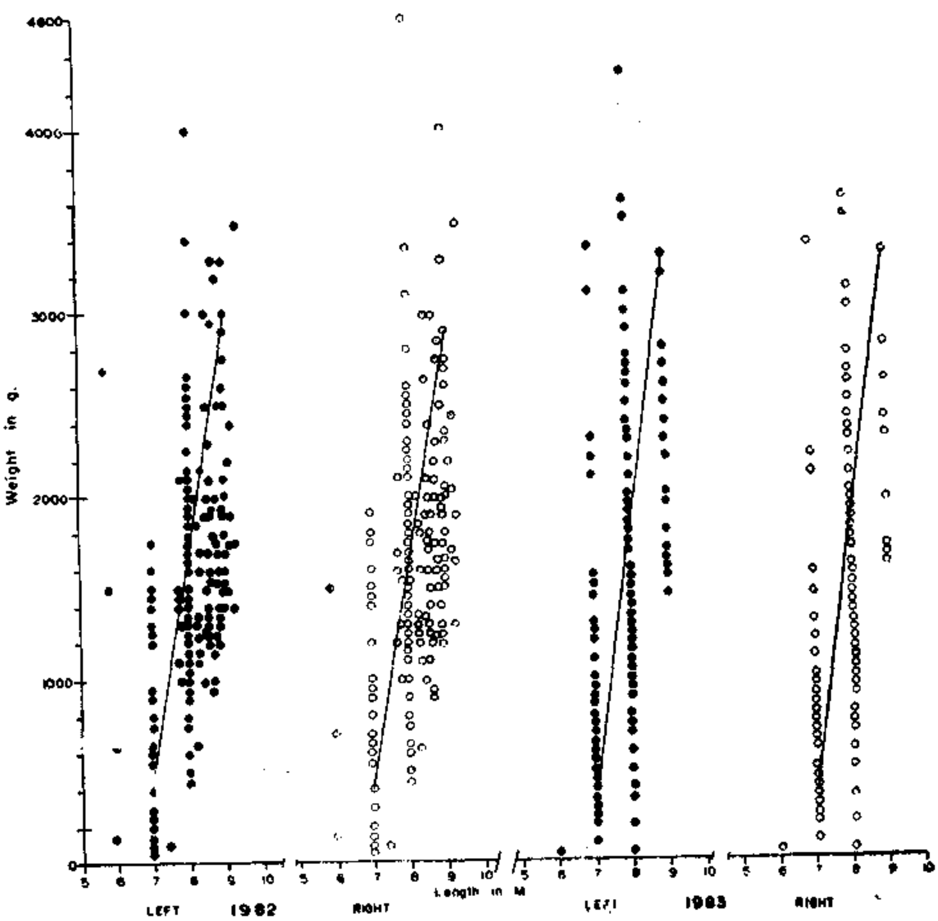

Fig. 3. Change in testis weight with body length in minke whale (1982—N—575 ; 1983—N—410)

weighing 15.5 Kg. The most conspicuous features were the unusually enlarged head with fully formed mouth, blow hole, and eyes; the latter still remained closed. The tail fluke with discernible notch and dorsal fin were well developed. The fore-limbs neatly modified into expanded flippers; the three central digits were distinctly elongated while the marginal ones were either reduced or all. Their blubber thickness is also considerably reduced; this is more so in females than in males (Singarajah, 1984 a). These animals possibly derive some of the energetics from the stored fats in the blubber, particularly during their breeding activities and migration. Increase in blubber thinckness had been shown to be correlated with feeding in blue whales in the Antarctic (Mackintosh *et al.*, 1929).

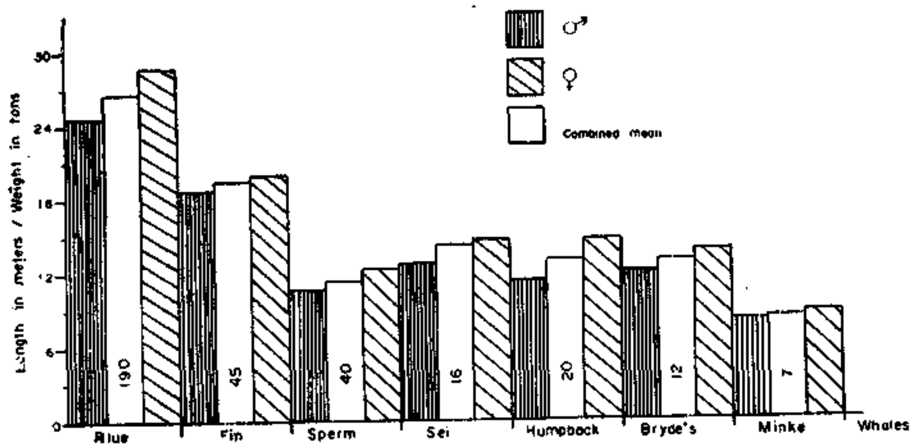

Fig. 4. Lengths and sex ratios of the different whales taken off Brazil. Weights were computed by adding different parts; blue whale is rough estimate.

indistinct under the folds of skin. The hind limbs were totally absent without any trace externally. The penis usually protruded out and the umbilical cord was relatively short. The skin was smooth with neither colour nor any hair; probably the body colour pattern develops only after the birth. Of the total 4 foetuses of minke whales recorded so far, two were females and two males.

Feeding :

Of the minke whales, whose stomachs were examined for contents, none reported to have had any identifiable food, either krill or any other species. Often the guts were empty but for the slimy fluids. During their mating time off Brazil, they do not seem to feed at

EXPLOITATION

Catch Composition

Although the catch data are incomplete, Table 1 gives a more precise information on all species of whales taken off Brazil from 1910 to 1984, including the quota of 600 minke whales allowed for Brazil this year. During this period, Brazil took 921 Sperm whales; 2 Blue whales; 25 Bryde's whales; 3,715 Sei and Bryde's (recorded as Sei) whales; 1,362 Sei whales; 87 Fin whales; 13,722 minke whales; and 1,552 Humpback whales; thus making up a total of (921 toothed + 20,472 baleen) whales. Following the IWC management procedure, Brazil concentrated her efforts on minke whales (though took a few other species occasionally until 1981) since 1964 to the present.

Exploitable Stocks of Southern Hemisphere

As explained earlier, and for the management purposes, minke whales of the Southern stocks are the only species allowed to be exploited. Accordingly, the major whaling nations, USSR and Japan operate pelagic whaling in the Antarctic, while Brazil operates coastal whaling, but only within Area II. Since the exploitable stocks are of common nature, a comparison of the catch data is thought to be important. Fig. 5 summarises catches taken during 1972/3-1982/3 seasons. By comparison, of the total of 8,0019 minke whales, in apparent order of numbers taken

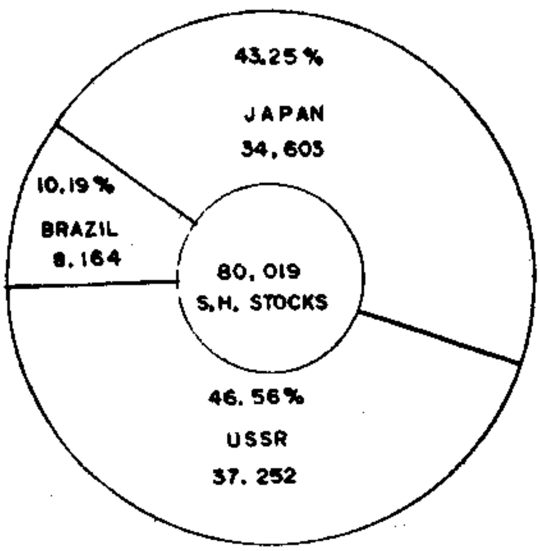

Fig. 5. Percentage of Minke whales exploited by the three major whaling nations ; Antarctic stocks based on 1972/3-1982/3 seasons.

during this period, the USSR ranked first, followed by Japan and lastly Brazil ; the latter took only 10.19 % of the total catch. Fig. 6 compares the catches by month in different geographical localities. The advantage of this comparison is that it helps to correlate the movements of minke whales of the Southern stocks, both spatially and temporally. It can also be used for estimating the seasonal abundance of Antarctic stocks.

Sightings and Schooling Patterns

Although not very precise, the data on sightings give some information on size of pods or schools of minke whales only. Whaling operations in Brazil are usually accompanied with a constant watch for whales at crusing speed, normally between 6 to 16 Hours. But, this strategy has been changed since this year and the average sighting hours per day is 8.95 hours. About 10 experienced topmen watch in the barrel at a time and sightings are recorded through the Captain as a routine part of the day's work. An analysis of the overall data of 1963-1983 on minke whales sightings and catches shows an annual mean ratio of sightings : catch at 1.67 : 1. Based on available data for this year, the number of minke whales sighted per hour works out to be 0.67. This is not very different from the results for the past years (Singarajah, 1983) though it reflects a slight improvement in the efficiency. The numbers of both sighted and caught were usually higher during September to October each year, which has been the peak period for Brazil. This rather higher ratio is indicative of the relative abundance of minke whales in the area.

Size of Schools

Table 2 presents the frequency distribution of school sizes based on 1981-1983 data. The size of schools for Brazilian waters varies for both years and months. The single animals (42.5 %) often predominate in all months of the whaling season, and the largest size is rare (0.2 %) ; and as noted above, the largest numbers of schools are found during the peak time.

UTILIZATION

Primarials and Products

Except perhaps the blood and a few other trivial materials lost both at sea and the

TABLE 2. *Frequency distribution of school sizes of minke whales based on monthly recordings during 1981-1983*

Size of pods or schools	Monthly mean sightings June	July	August	September	October	November	December	Total	%
1 ..		22	32	55	85	57	40	291	42.5
2 ..		16	26	58	61	42	17	220	32.1
3 ..		5	9	22	30	14	5	85	12.4
4 ..		3	5	11	16	5	6	46	6.7
5 ..		1	2	4	7	1		15	2.1
6 ..			3	3	3	2	1	12	1.8
7 ..				1		1		2	0.3
8 ..			1	1	1	1		4	0.6
9 ..				1	2			3	0.4
10 ..			1			1		2	0.3
11 ..								1	0.2
12 ..					1			1	0.2
13 ..						1		1	0.2
20 ..					1			1	0.2
		47	79	156	207	125	69	684	100

factory, the entire whale is utilized as meat, cartilage, gelatin, oil and fertilizer. The minke whales are highly edible due to their protein rich high yield of meat (Singarajah, 1984 a). As the commercial whaling is concentrated solely on minke whales at present, the oil is regarded as relatively inferior in quality than the sperm oil.

The full quota of whales is landed at Costinha shore station on the northwestern bank of a small harbour, Cabedelo (Singarajah, 1978). The whales taken at high seas are tied by their flukes to the sides of the catcher boat. They are first gutted by inserting special knives into the belly or ventrolateral aspect of the body to eviscerate and partially wash while they are being dragged and floated horizontally with the slow speed of the boat. This keeps the whales wet in fresh sea water, thus preserving the meat in good condition until they reach the factory.

Utilizable Whale Products

At the factory, the whales, after landing, are hooked to the steel wire by the fluke ends and winched through a huge tank of fresh water and washed before reaching the flenching platform. They are thoroughly washed again by flusing out with jets of water, using large hoses. They are then cut, one at a time, into various parts and carried by the electric winches to sorting platforms or storage tanks according to the criteria of the products. This involves careful removal of head, flukes, fins, flippers, blubber, meat, cartilage, and bones. The meat is classified into : (1) fresh consumption, a part of which is sold at the factory itself ; (2) frozen, largely for export ; and (3) sun dried, also for export. The frozen components are stored in large storage tanks at −35°C. These are soon packed into plastic containers and then sealed in wooden boxes, all under strict supervision of the Inspectors from the Ministry of Health and Agriculture & Food. About 30% of the whale products, particularly meat, gelatin, and cartilage are exported mainly to Japan. The blubber and other residual parts rich in fat are used for extraction of oil under compression boilers.

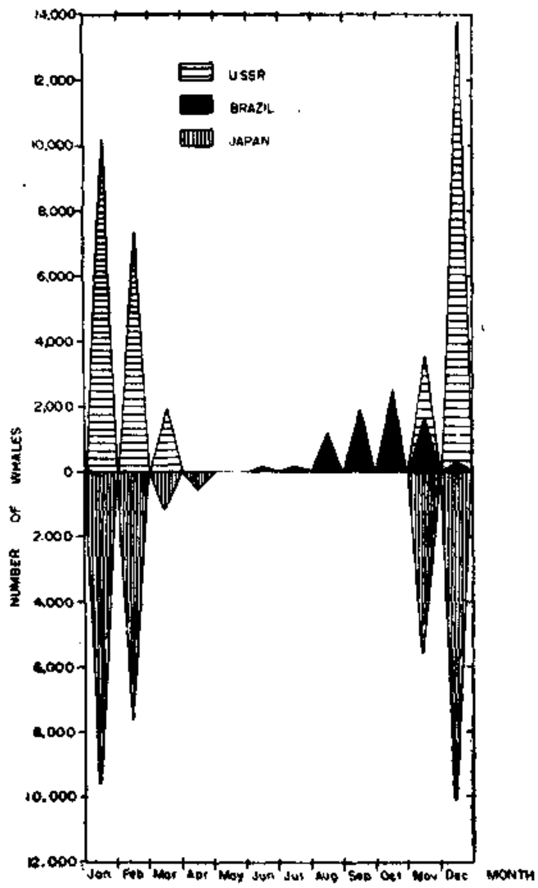

Fig. 6. Comparison of Antarctic minke whale catches by the major whaling nations in different geographical areas.

The boney elements are converted into fertilizer. The flukes, which contain a thick layer of gelatin, and the fins are used for making gelatin. The baleen plates are dried and sold as ornaments.

While a portion of the palatable whale fillets or stakes are reserved for local consumption and exportation, a good proportion of them are sun dried with or without salt (Table 3) by laying the fillets flat on nylon nets about a metre above the drying platform. The flukes and fins are commercially valuable for edible gelatin; the oil is sold at local markets for industrial applications and to produce a number of valuable bye-products.

Whaling Industry a Regional Strategy

Although the whaling season usually involves June to December, the factory operates all the year round. Consequently, there has been a major movement of people from the neighbouring states to Lucena, the Municipality which receives a greater revenue from the whaling industry. Nearly one third of the population of this area is employed in the factory on a permanent basis. The general growth of the work force, excluding executives and temporary employees, salaries and capital growth are presented in Fig. 7. How-

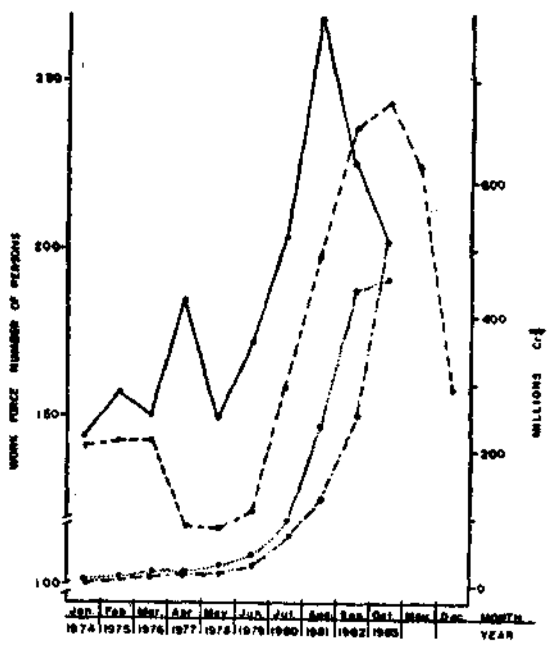

Fig. 7. Changes in the permanent work force; salaries and capital growth; 0—0 annual, 0— —0 monthly, 0 . . . initial capital and 0 . — . — . 0 capital growth.

TABLE 3. *Annual whale products based on mean of 3 years* (1980-1982) *catch-production data at Costinha factory*

Primary Materials		Initial Products Tons	% loss during processing of the initial product	Final Products Tons	*% of Total
1. Fresh meat	..	250	—	250	3.88
2. Frozen meat	..	700	—	700	10.85
3. Frozen dermis	..	250	—	250	3.88
4. Frozen fins, flippers, flukes etc.	..	25	—	25	0.39
5. Frozen cartilage	..	7	—	7	0.11
6. Sun dried meat	..	807	38.00	500	7.75
7. Dried-salted meat	..	938	52.00	450	6.98
8. Whale meat meal	..	1,200	75.00	300	4.65
9. Whale bone meal	..	667	70.00	200	3.10
10. Whale oil	..	1,875	60.00	750	11.64
Total	..	*6,719	*46.70	3,432	*53,30

ever, the increasing pressure of unemployment, in the already poverty striken northeastern part, added by drought, makes the preservation of this regional industry more vital. This industry has so far contributed directly to the vital regional prosperity and economic future, particularly of the state of Paraiba.

Discussion

Migrations and Stock Identity

Extensive seasonal migrations often up to tens and thousands of miles are characteristics of the Southern Hemisphere minke whales. The seasonal migrants from their feeding grounds in the Antarctic to the warmer mating grounds off Brazil are largely of a breeding stock (Singarajah, 1984 c). Although their migratory routes are still a conjecture, they probably turn to left off Falkland and follow up the waters along the continental edge, undulating between the neritic and oceanic zones off Brazil. Eliss (1969) suggested that they might follow the cold Falkland current, but this poses an interesting question as to how far? Williamson (1975), on the other hand, noticed the total absence of Southern minke whales off Southwest Africa (Benguela current area) and their presence off Southeast Africa (Durban). However, future studies are required to draw any specific conclusions.

Flipper colouration of minke whales in the Southern Hemisphere has been considered as the single most important external feature. The absence of a white patch or strand on flipper of Antarctic stock had been reported by a number of authors (Williamson, 1959; Van Utrecht *et al.*, 1962; Zemsky *et al.*, 1964; Ohsumi *et al.*, 1970). On the other hand, the existence of a white band or light band has been pointed out by others (Taylor, 1957; Aguayo, 1974). Accordingly, Best (1984) recognized three types of minke whales landed at Durban based on colour phases of the flippers, baleen and length of animals. He calls the smaller minke as 'diminutive' type. As already reported (Singarajah, 1984 a), observations based both in the field and at landing station so far confirm that principally only one substock dominates, the ones with dark calyx shaped (Singarajah, 1984 a), but the season 1983/4 shows that this trend has changed. Sex ratio based on catches of the Antarctic stocks are given in Table 4 (see also Figs. 2 & 8). This trend further suggests

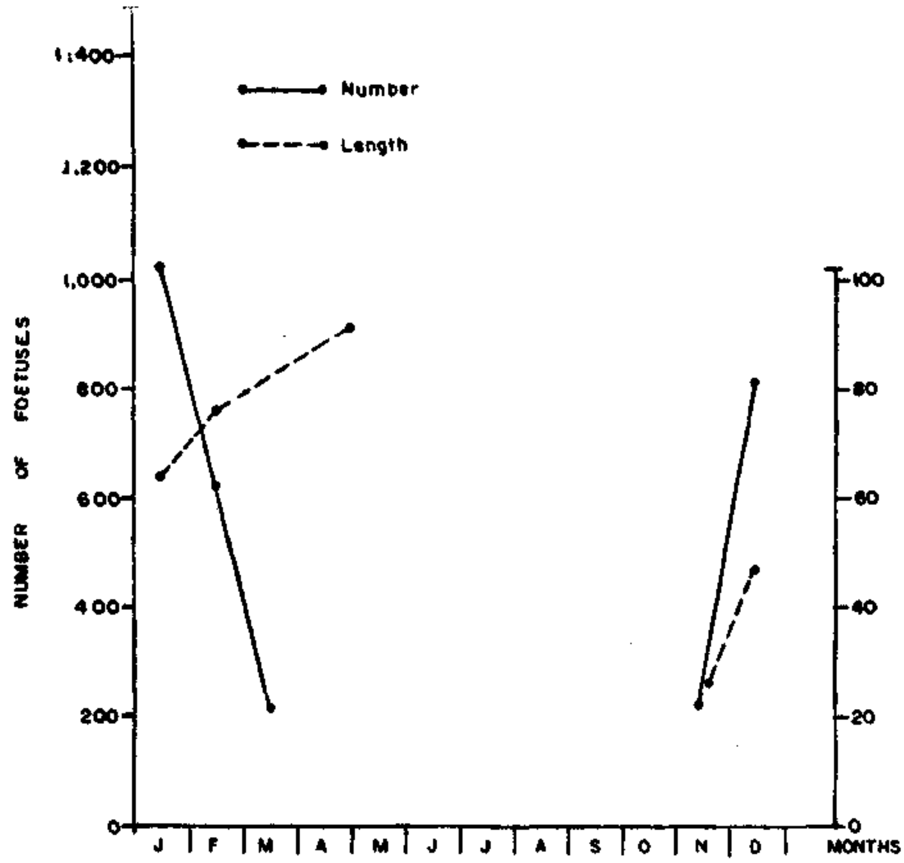

Fig. 8. Minke whale foetuses encountered in the catch during 1982/3 by months and numbers.

no white patch on dorsal side of the flipper (Williamson, 1975). A few cases recorded as Type 'B' off Brazil are not the regular substock. At present, the data on this 'B' type are not sufficient to accurately establish their origin or to call them as 'diminutive type' (Best, pers, commun.).

Ohsumi *et al.*, (1970) reported that the sex ratio of Antarctic minke whales, at least in higher latitude of Area IV, to be 70-80% males. However, an analysis of the catches taken by the three major whaling nations for that generally the females out number the male population. In view of this, the recent quota

TABLE 4. *Sex ratio based on catches of the Antarctic stocks of minke whales during 1983-84 season*

Season	Major nations	Sex ratio male : female
1983-84	.. USSR	1 : 1.6
1983-84	.. Japan	1 : 1.8
1983	.. Brazil	1 : 2.0

system by IWC to restrain from taking more females seems to need a review.

Age at Maturity, Pregnancy and Foetuses

Age at maturity for Brazilian minke whales is still incomplete. The average length of Brazilian minke whales by sex is 8.4 m for males and 8.7 for females; while the overall mean length based on 1963-1983 samples is 8.7 m. In fact, these figures are again almost comparable to those available data on length of Antarctic catches where the average length of male is 8.4 m, female 8.8 m; and the overall length 8.7 m.

Of the total of 4,046 females caught in the Antarctic during 1982/3 season, 81.7% were pregnant; and 3315 foetuses were recorded, including 9 twins. Of the foetuses, females comprised 46.99% while males 45.69% and the sexes were indeterminate in 7.32%. The maximum number of foetuses were recorded during December—January—February, a peak period of foetuses; the length of them also was relatively more (Fig. 8). Mean length being 0.65 m (N=2872). As already pointed out earlier (Singarajah, 1984 a), the lactating females and calves are rarely found in Brazilian waters, though only on one occasion a female was seen accompanied by a calf (author's observation 1980). Based on the very limited data (N 4), the mean length of Brazilian minke whale foetus was 1.20 m, with a sex ratio of 1 female : 1 male.

If gestation period of minke whales is 9.5 months, with peak mating period in early to mid-October and peak calving period late July (Masaki, 1979), and yet Brazilian waters are not calving grounds (Singarajah, 1984 a), then they ought to be calving somewhere else. It is interesting to know in which Area the maximum number of minke whale foetuese is taken. Unfortunately, there are no data available on this. It is commonly believed that the newly born minke calves are about 1.80 m in length. If this is true, again, according to Masaki's criteria, the foetuses are too small to be born in Brazilian waters. Williamson (1975) considered that minke whales prefer to give birth in cool southerly waters of about 15-20°C. Also, the data of 1982/3 Antartic catch clearly show (Fig. 8) that the greatest number of foetuses was taken during the peak, particularly January, with a mean length of, despite individual variation, 0.65 m. This would further suggest that the foetuses need to grow their full length rapidly during next six months or the calving must occur sometime later in the season.

That the Brazilian waters are not calving grounds receive further support from the absence of any evidence of their feeding. Nor do any krill rich productive upwelling areas where they usually concentrate exist. Feeding habits had been reported in the Antarctic minke whales (Ohsumi, 1979). Busheuv (1984) observed that minke whales feed principally on *Euphausia superba* particularly during 4 to 6 am and 4 to 6 pm in the Antarctic and they consume, provided weather conditions being favourable, between 150-200 Kg at a time. This may well coincide with the diurnal vertical migrations of plankton.

Relative Abundance and Population Estimates

Results of abundance of estimates generally proved a measure of confirmation that there was no direct evidence for serious decline of minke whales in this area (Singarajah, 1983). Despite some annual variations, the abundance remained constant. The variations, which were largely due to a number of parameters in calculating CPUE (Mackintosh, 1965); the main being efficiency strategy of the vessels. Although a number of vessels had been in use in the past (da Rocha, 1983), a relatively modern vessel, *Cabo Branco*, has been operating from Costinha since 1977. The essential characteristics of this catcher boat are sum-

TABLE 5. *Essential characteristics of the catcher boat,* *Cabo Branco *in Brazilian waters and the annual average catch : sightings ratio based on* 1977-1983

Specifications of vessel			Average catch : sightings per year	Ratio of catch : sightings
Length (overall)	..	49.65 m	794.14 : 1197.71	1 : 1.51
Gross Tonnage	..	395.18 t		
Net tonnage	..	112.53 t		
Cruising speed	..	11.00 knot		
Maximum velocity	..	11.10 knot		
Horse power of the main engine	..	3,150		
Crew number	..	28		

* *Yatsu-Maru* 10 had been renamed.

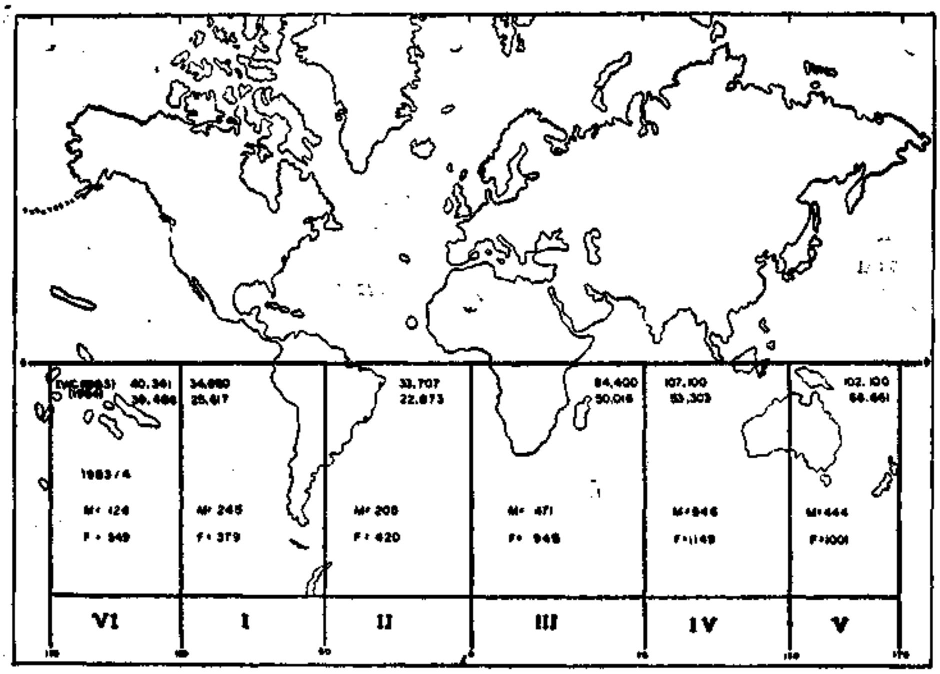

Fig. 9. Southern hemisphere minke whale stocks : estimates of population by areas and the actual catches by sea during 1983/4 season.

marised in Table 5, together with sighting and catch ratio corresponding to the period of her operation.

Population Estimates of Southern Hemisphere Minke Whales

All the larger species of whales are under IWC protection now. All the available evidence indicates that Southern minke whale stocks were increasing to a level prior to exploitation (FAO, 1981). Often, even the most conservative estimates so far proved to be only approximate. However, based on the recent IWC/IDCR sightings estimates, and after making some corrections for errors inherent in parameters, re-estimates of the Antarctic population have been made (IWC, 1984). These are summarised Areawise in Fig. 9. As can be seen, the total population for all six Areas in the Southern Hemisphere for 1983 was 405,298 minke whales. By re-estimation, this population has been reduced by 36.26% for the whole Antarctic. Catch limits are now based on replacement rates of 3-4% on the estimated size for each Area. Brazil comes under Area II, and the calculated allowable quota for this Area was between 513-684 minke whales. An analysis of Brazilian data revealed a 2.5% recruitment rate for Brazilian population. Using this growth rate on a density-dependent basis, our projections showed surprisingly very similar results of 684 minke whales for Brazil for 1984 (Singarajah, 1984 c). Fig. 9 compares the estimates for different Areas and also the number of minke whales caught, by sex, during 1983/4 season by the three major whaling nations who share the Southern Hemisphere minke whale stocks at present.

Conclusions

Altogether this article gives a general account of whaling in Brazil, particularly of minke whales. Obviously, major concentrations of other species of whales are found off Brazil. Almost all of these are now protected under IWC.

At the present state of many uncertainities of parameters, the real population abundance is poorly conceived. Many sensitive mathematical models and simulations are used to predict whale stocks, but these are little understood by most.

Even though the larger species are under protection, recent estimates indicate that minke whales are increasing (FAO, 1981; IWC, 1984). If minke whales have truly increased, careful management is still needed. Future researches should be designed with objectives of carefully monitoring the whale resources, without endangering the species. Brazil for one is always committed to abide by decisions based on sound scientific findings in implementing any long term policy.

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THE USE OF PROFESSIONAL SEAFARERS IN DATA COLLECTION ON VARIOUS MARINE SPECIES

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ABSTRACT

The requirement for more data on present populations of marine animals as a prelude to any conservation programme is recognised. This paper shows how non-scientific personnel engaged in a marine occupation have a part to play and can assist with the data gathering. The format of report forms and the amount and type of information sheets are discussed and examples given.

INTRODUCTION

THE NEED for the continued collection of data on the movements and distribution patterns of marine animals is of the utmost importance for the support of any programme for conservation and management of the marine ecosystem. Observation and monitoring of the various populations present differing problems according to the species being observed. Marine animals such as seals, sea lions and turtles return to land to give birth to young or to lay their eggs and consequently are much easier to observe than are the totally aquatic cetaceans. There are many ways in which data has been and continues to be collected. The catch statistics for both large and small cetaceans have been published annually as International Whaling Statistics by the Committee for Whaling Statistics since 1930. Special Publications of the Scientific Committee of the International Whaling Commission are an excellent source record. Periodic whale sighting cruises by ship or aircraft organized for a special purpose (Compton-Bishop *et al.*, 1979 ; Jackson, 1980 ; McBrearty, 1981) are invaluable as a means of data collection and every effort should be made to find financial support for them. However, these cruises have the disadvantage of being very expensive to mount, difficult to arrange a time suitable to all those taking part and also they are vulnerable to periods of bad weather or other problems (Pilleri, 1977).

A limited experiment on a low-cost solution to the problem of collecting data was tried by the author in collaboration with Professor Sir Richard Harrison and the late F. C. Fraser from January 1975 for a period of two years using the facilities of the Royal Air Force Air Sea Rescue Service. These high speed launches were, in the nature of their duties, based on six stations strategically placed around the British Isles. They remained 'On station' before, during and after normal flying and training routines and were in an ideal position to observe and report cetacean movements. Identification sheets and observation report forms were provided for use by on board personnel. Initial results from this experiment showed some difficulties due principally to the requirements of an active service unit. However, they were sufficiently encouraging to try something a little more ambitious. With this in mind a new exercise, the 'Dolphin Survey Project' was started in conjunction with International Dolphin Watch. This project involves the identification and reporting of cetaceans principally by deck officers of the British Merchant Fleet although a most useful contribution is made by the Royal Navy, Trinity House, the inshore fishing fleet and many private yachtsmen.

The author wishes to thank Dr. E. H. R. Ford, MD, Acting Head of the Department of Anatomy, Cambridge for permission to use the facilities of the department. I am also indebted to Dr. J. T. Houghton, CBE, D. Phil., FRS, the Director-General for permission to use the services of the Meteorological Office, to Captain G. V. Mackie, MNI, Marine Superintendent and to Captain J. F. T. Houghton, MNI, of the Marine Division for their provision of material for our programme. Finally but by no means least, to my colleague Gillian King go my special thanks for her untiring help and encouragement with the Dolphin Survey Programme, with this and with many other projects.

Methods of Operation

Identification material

It is essential that some kind of identification material be provided for the use of all observers. This material can be either in the form of a booklet or as single sheet descriptions of one or more animals per sheet. Each description must be accompanied by at least one drawing or photograph of the whole animal. The question of what kind of identification material to provide does present a few problems, not least that of financial outlay. There are now commercially available, several books on the field recognition of cetaceans of which those of Leatherwood *et al.* (1976, 1982, 1982), Watson (1981) and Hoyt (1984) are excellent examples. It should be remembered, however, that in the main, ship's crews are not permanent and that during transfer and periods of leave, books left aboard a vessel often go missing and require replacement.

There are many obvious advantages but also some disadvantages in the use of comprehensive books containing descriptive notes of all cetaceans. Certainly they contain everything an observer is likely to need in any sea area but as previously stated, they are initially expensive to provide. They do contain much that may not be required by the observer during some voyages as a ship's company regularly engaged in the North Atlantic for instance, will not see animals found only in other ocean areas. Alternatively, single sheets with a brief description of several animals which could be expected in a particular area can be as effective at a lot less expense. Our own Dolphin Survey Project uses single sheet posters containing between six and ten animal descriptions. The sheets are printed by Litho-process on standard A4 paper (Plates I and II).

Report sheets

Report sheets can be simple or complex in design to suit the programme requirements. If the report is intended primarily to cover only a few species, then the single sheet from carrying a series of drawings which the observer indicates by mark are useful indeed. Excellent examples of this type of report form are those of Allied Whale and of New Zealand Fisheries. However, where more species options are available, this format has a tendency to look somewhat overcrowded. If a report form becomes too complicated or demanding of information it can be self-defeating and potential observers will tend not to use it. The form used by the Dolphin Survey Project (Plate III) asks for basic information on the position of the sighting, the direction of travel and numbers of animals together with details of prevailing weather conditions including the sea surface temperature. We also encourage

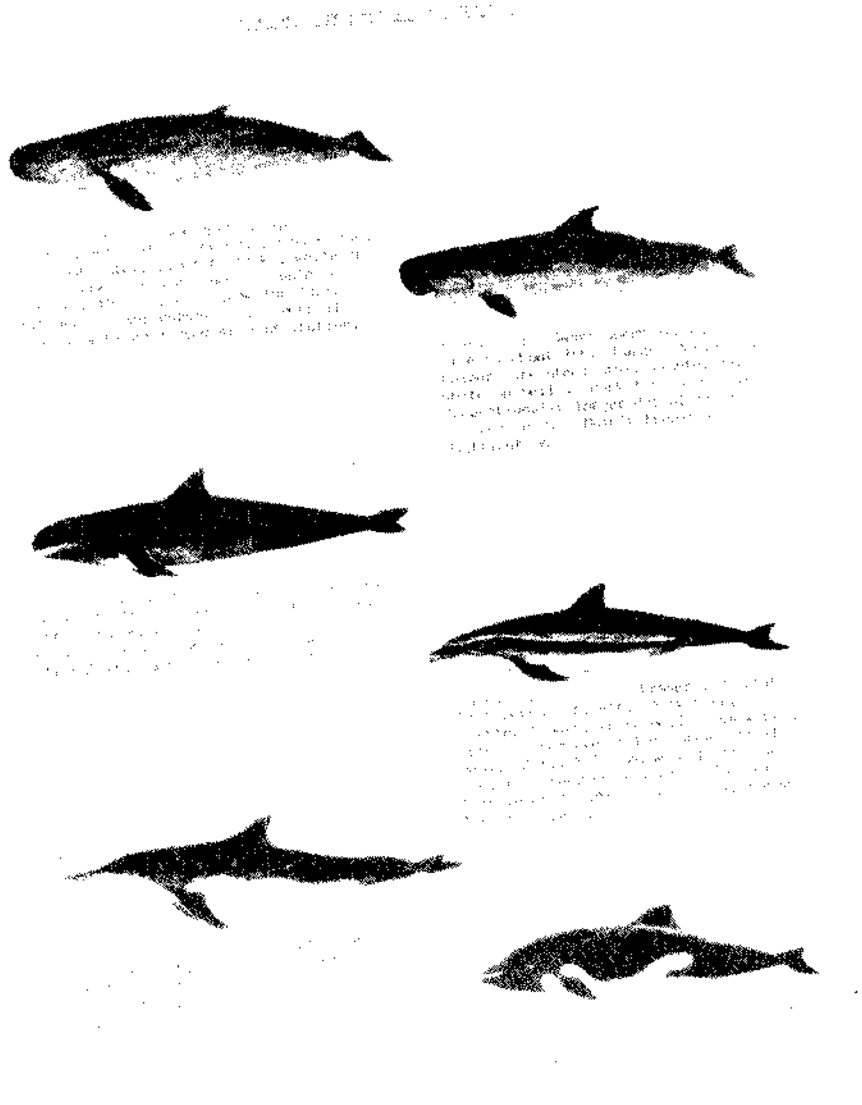

PLATE II. Identification Sheet - Dolphin Survey Project poster.

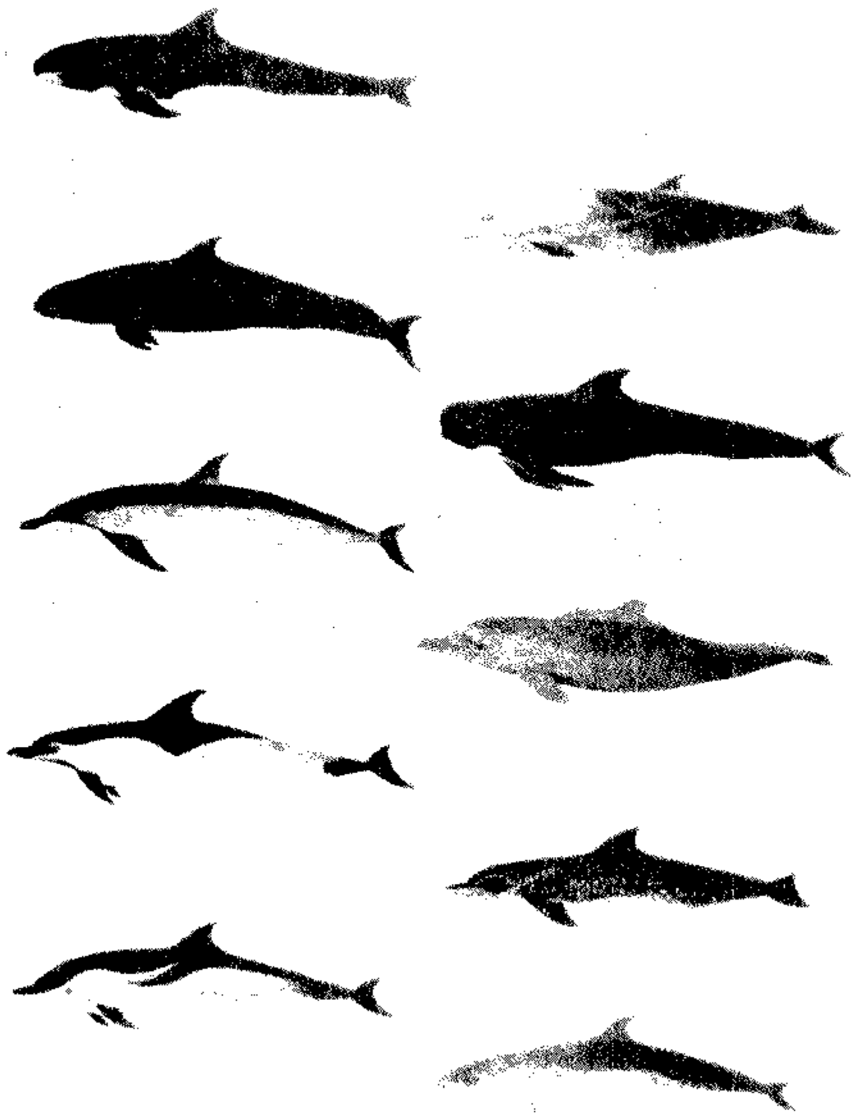

PLATE I. Identification Sheet - Dolphin Survey Project poster.

INTERNATIONAL DOLPHIN WATCH

PLATE III. Dolphin Survey Project Report form.

observers to give details of the identifying characteristics of the animal they are reporting and to make their own drawing or sketch of what they actually see rather than be bound by book descriptions.

Information collected by the observers is returned using either one of two methods. Firstly by direct contact where the observer sends a completed standard Report Form (Plate III) to me at the address shown on the form. These contributors, who provide the majority of our reports, have been recruited over a number of years principally through personal contact and visits and also by recommendation of other observers and by articles in maritime journals. Secondly, by indirect contact where copies of the log book entries of the Meteorological Office's voluntary observing fleet are provided by that office's Marine Division. This fleet of 'Selected Ships' comprises some 421 vessels (16 March 1984), not all of which are at sea at any one time, a number will be in port and others may be temporarily laid up or under repair.

Processing the information

On receipt of each report form the information contained is checked against the description given or any drawing or photograph enclosed for accuracy of identification and allotted a degree of probability rating marked from 1-3 dependent upon the details quoted. Species are enumerated 1-79 using a taxonomic code based upon Mitchell (1975) and Rice (1977) and given a quick reference rating of small, medium or large. Morphological details of form and colour pattern are expressed as a code 1-9, as also are details of behaviour of the animals. Geographical coordinates are entered in terms of latitude and longitude to the nearest minute. To these coordinates another reference number is added based upon 10 degree statistical rectangles similar to the well known 'Marsden Squares' but having a different numbering system. Beaufort Scale numbers are used to encode weather details, sea water temperature to the nearest tenth °C is added in plain language. All data is written onto an 80 column computer statement form prior to transfer to a magnetic disc which itself serves to update the data-base or Master File held in the IBM 3081 computer in the University Computer Laboratory.

Discussion

This system of collection and storage of information enables precise details of each observation to be retrieved in many different forms tailored to suit requirements. It is of course, dependant upon the accuracy of the information fed into the system and the reliability which can be placed upon any individual report or identification. Obviously, some species are easier to identify than others and there is a requirement to frequently update the information available to potential observers. In our programme, we have found that personal contacts have worked extremely well and through these contacts we have been able to improve the reliability of identification from some 50% in 1978 to over 70% by 1982. The current reliability figure for positive identification is approximately 73% with a further 10% of identifications probably correct (Mc Brearty *et al.*, 1985 *in press*). We have also found that the interest that this programme has generated within the British Merchant Service has been considerable. Prior to our programme, many observers were unaware that so many different species of cetaceans existed and of course, neither did they know what the differences were or how to recognise them. The programme has therefore not only collected much information on the distribution of cetaceans (McBrearty *et al.*, 1985 *in press*) but has had the added benefit of creating interest and awareness amongst a very large section of people.

As at 1st January 1984 there were 33 Selected and 207 Supplementary Ships together with 33 Auxilliary Ships in the Fleet List of India voluntarily co-operating with the supply of data to the meteorological services of the British Commonwealth (Anon, 1984). If the personnel on these vessels could be encouraged to observe and report cetaceans within their trading areas much information can accrue, information which could be most helpful to any considered programme of conservation.

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STRANDED CETACEANS—HOW DO THEY OCCUR, AND WHAT DO YOU DO WITH THEM?

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ABSTRACT

In this account the author presents a precise report of a workshop held in October 1983 at Bishops Stortford, England along with the incidences of cetacean strandings outlining the probable causative factors. Some suggestions as to what should be done in the event of a stranding and guidelines have been enumerated here.

INTRODUCTION

THE ROYAL SOCIETY for the Prevention of Cruelty to Animals (RSPCA) and the Scottish Society for Prevention of Cruelty to Animals (SSPCA) have a number of field Inspectors whose duties include dealing with abandoned, distressed and injured animals ; through these officers, an increase in the number of reports of stranded cetacea has been noticed. This may not represent an actual rise in numbers, but may simply reflect the rising awareness and concern on the part of the public.

In recent years, at least three important workshops/symposia have been held to discuss stranded cetacea ; in the United States of America, Australia and New Zealand. However, I was concerned that, regardless of the excellence of the reports of these meetings, there was a dearth of practical advice. I also felt that it would be valuable to gather together a small, international group of scientists with cetacean expertise, along with a group of individuals with practical experience in dealing with strandings. I therefore arranged a Workshop, which was held in October 1983, at Bishops Stortford, England, and I present here a précis of the Report of that Workshop.

WHY DO WHALES STRAND

Why do animals strand? There is certainly no single phenomenon that is the cause of all cetacean strandings, and there are many theories as to possible causes, ranging from the scientifically plausible to, frankly, the ridiculous. Even so, in many stranding incidents, there is little, if any, ultimate certainty about the cause.

Sonar, and other sound reception in cetacea, may be disturbed by diseases, such as parasite loads, that affect the transmission of the nerve impulses to the brain. Thus, the diseased animal becomes disorientated and may be unable to recognise the approach of a beach or, if it can, may be unable to respond appropriately. Disorientation may also be caused by necrosis of the brain, (the equivalent of a stroke) which has been associated with infestation of flukeworm. A migration of flukes has been identified, from the earbones along the eighth acoustic nerve to the brain, in *Delphinus delphis* (common dolphin) stranded in southern California ; these animals swim to the beach in an uncoordinated fashion. This has not yet been identified in animals stranded in the United Kingdom, nor in *Kogia* (dwarf, or pygmy, sperm whale) stranded in South Africa, but it has been seen in brains of *Kogia* (dwarf, or pygmy, sperm whale) in California.

When cetaceans are in shallow waters and are using directional sonar, it is possible they will receive echoes from every direction and may thus be confused. In Iceland, where *Globicephala malaena* (pilot whale) are driven ashore and killed, it is said to be possible to do this only on gently sloping beaches ; evidencing the animals' inability to detect the danger they are approaching.

This hypothesis has been developed by Dr. Dudok van Heel, who, in 1962, reported on 133 live strandings, nearly all of which occurred on gently shelving shores. He tested the response of a boat's sonar to the approach of a shelving beach and confirmed the impossibility of detection. A flaw in the argument is that the animals which strand under these circumstances are nearly all pelagic odontocetes, indicating that coastal species may be able to recognise the problem areas. A possible explanation is that the pelagic species branched off at a relatively early stage of cetacean development, so that the sonar apparatus of coastal species may be relatively more advanced or, at least, developed in the right way to cope with coastal topography.

It has been suggested that the higher frequency components of echolocation in odontocetes are used in the pursuit of prey, and that the lower frequency components are used in orientation and navigation. One might, therefore, expect that a representative of a pelagic species chasing its prey and relying on echolocation (e.g. in murky water) could blunder into a gently shelving shore. This also assumes that non-sonar auditory information does not help the animal to detect the beach ; this assumption, if valid, may only be so in certain circumstances. Equally, it could simply be that coastal animals are more familiar with the signs associated with a shelving beach and their evolutionary development is not relevant.

It has been reported that dolphins have a magnetic receptor and can detect geomagnetic topography. Dr. Margaret Klinowska, of Cambridge University, believes that this ability is utilised for the purpose of orientation, i.e. recognition and maintenance of direction, and hypothesizes that this can result in strandings. When outside their home range, she believes, cetaceans are reluctant to enter areas of high magnetic anomalies, so they follow the lines of the minimum magnetic field. Dr. Klinowska's examination of geomagnetic fields and the statistics of strandings around the United Kingdom indicates that live strandings occur exclusively where such lines of minimum field cross the coast (carcases of dead animals are more generally distributed). This provides yet another explanation as to why offshore species, travelling outside their usual range, strand more frequently than inshore species. In summary, a cetacean in unfamiliar waters may be guided in its orientation more strongly by magnetic forces than by the topography of the coast, and may be directed into the coast.

Yet a further suggestion is that the ancestors of cetaceans were land-living mammals whose descendants were progressively better adapted to a marine environment. At some stage, they would have been amphibious ; as pinnipeds are today. Dr. F. G. Wood hypothesizes that, at this stage, the need to seek the safety of land as a response to stress whilst at sea became ingrained in the subcortical systems of the cetaceans and has persisted to the present day. Thus, a cetacean under stress, for instance from attack by predators, or from injury or disease, would instinctively still tend to seek the ' safety of land ', or, at least, shallow water, (but the land is no longer safe, because these animals have lost their adaptation to a terrestrial environment).

This theory would certainly help to explain some of the mysteries surrounding a number of strandings, such as the persistent re-stranding of animals returned to sea. It is also supported by the fact that a number of observed strandings have been highly directional and not the result of animals blundering into shore. A *Steno bredanensis* (rough-toothed dolphin), stranded on Maui, Hawaii, for example, returned immediately to the shore after being taken 2-3 miles out. Mass strandings could occur when a stressed animal of a pelagic species heads towards land, accompanied by the members of its social group which then become stressed, finding themselves in unfamiliar and shallow waters.

The theory is explained at length in ' Biology of Marine Mammals ; Insights Through Strandings ', edited by Geraci and St. Aubin. It does not account for all strandings, but Dr. Wood believes that it appears to account for more of the reported features and circumstances of strandings than any other proposed explanation.

Rather than asking why whales strand, Mr. Tom Bergin asks ; ' Why do whales usually not strand ? ' The answer is that they automatically perform three essential functions : (1) they perceive the presence of land ; (2) they decide to avoid it, and ; (3) they make the appropriate motor effort to do so. Interference with a cetacean's ability to perform any one of these three functions at the crucial moment may result in a stranding.

Clearly, the effects of disease are an important consideration. An animal whose senses are impaired by disease (whether by parasitism, secondary bacterial infection or some other problem), or whose thinking process is interfered with (for example, through cerebral abscess, epidural haemorrhage or pyrexia due to septicaemia), or whose motor functions are disturbed (for example, by traumatic injury, hepatitis, pneumonia, peritonitis, nephritis, dystocia, metritis, starvation or emaciation), could easily be unable to respond appropriately to the approach of land. However, as Bergin points out, disturbances in the sensor-analysis-response sequence are not confined to those resulting from disease. An inability to detect land may be the result of environmental factors such as gently shelving beaches, murky water or geomagnetic alignment. If the land is perceived, the decision to avoid it may be ill-affected by inexperience, (especially if the animal is very young), panic or mass hysteria, or even a faulty memory. Once a cetacean has come close to the beach, even if it has decided to take evasive action, it may be prevented from avoiding it by environmental phenomena, such as entrapment by the tides.

Frank Robson has suggested a cause of mass stranding in social species, such as *Physeter macrocephalus* (sperm whale), where, when young males become sexually mature, they may represent a potential threat to the harem bull, and are chased away ; the females in the group may also reject a male which is approaching sexual maturity. Such a reject is likely to be inexperienced and distressed and, while rapidly trying to escape the attack, may become stranded if rejection occurs close to land. In such an event, its distress calls might conceivably attract other members of the social group if they are in the vicinity.

It should be mentioned that cetaceans do strand temporarily from time to time ; for instance on sandbanks. This is thought to happen when they are chasing their prey, so that their concentration is not on beach orientation, but it may only take a large wave or a change of tide to remove them. In light of this, it may be wondered how many coastal strandings would be temporary but for the topography and the sea conditions.

A number of cetaceans are so sick that they are clearly unable to guide themselves properly through the water ; under these circumstances there seems little point in seeking other reasons to explain the event. However, even in these cases, the location of the stranding might be explained by Dr. Klinowska's theory, or the reason for the coming to land might be provided by Dr. Wood's postulation. These hypotheses though, like that of Dr. Dudok van Heel, are also applicable to healthy animals which strand.

None of the existing theories adequately explains why mysticetes (Baleen whales) almost never strand alive, or why strandings of coastal species of odontocetes are very rare. With regard to the latter, however, common sense tells us to expect that species which constantly live in association with the coast might be better equipped than pelagic species to recognise and respond to the intrinsic dangers.

Of the possible causes of stranding we have considered, any one, or a combination of several, might explain the stranding of a single animal. Mass strandings might be the result of either the group responding to the distress calls of a single stranded animal, or of the entire group being affected by one of the stranding causes outlined above.

The French experience, outlined by Professor Duguy, reinforces the suggestion that pelagic species are more vulnerable than those which are more coastal inhabitat ; in *Tursiops truncatus* (bottlenose dolphin) and *Phocoena phocoena* (horbour porpoise) the percentage of live strandings is very low ; 3.6% and 3.4% respectively. In *Delphinus delphis* (common dolphin) and *Stenella coeruleoalba* (striped dolphin) the percentage is much higher, 22.9% and 29.9% respectively ; *Globicephala melaena* (longfinned pilot whale) also shows a relatively high percentage at 13.9%, although only single specimens have been involved. Another species in which live strandings are very high is *Grampus griseus* (Risso's dolphin), at 57.2% of the total strandings of this species.

The French work shows that of *Balaenoptera physalus* (fin whale), 55.6% are stranded dead, but it is noteworthy that only newborn animals were recorded on the Mediterranean coast. They all weighed slightly less than normal and it is possible that the births were premature ; Professor Duguy speculates that this may be a result of pollution.

Dr. Dudok van Heel also reported significant numbers of animals containing high levels of pollutants, yet Dr. Klinowska pointed out that there is no proof of the effects of pollutants on cetaceans.

In Canada, most strandings involve large species ; *Balaenoptera physalus* (fin whale), *Physeter macrocephalus* (sperm whale), *Megaptera novaeangliae* (humpback whale) and *Balaenoptera acutorostrata* (minke whale), large numbers of *Globicephala melaena* (long-finned pilot whale) ; of which 25% were returned to sea, and the occasional *Orcinus orca* (killer whale).

Canadian work indicates large parasite loads in the gastro-intestinal tract, liver, spleen, kidneys, lungs and brains of stranded whales ; even the eye has been found to be involved. However, there is no indication that these loads are any greater than those in most wild animal populations.

How Do We Deal with Strandings

The Workshop attempted to provide some guidance as to what to do in the event of a stranding and suggested that :

1. The public should be kept well away, to protect them, and the animal, from injury or any possible transmission of disease to the humans.
2. It should be determined whether the animal is alive. Life is detected by observing the blowhole for breathing ; it is important to realise that breathing in cetacea is a voluntary operation, and not automatic, as in other mammals,

There may be a considerable delay between breaths. It is unnecessary and could be damaging to test for corneal reflex.

3. Live animals should be kept cool and wet using wet cloths, sacking or seaweed. Shade should be provided if possible.
4. The animal should not be dragged.

It is extremely difficult to ascertain when a live animal is in a terminal condition and requires humane destruction. Various suggestions were made as to criteria for assessing this condition, and it was agreed that there is no minimum time limit after which an animal's condition can be considered terminal; it depends, mostly, on weather conditions and the condition of the animal.

In general, a stranded individual of an inshore species is less likely to survive and humane destruction may be the best solution, but a single stranding of a pelagic species could be successfully returned to the sea. Prior to release, some attempt should be made to mark the animal to ensure easy recognition for at least a short period after; this could be achieved using coloured tape loosely wrapped round the peduncle.

Ofcourse, mass strandings result in considerable publicity and cause a great number of logistical problems.

Groups of animals have been successfully refloated, but this has often meant that part of the group (individuals identified as casuing the incident) had to be killed. Animals, whether stranded singly or in groups, which have been out of the water for a reasonable period of time should be rocked gently in shallow water to alleviate muscle stiffness and aid re-orientation.

In most cases, animals will probably need to be killed; shooting is a proven technique for most small species, and this is accomplished, depending on the species, in one of two ways. High calibre rifles or handguns using low velocity ammunition, or a shotgun with appropriate gauge and cartridge load, can be used. This should only be attempted by an expert with the appropriate instructions.

Explosives have also been used, but great care must be taken, both to ensure the animal is instantly made insensitive to pain and to avoid danger to the public.

Frank Robson uses a lance to despatch large whales, it is pushed in to sever the carotid artery and puncture the heart; this method requires a great deal of expertise and detailed knowledge of whale physiology, therefore it should not be undertaken by non-experts.

Drugs also seem to be a practical method of humane destruction; for instance, barbiturates, Immobilon (Etorphine hydrochloride), Ketamine, or a cocktail of a narcotic and an analgesic for neutroleptanalgesia. Immobilising (non-anaesthetic) drugs, such as Succinyl choline, must not be used. Drugs should be introduced in the caudal peduncle with extreme care to avoid injury to the operator from violent movement of the tail. A long needle, 12-18 inches for large animals, and 6 inches for small, should be used.

There are three main objectives in dealing with a stranding: eliminating, or reducing, the nuisance caused by the public; restoring and saving, or killing, the animal; and collecting scientific data.

In practical terms, it is necessary to appoint a beachmaster who has the assistance and approval of local authorities, such as District or County Councils, in the United Kingdom; law enforcement authorities; animal welfare organisations and veterinary surgeons.

We still do not have a clear idea of why these animals, which appear to be so superbly adapted to the marine environment, become stranded. It is certainly a strange enigma, and one that is creating more and more public sympathy. Television, and the media in general, has presented these creatures as intelligent, graceful and benign cousins to man, so that pictures of them, floundering, totally helplessly, strikes a chord in the breast of the most hard-hearted of men.

It is to be hoped that the Workshop will add significantly to the debate and that a practicable solution is eventually found.

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TURSIOPS ADUNCUS EHPENBERY, (1833) FROM JAVA SEA

TAS'AN

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ABSTRACT

Jaya Ancol Oceanarium Jakarta has made observations on catching, captivity, training and breeding of *Tursiops aduncus* from Java Sea. The staff of this oceanarium have made records of its behaviour. Empirical data have been accumulated for this paper specially on the distribution of the species in Indonesia Waters, population in Java Sea, natural behaviour, catching, captivity and breeding. This paper also presents some comparative data on morphology, organ measurements, blood analysis, body temperatures, hearts beat, etc. among *Tursiops* spp.

INTRODUCTION

Tursiops aduncus, the bottlenosed dolphin, abounds in the Indian Ocean and the adjacent seas : from Red Sea to the Strait of Maccasar and from North of Australia to Japan Sea. Some people from Taiwan and Japan catch them for food, but, since it was known that this species can be trained, oceanaria in Japan, Hong Kong and Indonesia use them in captivity. Since 1975 the Jaya Ancol Oceanarium in Jakarta has been utilising the dolphin for show. They can be bred and reared in captivity.

The catching of this dolphin for the Oceanarium was done in 1979 and 1982 using purse seine net in Java Sea, about 28 miles north of Pekalongan Town, Central Java.

Up to now Jaya Ancol Oceanarium have 17 animals in captivity which include three born in captivity one each on January 21, 1979 ; July, 17, 1979 and July 25, 1984.

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DISTRIBUTION IN INDONESIA

The observation of *T. aduncus* was carried out by Jaya Ancol Oceanarium, Jakarta from 1974 and began in Jakarta Bay, Thousand Island, and in 1976 was extended to Central Java Sea and the Strait of Maccasar. In 1979 the author watched the abundance of *Tursiops aduncus* in the Strait of Bali. The fisheries information mentioned they also can be found in the North of Aceh, South of Sumatra Barat, Strait of Sunda, Strait of Bangka, South of Kalimantan, South of Java, Timor sea and Banda Sea. Usually in the same area, *Stenella* sp. and sometimes *Neophocaena* sp. also occur.

POPULATION IN JAVA SEA

This species in Java Sea can be seen from Sunda Strait to Bali Strait, especially in areas where schools of mackerel and sardine occur. There is belief among fishermen in Indonesia not to catch dolphins because they can help them in trouble, although they steal the fish from their net. A school of *T. aduncus* consist of 10-30 heads, they also live together with *Stenella* sp. but always in separate schools. From direct observation by Jaya Ancol Oceanarium catching Team in Thousand Island and Centre of Java Sea, it is seen that the species is not in danger of depletion, but this is not supported by a sighting and census data. The Government of the Republic of Indonesia also protect the dolphins by law.

SOME NOTES ON BEHAVIOUR IN NATURE

Generally they swim in schools of 10-30 heads, but sometimes as noted by us in Jakarta Bay and Centre of Java Sea, a couple with a young may be found separated from the main school.

When observed from the catching boat, they seem to swim fast when the sea is rough, while in calm sea they prefer to swim around the boat and play. Sometimes they jump high in to the air, falling supane and also sometimes they dance with their head and body above the water. When the boat moves they follow and also ride the bow wave.

Catching, Transportation and Captivity by Jaya Ancol Oceanarium, Jakarta

Catching

Some Oceanaria in the world, catch dolphins with the fork net or hoop net. But, to operate that system needs a proper boat and skilled men. This was beyond the capacity of the Jaya Ancol Oceanarium.

In 1976 we found that we can catch *Tursiops aduncus* by purse seine net. Two purse seine net boats were used, one of them to encircle fish to attract dolphins. When the dolphins come near the net and try to steal the fish from the net, the second purse seine boat operates a net to encircle the dolphins. Jaya Ancol Oceanarium had carried out three successful catching operations in Central Java Sea.

Transportation

From the catching ground, the captured dolphins are laid on the deck of the catching boat supported by thick rubber foam and as quick as possible they are transported to the harbour. Usually it takes about 4-6 hours, and during that time the dolphins are kept in the shade moistening the skin by spraying sea water on their body. From the harbour the dolphins are transported in a covered truck in stretchers to Jakarta.

The whole transportation from the catching ground to the captive pool should not take more than 24 hours and the animals must be kept cool by spraying water on their body.

On their arrival in the Oceanarium before they are released in the quarantine tank, a blood sample from the fluke vein is taken for the laboratory examination to detect any infection.

Captivity

Newly captive dolphins put in the quarantine tank are tense, afraid and refused feed. So, the trainers attend to them around the clock, ready to give any emergency aid if they show slight signs of fatigue, and keep them from drowning or hitting their body against the sides of the pool.

On the second day in captivity they are force fed and this is done for about a week, after which they are trained for self-feeding slowly and gradually until they can do it themselves. The whole force feeding and feeding training commonly take about two weeks. They are given vitamin supplement by putting them in the fish given as food.

Once they eat frozen fish themselves, they adapt their new environment, but, they are acclimatised for about three months and their health carefully monitered before the training programme is started.

The Oceanarium is located near the sea shore, and sea water is pumped to the dolphin tank. However, because the sea water may be polluted, it is filtered and treated with chlorine gas to get the clean water free from pathogenic bacteria. With a semi-closed water system the water quality is maintained as follows :

PH	: 6.9- 8.3		*Water circulation* :	
Total chlorine	: 0.8- 1.0	ppm.	- Turn over	: 3-4 hours
Free Chlorine	: 0.6- 0.8	ppm.	- T.P.C.	: negative
Temperature	: 27.5- 31.0°C.		- Total coli	: negative
Salinity	: 26- 32%			

The table for chlorine treatment and the diagram of water flow system in the Jaya Ancol Oceanarium are given in Table 1 and Fig. 1.

After three months in the quarantine tank when the dolphins are fully adapted to captivity, the training programme is started in different stages.

Some of the dolphins are kept for the breeding programme and the Oceanarium have succeeded with 4 births in captivity during the last 5 years. Three of the young survived while one died due to premature birth.

Morphology

Tursiops aduncus resembles *T. truncatus* (Atlantic bottlenosed dolphin) but is smaller than *T. gilli* (Pacific bottlenosed dolphin).

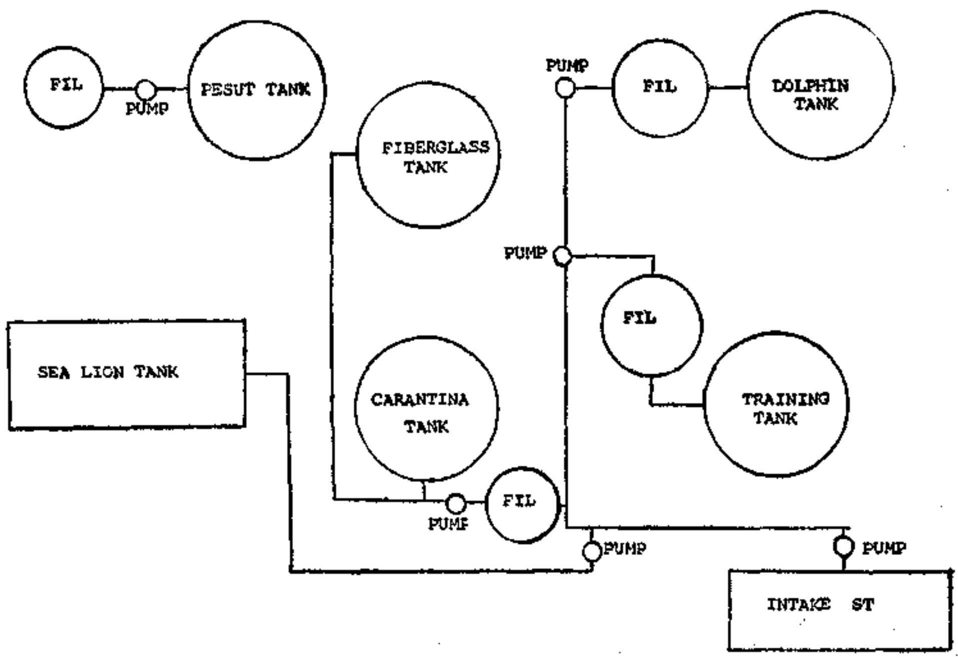

FIG. 1. Diagram of water supply in Jaya Anco lOceanarium.

TABLE 1. *Chlorine Treatment*

Item/tank	Quarantine tank	Dolphin tank	Training tank	Fibre tank	Orcaella tank	Sea-lion tank	Intake tank
Volume of tank	320 m^3	1,200 m^3	600 m^3	200 m^3	460 m^3	200 m^3	100 m^3
Level of free Cl	0.6-0.8	0.6-0.8	0.6-0.8	0.6-0.8	0.6-0.8	0.4-0.6	4.0
Level of total Cl[1]	0.8-1.0	0 8-1.0	0.8-1.0	0.8-1.0	0.8-1.0	0.6-0.8	4.0
Kinds of water	Fresh	Marine	Marine	Fresh	Fresh	Marine	Marine
Period of water change	2 weeks	2 months	2 months	2 weeks	1 month	3 days	every time
Number of animals	4	7	4	4	5	5	..
Turn over	2½ hours	6 hours	5 hours	2½ hours	2½ hours	2 hours	2 hours

TABLE 2. *Morphometric differences between* Tursiops aduncus, Tursipos truncatus *and* Tursiops gilli*

Measurements	Boncel (T a)		Ahikani (T t)		Ehukai (T g)	
	cm	%	cm	%	cm	%
Length (total) ..	199	100	258	100	256.5	100
Tip of upper jaw to apex of melon (rostrum)	13	6.5	11	4.2	9.5	3.7
Girth, on a transverse plane intersecting axilla	98	49.2	102.5	39.7	102	39.7
Girth, maximum ..	99	49.7	110	42.6	105	40.9
Height of dorsal fin ..	19	9.5	25	9.6	37.5	14.6
Width flukes (tip to tip) ..	41	20.6	66	25.5	60.5	23.5
Flipper length (anterior-insertion to tip) ..	36	18	44	17	30.5	11.8
Flipper length (axilla-to tip) ..	21	10.5	30.5	11.8	16	6.2

* The age of the specimens : undetermined.

The different morphometric details between *T. aduncus*, *T. truncatus* and *T. gilli* are give in Table 2.

The Organ measurements and blood analysis in three species, and body temperature in *T. aduncas* are given in Tables 3 to 5.

Breeding

Observations in nature by Jaya Ancol Oceanarium's catching team have never reported babies of dolphin during December to June, either in Central Java Sea or around Thousand Island waters.

TABLE 3. *Organ measurements in three species**

Name of organs		Dolphin No. 10		Ahikani†		Ehukai†	
		Tursiops aduncus		Tursiops truncatus		Tursiops gilli	
		Size	Weight	Size	Weight	Size	Weight
Heart	..	—	461 g	—	2500 g	—	2500 g
Lung (L + R)	..	—	3000 g	—	5420 g	—	5500 g
Liver	..	—	2200 g	—	—	—	2500 g
Pancreas	..	—	—	—	215 g	—	365 g
Spleen	..	—	30 g	—	68½ g	—	105 g
Kidney : right	..	—	215 g	17 × 7 cm	2380g	—	770 g
lift	..	—	212 g	20 × 8 cm	379 g	—	785 g
Intestine	..	13.25 m	—	29 m	4500 g	—	—
Brain	..	—	2200 g	—	—	—	—
Blubber (thickness)	..	1.3 cm	—	2 cm	—	2 cm	—
Body	..	195 cm	—	258 cm	187½ kg	256.5 cm	210 kg

* The age of specimens ; undetermined.
† Imported from Sea life Park Hawaii USA by Jaya Ancol Oceanarium on April 1974 and kept in captivity until death on August 7, 1976 (Ahikani) ; and May 21, 1977 (Ehukai).

TABLE 4. *Blood analysis of Tursiops aduncus, T. truncatus* and *T. gilli* (Jaya Ancol Oceanarium)

Blood analysis		BONCEL	AHIKANI	EHUKAI
		Tursiops aduncus	Tursiops truncatus	Tursiops gilli
		March 28, 1980	August 13, 1974	August 13, 1974
B.S.R.	..	18/41 mm/hour	7/25 mm/hour	2/7 mm/hour
Haemoglobine	..	14.49 g %	16.6 g %	14.4 g %
Haemotocryte	..	46 %	43 %	44 %
Erytrocyte/RBC	..	4.3	2.98	2.98
Leukocyte/WBC	..	5,800	5,200	7,800
Basofil	..	—	—	—
Eosinofil	..	8 %	12 %	10 %
Stab	..	3 %	2 %	1 %
Segmen	..	53 %	59 %	77 %
Lifmphocyte	..	35 %	27 %	12 %
Monocyte	..	1 %	—	—
Bank		—	—	—
S G O T	..	13.17 mU/ml	28 mU/ml	28 mU/ml
S G P T	..	11.80 mU/ml	4.5 mU/ml	4.5 mU/ml
Creatinin	..	1.57 mg %	—	—
Total protein	..	6.85 g %	7.400 g %	8.140 g %
Albumin	..	4.14 g %	4.070 g %	4.440 g %
Globulin	..	2.700 g %	2.330 g %	4.440 g %
Ureum	..	61.33 mg %	88 mg %	93.30 mg %

TABLE 5. *Anal Body temperature in healthy T. aduncus*

Name	Date	Temperature (°C)
Topan	September 11, 1979	35.8
Saburo	September 11, 1979	36.01
Menuk	September 11, 1979	35.8
Boncel	September 11, 1979	36.01

The gestation period in *T. aduncus* is suspected to be about 13-14 months. The mating season of this species is suspected to be during the rainy season or east monsoon in this location.

The process of birth in captivity take about 2-3 hours. The baby's tail comes out first followed by the body and the head last.

The new born is about 70-80 cm in length and 6.5-7.5 kg in weight. In twelve hours after birth, the baby normally commence suckling milk and does so for more or less 6 months, but is still nursed by its mother for about 2 years. After 6 months the baby will start to eat fish. In captivity the trainer starts to give small fish of about 4-5 cm in length. The full feeding on fish begins after 8 months but sometimes even as late as of 12-15 months as the young are not completely weaned. The training for this species can commence at 2 years.

CONCLUSION

Tursiops aduncus distributed widely around Indonesian waters can be kept in captivity and trained. *T. aduncus* in Japan Sea and Australian waters are larger in size than those occurring in Java Sea. This paper is limited to only *T. aduncus* from Java Sea and is not based on a well designed research programme, but is more an information paper based on the working records made by Jaya Ancol Oceanarium and empirical data collected by the author.

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THE DUGONG IN INDIA—IS IT GOING THE WAY OF THE DODO

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ABSTRACT

The residual population of the dugong *Dugong dugon* in the Gulf of Mannar and Palk Bay is today the most vulnerable marine mammal in this region. The sudden escalation of the illegal take of dugongs is discussed here. The number captured or slaughtered has multiplied by 14 times or more within the past 2 years. The use of dynamite sticks is accelerating the possible depletion of this animal aided by other factors such as sail boat trawling along the shore line and the sea grass beds both day and night. The habitat perturbations due to excessive and unregulated mechanised fishing has also become a very critical factor not only disturbing the animals but in incidental capture as well as destroying their grazing grounds. The methods of illegal take, disposal and other related aspects are discussed here. The role that Community Councils and religious leaders could play in the conservation programme for the dugong is stressed. There is a need for an international approach to the problem of conservation and management of the dugong population in this region. This as well as the priority steps to be considered at national level are detailed here.

INTRODUCTION

There is a world wide concern for the protection of the dugong and in India today the residual population of this species in the Gulf of Mannar and Palk Bay is the most vulnerable of species facing extinction. The listing of the dugong in the IUCN Red Data Book, nor its total protection under the Indian Wildlife (Protection) Act 1972, and the efforts of the authorities to curb its illegal take has in anyway slackened the pressure on the remnants of the once large population in the Gulf of Mannar and Palk Bay. Much has been written about the dugong from the Indian seas (Annandale, 1905; James, 1974; Jones, 1959, 1967, 1977, 1980, 1981; Mani, 1960; Mohan, 1963; Moses, 1942; Nair *et al.*, 1975; Pocock, 1941; Prater, 1928; Silas, 1961 and others).

According to Marsh (1981) dugongs 'appear to be long-lived animals with a low reproductive rate, a long generation time and a large investment in each offspring. As such they are very susceptible to over exploitation. Their vulnerability is increased by dependence on a specialised environment which must also be protected'.

At the recently held Indian Ocean Alliance Conference in the Seychelles in 1981, a major recommendation was that priority be given to a dugong survey in the Indian Ocean, with the aim of monitoring and protecting local populations and consider the feasibility of reestablishing the species in the areas where it no longer occurs. Despite the greater awareness to this pressing problem, there are large gaps in our knowledge about the biology, ecology and the behaviour of the dugong. Nor have we mastered the management of the environment of the dugong, especially their feeding grounds. More specifically our knowledge of the unit population, feeding biology, age determination, parasitology and pathology in wild populations to mention a few are greatly inadequate.

The dugong has been kept in captivity in some places and here again the range of observations on its life habits could certainly be improved for a better understanding of the animal itself. In the light of this, we consider that the Seminar/Workshop on the Dugong held at the James Cook University, Townsville, Australia in 1979 to be a land-mark as it brought together for the first time scientists and administrators concerned with dugong research, conservation and management problems and a fund of information on the species from various locations of its distributional range in the Indo-Pacific. In India, unless we build up a greater awareness among the local coastal population on the importance of conserving this resource all efforts as it stands today may turn out to be futile. Today we have no mechanism of thoroughly monitoring the non-legal take of dugongs especially as incidental catch as well as in unauthorised gears deliberately meant for dugong capture. There is a need for an assessment of the fishing activity in the Gulf and Palk Bay areas to evaluate the impact of this type of human interference on the dugong population. Hence it is felt that this report should be timely to highlight the depredation taking place and the urgent need to call a halt to the same.

Fishery in the Past and the Present

From our knowledge as well as from enquiry about the fishery of dugongs in this region we are able to gather that in the past 25 years starting from 1960 only 20 to 25 dugongs were caught accidently as well as by fishing efforts in a year. When Nair *et al.*, (1975) warned of the possible depletion of dugong population the capture figure stood at an average of 40 per year. The following fact is to be noted with grave concern that in Kilakara-Tondi region in one year period starting from April, 1983 to August, 1984 more than 250 dugongs were caught and butchered, an average of 4 per week. This figure was arrived at by head counting the animals butchered at Kilakarai and Periapatnam. Therefore this figure does not include those that were consumed at Tondi, Karangadu, Tiruppalaikudi and other minor landing centres.

Kilakarai is the foremost place in this unscrupulous exploitation and consumption of dugongs followed by Periapatnam, Thiruppalaikudi and Tondi. Only in these places dugong meat is highly priced. In Gulf of Mannar, Pudumadam and Vedalai and in Palk Bay Karangadu, Nambuthalai, Morepanai and Mullimunai are some of the minor fishing villages where dugongs are caught and consumed. In all these places butchering is done with admirable secrecy that a buyer informs only the closest of kith and kin about the sale of meat and not any one else. The craze for the flesh of dugong is so intense in Kilakarai that the failure to inform a friend of the availability of the meat is despised and is known to cause misunderstanding among relatives. With the exception of Tondi in all other centres mentioned the animals are butchered right at the landing centres and not at the market place. In Kilakarai before the promulgation of the Indian Wildlife (Protection) Act 1972, the capture of a dugong was required to be informed to all the residents by a town-crier. Obviously it is not possible now and so the information has to be passed by word of mouth with utmost discretion. To keep the demand for meat at a sustained level, when more than one animal is caught they are kept alive in the sea by tethering them to some heavy object. At Periapatnam and Vedalai fishermen ever anticipating law enforcement by officials bring ashore dugongs with heads cut off and thrown into the sea. Thus only the headless carcass is landed with the convenient explanation, if at all one demanded that a headless carcass was floating in the sea and the fishermen himself does not know what it is.

When the price of mutton is as high as Rs. 26 per kg less expensive dugong meat is naturally sought after and this is one more reason for the sudden spurt in the fishing efforts for dugongs. However, this statement does not apply to Kilakarai where the demand for dugong meat is formidable.

Places of Capture

In the Palk Bay region Tondi and Thiruppalaikudi are the two places where dugong patnam in Palk Bay region as dugong fishery centres but now at these places this fishery does not exist. Karangadu emerges now in Palk Bay region as a new marketing centre both for dugongs and sea turtles after 1970. Prior to that, Karangadu was the place which honoured turtles and dugongs owing to religious beliefs. Now changing fishery pattern of this region has attracted migrant fishermen from other parts of Tamil Nadu to this place. These migrant fishermen at Karangadu relish the meat of dugong and so the exploitation

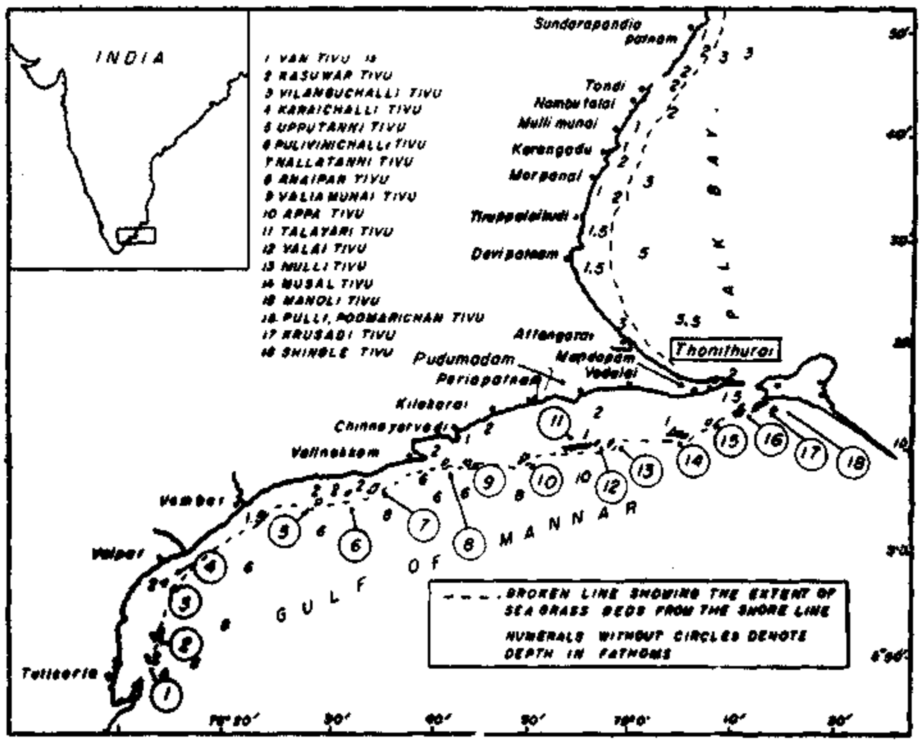

Fig. 1

capture is carried out with nets regularly followed by Karangadu, Nambuthalai, Mullimunai and Morepanai. The catches are either locally consumed or transported to Kilakarai or Tondi or Tiruppalaikudi as the occasion or market trend demands. Nair *et al.*, (1975) include Adirampattinam and Sunderapandia- of this endangered animal began and continues unchecked.

In Gulf of Mannar region the chain of islands comprising Mussel tivu, Talayari tivu, Valai tivu, Appa tivu, Valiamunai tivu and Anaipar tivu and a particular ground near

Sethukarai still offer the right grounds for fishing this animal. South of Vaipar, capture of dugong is unknown now. Nair *et al.* (1975) correctly included all islands near Tuticorin including Pandyan tivu (which is now the part of Tuticorin harbour complex) as fishing grounds of dugongs. But during the past 10 years no dugong was ever captured around islands near Tuticorin namely Van tivu, Kasuwar tivu, Karaicahlli tivu and Vilanguchalli tivu. Excessive exploitation of corals around these islands has very much altered the ecology of the islands resulting in the loss of certain portions of islands. This was followed by the disappearance of sea grass beds around them. Islands such as Vilanguchalli tivu does not exist at all now which was nine years back 3 m high above high water mark and 0.5 ha in area with dugong browsing grounds all around. Fishermen from Kilakarai and Periapatnam regularly visit the islands near Mandapam, namely, Musal tivu, Appa tivu and Sethukarai ground as well as Anaipar tivu and Valiamunai tivu for dugongs.

Mode of Capture

Accidental catches in nets with mesh size of 7 cm to 10 cm meant for large perches is only a myth. These large size perches do not at all occur in good numbers in the shallow water i.e. in 1.5 fathom range (within 2 km from the shore). But fishermen at least now come with a neat fabric of story that they were accidentally caught. Dugongs usually do not stray beyond 5 fathom line from the shore for feeding whereas these gill nets are used within the 5 fathom area only (6 km from the shore). What actually happens is that, when dugongs are sighted as they surface for breathing without much effort they are encircled with nets. Even after capture usually these mammals do not become very much agitated. The animals is tied to the boat by the tail and towed to the landing centre.

Investigations reveal that during the past 5 years when there had been a hectic activity of dugong capture there has not been a single report of net damage caused by dugongs. Fishermen themselves admit that only inexperienced fishermen shall have their nets damaged by dugongs and for such fishermen they have only scorn. In September, 1983 at Thonithurai and in December, 1983 at Mandapam north landing centre close to the shore stray dugongs were sighted. Immediately the fishermen who were idle on the shore deftly slipped into the sea with nets and encircled them without any damage to the nets.

Special Dugong Nets

At Kilakarai special bottom set gill nets are operated for dugongs. Two families operate 20 of such nets and these nets are made of nylon yarn of 4 mm thickness. They are cast in the sea for a period of one week at a stretch with daily checking for any catches. These nets have weights which also allow the animal to surface for breathing. The fact must be remembered that nets are operated in feeding grounds where the depth is hardly 1 to 1.5 fathoms and the mesh size is 30 to 35 cm when stretched.

Valivalai

These drift nets with mesh size of 8 cm to 14 cm when stretched are operated in the shallow water feeding grounds whenever the fishermen decide on capturing a dugong. In the normal course, these nets are operated in 6 fathom deep grounds. In this case also no net damage is reported.

Thirukkaivalai (Ray fish nets)

Tondi is the only place in the region reported where ray fish nets are used to capture dugongs also. These ray nets are nylon nets with a mesh size varying from 30 cm to 45 cm when stretched and height of the net is 3 m and length, about 12 m. Accidental catch of a dugong in ray fishnets is not a fact because dugongs do not stray to 10 fathom deep area where alone these nets are operated for rays. At Tondi these nets are set for dugongs near the shore within 0.5 km.

Explosives

This is a new method introduced for dugong capture in the recent past and this is a cause for alarm to anyone interested in conservation. The explosives were introduced for fishing in 1981 in Palk Bay region and is on the increase from day to day. Formerly at Thiruppalaikudi and Devipatnam country bombs were used to kill fish shoals on sighting. Now this is a regular feature adopted by fishermen in general in this region. At Thiruppalaikudi big shrubs and small trees are uprooted and carried to 5 fathom deep area and are laid on the sea floor and are allowed to rot and form a site for fish aggregation. Within a week good aggregation of fish occurs in such areas. Once the fisherman is satisfied with the size of the fish aggregation he explodes a bomb and makes a number of dives to collect the stunned fishes. Once in the vicinity of these submerged shrubs a dugong was killed. Encouraged by this fishermen took to killing dugongs with explosives which seems to be a very easy method. Now country bombs are replaced by factory made dynamite sticks which are brought and supplied by fish merchants from Sivakasi to fishermen at the rate of Rs. 12 per piece. The boats are run with sails in the grazing grounds of dugongs and when the animals is sighted as it surfaces the lighted dynamite stick is thrown at the animal with ease because the sluggish animal remains at the same spot for certain. To facilitate the lighting of the dynamite stick in the open air three match sticks are tied to the wick of the dynamite and struck against a match box. Usually the head of the animal gets mangled because the aim is so deadly and accurate. Even those who carry dynamite sticks on board for killing large fish shoals on sighting them are easily tempted to kill dugongs which naturally is more lucrative than a day long effort for fishes. For example, in the third week of August, 1984 alone six dugongs were dynamited in a single day off Thiruppalaikudi.

Shore Seines

Nair *et al.*, (1975) mention the capture of dugongs in shore seines operated in this region. In the past 9 years this has not been reported clearly indicating the absence of dugongs in the near shore waters.

Mode of Transport

As late as 1982 dugongs caught in Gulf of Mannar were invariably transported whole to Kilakarai either by boats or by motor cars not minding the high cost of transport by taxi which is as high as Rs. 350 from Vembar or Vaippar. Nowadays animals caught around the islands of Gulf of Mannar are either cut into huge chunks of meat or as headless trunk and are transported without ice in taxi cabs or boats. But to Madurai and Madras the meat chunks are sent packed with ice in innocuous looking Thermokool boxes by express trains to those agents who specialise in supplying this meat to connoisseurs.

Price Structure

The price of meat varies according the place, the highest being offered at Kilakarai. A full grown animal that is 2 m long is bought by merchants at Kilakarai for at least Rs. 1200 to Rs. 1500 whereas the same would fetch only Rs. 500 from merchants at Tondi and Thiruppalaikudi.

	Price of meat with blubber per kg	Price without blubber per kg
Kailakarai ..	Rs. 20	Rs. 22
Periapatnam ..	Rs. 10	Rs. 15
Tondi ..	Rs. 4	Rs. 6
Thiruppalaikudi ..	Rs. 5	Rs. 6
Karangadu ..	Rs. 3	—
Tuticorin ..	Rs. 8 to 10	—

Feeding Grounds of Dugongs

Cymadocea serrulata and *C. isoetifolia* form the main food items on which the dugongs of this region feed. They graze on the sea floor pulling the grasses or they easily pick up the floating sea grasses. It was observed by the authors around islands of Gulf of Mannar and at Tondi that dugongs always prefer picking up floating grasses with other algae which happen to grow there. The beds of these sea grasses as feeding grounds occur within 1 to 2 km from the shoreline at a depth of 1 to 3 fathoms. *C. serrulata* does occur even in places where the depth is 5 fathoms but the growth is sparse and so dugongs are not found in such deep areas. Dugongs seem to prefer the zone of 0.5 fathom only where growth of grass is abundant. As the map given indicates there is luxuriant growth of this grass from 10 km north of Tondi to Attankarai in Palk Bay region and around Mandapam it becomes sparse. In Gulf of Mannar there are patchy grounds near Krusadi island and Thonithurai. On the landward side of islands such as Musal tivu, Talayari tivu and Valai tivu they abound. Near Sethukarai there is a lush ground of sea grass. Then they are good near Anaipar tivu and Valiamunai tivu. Around islands Nallatanni tivu, Uppu tanni tivu and Puluvinichalli tivu the growth of sea grass is sparse.

In the late 1960's the fishermen of Palk Bay region used to bitterly complain about the disappearance of large beds of sea grasses and algae (sea weeds) owing to the *cyclone* of December 1965. At that time huge quantities of sand brought by floods were deposited over those seaweed beds completely destroying them and this area ceased to be the feeding grounds of dugongs and turtles. Therefore there was near total absence of turtles and dugongs and their fishery in the late 1960s and early seventies. Now fishermen gladly inform that the same beds have sprung up once again with luxuriant growth of sea grass extending upto Meemisal in Palk Bay. The reappearance of seaweed beds has turned to be a double blessing for fishermen of this region because they support dugongs as well as small prawns such as *Penaeus indicus* and *P. semisulcatus*.

Factors Affecting the Feeding Grounds of Dugongs

Enacted laws specify that mechanised boats should not operate within 5 km from the shore. But almost throughout the year some 500 mechanised boats churn the most important dugong feeding grounds in Gulf of Mannar namely (i) ground between Vedalai-Periapatnam shoreline and Valai-Appa tivu, (ii) ground near Chinna yervadi. Both day and night fishing is carried out in shifts with a steady throbbing of engines of the mechanised vessels. This is a fact which should not be ignored because the feeding grounds are not extensive and number of boats have quadrupled in the past five years and fishing time is not restricted to a part of the day. Dugongs hit by the propellers of these boats are not uncommon. Usually dugongs hit by the propellers are small measuring 100 to 150 cm in length. The reason is not clear. Perhaps the smaller ones are too sluggish to avoid an approaching trawl boat or they are more curious than the adults or do not sound deep enough to avoid the propellers.

In the recent past, beginning from 1972 sail boat trawls are operated in the shallow water zone close to the shore viz., 1 to 1.5 fathom range, for small sized prawns *Penaeus indicus* and *Pendeus semisulcatus* which usually abound among sea grasses especially in Palk Bay. In Tondi-Tiruppalaikudi area when winds are favourable some 320 sail-boats operate trawls in these grounds. To gain more catches each boat operates two trawl nets instead of the usual one, tied together. This trawl fishing also to a great extent disturb the browsing dugongs and trawl nets uproot the rhizomes of sea grasses. The arguement that the dugongs may safely graze when there is no trawling operations cannot be welcomed because this trawling is not restricted to certain hours of the day but whenever there is a favourable wind. However, there has been no report of dugongs being caught in these trawl nets.

CONSERVATION

Dugongs are not prolific breeders. They give birth to only one young at a time. The fact that all captured animals in 1983-84 measured more than 1.5 m must cause grave concern to us. Thus nearly more than 250 adult dugongs have been exterminated in this one year period. We are not certain that there could be a large population of dugong in this small area. Moreover the destruction of grazing beds has confined the animals to a not-so extensive belt of sea grass. As indicated earlier, hardly 40 animals per year were captured upto 1975. Thus it is the direst need of the hour in our efforts to conserve marine mammals that dugongs must be given top-priority over all the other marine vertebrates.

Existing laws alone cannot save dugongs owing to certain loopholes and constraints in its execution. When huge chunks of dugong meat without head or flippers are brought ashore it may be difficult for the law-enforcing official to book an offender who himself declares to be ignorant of the identity of the animal. A confiscated turtle can be produced alive in a court of law easily as evidence and it can be identified by a competent official but not a chunk of meat.

Therefore the consumers must be educated of their colossal mistake and they must be persuaded to give up eating dugong meat. This can be effectively done by requesting the elders of village councils like those in Tondi and Thiruppalaikudi. At Kilakarai and Periapatnam religious leaders can play an important role in saving dugongs. If the leaders of the mosques are persuaded to exhort the people to avoid eating dugongs this measure may certainly prove successful.

On considering the urgency of the matter wildlife protection officers should be posted immediately at Kilakarai-Periapatnam sector and Tondi-Tiruppalaikudi sector. Daily visit of the official to these places will certainly act as deterrrent both on consumers and fishermen, especially on the former.

By all means fishing with dynamite also must be stopped. Existing laws provide adequately for preventing the fishermen from buying, possessing, trafficking and using dynamite sticks. Therefore stringent measure in this line also must prove effective.

While we mention this specific action plan, it is time that we develop a national action programme for the conservation and management of the dugong. This is particularly so in view of the international implications of this resource as it is likely that the dugongs in the Palk Bay and Gulf of Mannar may also be migrating the shores of Sri Lanka and back. In addition, we have indications of stray occurrence of dugongs in the Andaman Nicobar Islands which also need immediate attention. Sporadic occurrence of stray animals as incidental catch or strandings along the mainland coast has been reported in the past even as northwest as Saurashtra. Hence we propose the following action programme for immediate follow up:

1. Aerial surveys may be conducted in Palk Bay and the Gulf of Mannar region for delineating the sea grass beds and carry out a census of the dugongs with repeat surveys from time to time. The census may be aimed at recording not only herds, but the number of cows with calves, feeding actively and noting whether they are swimming or idlying. A good amount of information on aerial survey and the type of useful information to be obtained had already been standardised over a long period in Australia mainly through the efforts of Heinsohn and his collaborators. We should take advantage of this experience to carry out such surveys.

2. The carcases of dugongs wherever they are found or when occurring as accidental catch in fishing operations should be available for detailed scientific study. Major gaps still exist in our knowledge about the dugong and such studies would help to bridge some of these. The type of studies that could be undertaken and the standard procedures for examining carcases have already been well documented by Heinsohn at the 1979 Workshop on the Dugong held at Townsville, Australia. The standard procedures may be adopted so that eventually uniform data becomes available from the entire range of distribution of the dugong in the Indo-Pacific.

3. There is a need for tagging of the dugong so that its movements, growth and other parameters could be studied. This would also involve considerable effort of search and capture and the cooperation of the fishermen could also be enlisted in such operations where live animals could be obtained if accidentally caught in fishing operations. Along with tagging, photo identification of dugongs should also be encouraged. We may here cite the work of Dr. Paul K. Anderson in Australian waters where he has shown that photo identification of individual animals is possible which also tell a lot about the movements and life habits of the animals.

4. Captive rearing helps in studying some aspects of the animals physiology and behaviour. In the present context we could also maximise focusing attention on the dugong for creating a greater awareness for the conservation of this animal to the people living in the coastal sector. Its educational value to the people especially children should not be lost sight of. This has to be closely linked with issue of suitable illustrated literature.

5. There is an urgent need to study the extent and ecology of the sea grass beds in the Gulf of Mannar and Palk Bay and Andaman Nicobar Islands. Since this is the major habitat of the dugong, the environmental factors which affect this should also be investigated. Factors such as siltation and industrial pollution are matters of serious concern in maintaining and upgrading this habitat. Efforts should be made to organise suitable environment monitoring programmes in such areas.

6. The historical importance of dugong and its cultural significance should not be lost sight of. All earlier records on dugongs should

be collected and collated and brought out which should also create a public awareness and interest in the subject.

7. The aspect of legislation should once again be looked at carefully to see to what extent loopholes could be plugged and the legislation could be constructive involving taking into confidence the coastal population.

8. The proposed National Marine Park in the Gulf of Mannar should become a reality as early as possible so that human interference in the grazing grounds of the dugong could be minimised or phased out. The Park would also afford protection to the animals and as such the delineation of the park to embrace all the 21 islands between Rameswaram and Tuticorin should be taken up. Other perturbations such as mechanised fishing and allied activities which disturb the animals should be phased out in the park area. A major threat is likely to come if the proposed Sethusamudram Project comes through. This cut in the coral reef areas between and through the islands would certainly affect the dugong population and their local movements. It is known that dugongs are hit and mained or killed by boats or impaled by their propeller.

9. A proper data acquisition system of the biological and other aspects of the dugong should be developed and this could be closely linked to a computarised system. The Marine National park should develop such an input system.

10. An international effort is necessary to understand the population structure of the dugong and this calls, for cooperation between India and Sri Lanka. Modalities will have to be developed for such a programme.

11. The Indian Ocean Alliance Meeting Recommendation made at Seychelles in 1981 may be followed up to carry out an Indian Ocean Survey of the dugong populations and their present status.

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THE SHARK BAY DUGONG HERD : STATUS, BIOLOGY AND RECOMMENDATIONS FOR RESEARCH AND MANAGEMENT

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ABSTRACT

The large and apparently isolated dugong population in Shark Bay, at the southern limit of the dugong range in the eastern Indian Ocean, offers both an exceptional opportunity to investigate dugong biology and a challenge to devise a model for dugong conservation. Shark Bay waters are relatively clear and human impact on the population is slight at present. Studies from 1978 to 1983 have shown that dugongs use only a fraction of the total area and that seasonal migrations among preferred habitats correlate with changing patterns of water temperature. Diet and foraging mode vary with the annual migratory cycle. The warmest water available in winter is at the apparent lower limit of sirenian tolerance and local movement patterns correlate with minimum water temperatures in the winter refugium. In 1983 predation on dugongs by killer whales (*Orcinus orca*) was observed and there are grounds for believing this may increase. Reproductive and social behaviour are the least understood aspects of dugong biology in Shark Bay ; approaches which I hope to be able to take in future research are outlined.

Residents of the Shark Bay area seek development which will improve and diversify the economy of the region and increase educational, medical, and other amenities. Increased tourism and pressure for industrial development are anticipated. A conservation-oriented development plan is suggested as an alternative to extractive or ecologically unsound development approaches.

INTRODUCTION

IT is possible that the dugong is the most threatened of the Indian Ocean's marine mammals. While our ignorance far surpasses our knowledge, the little we know suggests that extinction of local dugong stocks may have occurred or be impending along all western and northern shorelines.

It is in a sense ironic that what may be the largest, best studied and least disturbed dugong population remaining occupies what appears to be a thermally stressful and atypical habitat on the Indian Ocean's eastern margin. This paper deals with the biology and conservation of that population, which is found in Shark Bay, Western Australia.

I first visited Shark Bay and made aerial, surface, and subsurface observations of dugongs there in June of 1978. Intensive studies were undertaken in the winter habitat in June and July of 1979, and a year was spent in investigations of seasonal and local movements, forage analysis, and observations of feeding behaviour in 1981-82. Two short visits, again concentrating on subsurface observation of feeding behaviour, were made in June and September of 1983.

My intent here is to present the major findings of these studies from the point of view of insuring the future well being of the dugong population, outline my hopes for future research and take up the problem of economic development which will be compatible with conservation of the dugong and other natural values in the Shark Bay region.

Shark Bay and its Dugong Population

The Dugong Population

While aerial survey technique has yet to be developed to the point where precise estimates of dugong population size and composition are available (Anderson, this symposium), aerial counts specify the minimum number of dugongs, and cow-calf pairs in the surveyed area. The maximum count obtained in a single survey flight at Shark Bay has been 496. Included in this count were 51 cow-calf pairs (slightly less than the average of 11.5 per cent calves for winter surveys). Correcting this total for the area not visible directly beneath the aircraft, adding a count for an adjacent area not covered on that flight, and extrapolating a previous survey of low density areas to account for the remaining dugong habitat, I estimated that the minimum count expected in a thorough survey of the entire Bay in 1979 would have been over 900 (Anderson 1982a). As we certainly do not, in an aerial survey, see all dugongs present I am confident that this estimate is conservative and that Shark Bay supports one of the largest surviving dugong populations.

Shark Bay as Research Site

Besides the large number of dugongs present there are other factors which make Shark Bay an especially good place to study dugong biology. Due to the arid climate, Shark Bay receives very little runoff; the prevailing winds are offshore; the range of spring tides only slightly over 1 m. As a result the water is relatively clear. While subsurface visibility is rarely more than 10 m, this is a great improvement over most Australian dugong habitat in which the water is continuously or seasonally clouded with suspended sediments. Water clarity facilitates both aerial survey and surface and subsurface observation.

A second advantage at Shark Bay is the relatively low level of human impact on the environment at large and the dugong population in particular. There are no aboriginal reservations on the Bay, and there are only two small settlements in the Bay proper (Fig. 1). Denham and Useless Loop (a solar salt works), each have a year-round resident population of about 300. Carnarvon, with a population of 5,400, is located at the extreme northern end of the Bay, remote from the main dugong habitats. The southern half of Shark Bay is protected from trawling operations as a nursery area for prawns and other commercial fishery stocks. Commercial or amateur netting with large-mesh nylon nets is prohibited. Sportfishing is largely restricted to the winter months and concentrated in deeper waters and about coral patches. Recent restrictions have greatly reduced recreational use of small-mesh gill nets. Commercial beach-seining operations (about a dozen professional fishermen operate from Denham and Monkey Mia) pose no threat to dugongs. Illegal hunting of dugongs is uncommon. The estimated take of perhaps a dozen per year is considered tolerable (policing is difficult, however, and significant episodes could easily go undetected). Collisions between boats and dugongs appear to be rare events. With the cooperation of local fisheries officers I have attempted to collect reports of such boat strikes over the last six years and there appear to be only one or two episodes annually.

Two apparently unique (though unreliable) advantages of Shark Bay from the research point of view are that in some mild winters dugongs may feed regularly in water two-to three metres deep in inshore areas below 100 m cliffs from which behaviour can be observed

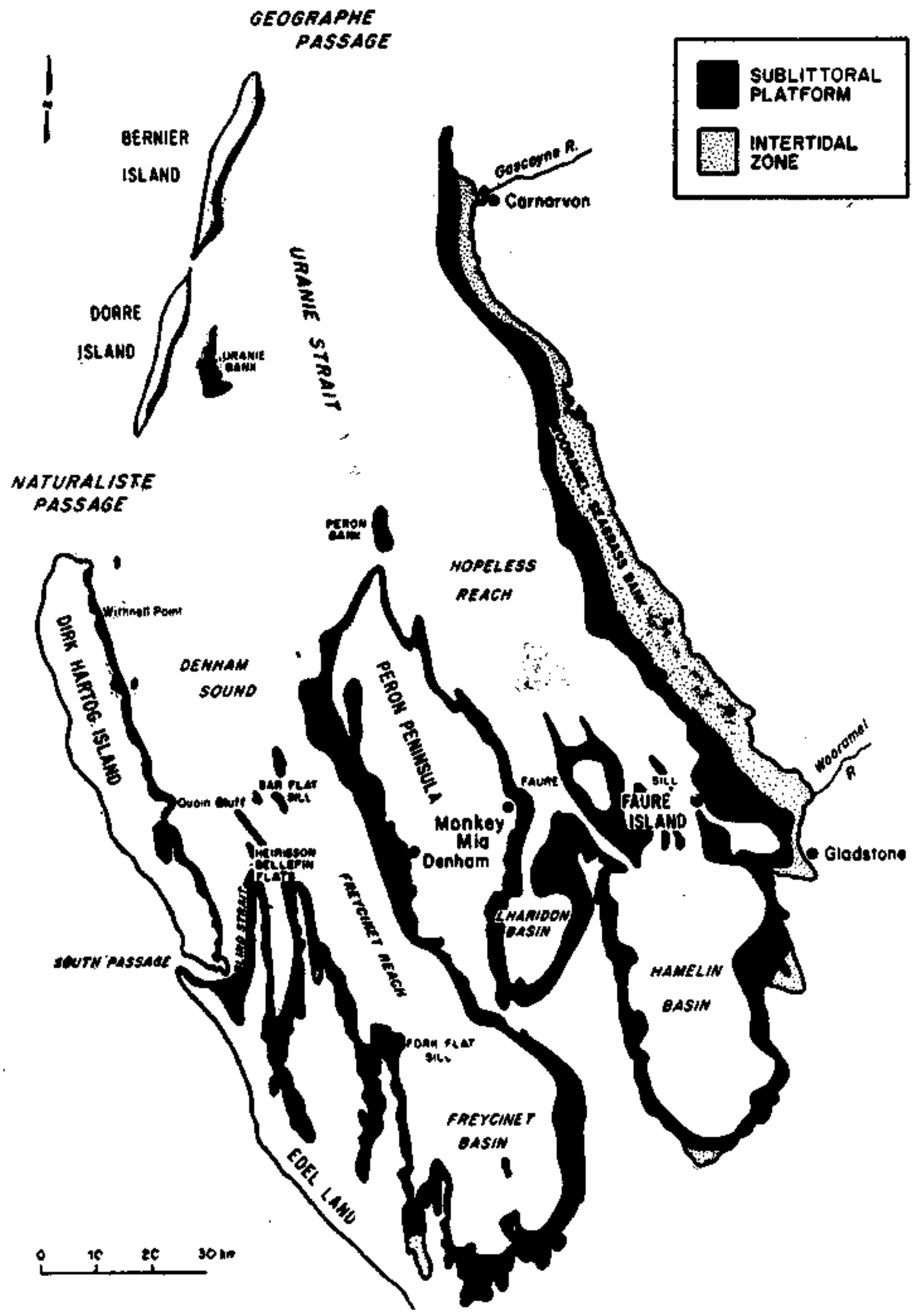

FIG. 1. Shark Bay, Western Australia showing distribution of intertidal and sublittoral zones and localities referred to in the text.

on clam days and in some cold winters large groups may move into an area where inflow of clearer ocean water may increase subsurface visibility to 20 m or more.

The area is accessible by road and has several airstrips, while food, fresh water and fuel, as well as basic communication and repair services are available at Denham. Both Denham residents and the Western Australian Department of Fisheries and Wildlife are interested in and supportive of dugong research.

While the area is remote from the facilities of the nearest large urban center (Perth) its dugong population is uniquely valuable because of its size, its freedom from disturbance, the favourable conditions for observation, and the logistic base for research activities. Much can be learned about dugongs here that will be of use elsewhere.

Shark Bay as Dugong Habitat

With the single exception of a sighting of a cow-calf pair at Geraldton, 250 km farther south, the southern end of Shark Bay (26 degrees 40 minutes S latitude) marks the southern limit of recent dugong sightings on the eastern shore of the Indian Ocean. As the coastline to the north lacks sheltered waters with suitable foraging areas for dugongs for several hundred km, Shark Bay is isolated from other dugong habitats (Prince, *et al.*, 1981).

The total area of Shark Bay is approximately 13,000 sq. km. Dugong utilization of this area is associated with variation in depth, temperature, and the nature of seagrass communities.

Depths within the Bay average 9 m, ranging up to 42 m in the north. Except along the eastern shore the intertidal zone is only a few m wide. The sublittoral areas encompassing the 1 to 8 m depths at which dugongs prefer to feed are most extensive along the eastern shore lines (Fig. 1). Excluding hypersaline areas which support little or no seagrass, the sublittoral available to dugongs has an area of perhaps 3000 sq. km, much, but not all, of which supports seagrass.

The bulk of the seagrass biomass is made up of species belonging to the temperate genera *Posidonia* and *Amphibolis*. Dugongs do not feed on *Posidonia*. *Amphibolis* reaches the northern limit of its distribution in Shark Bay and is encountered and consumed by dugongs only at this locality. Dugongs typically feed on tropical seagrasses (species of the genera *Halodule*, *Halophila*, *Cymodocea* and *Syringodium*). Species of all of these genera are present in Shark Bay, but rarely form dense single species stands with high standing crop biomass. An exception is the seasonal growth of *Halodule* on the black muds of the delta of the intermittently flowing Wooramel River in the southeast (Fig. 1).

Temperature of surface water in the Indian Ocean at this latitude varies in the 21-24 degree range. Within the Bay, temperature varies more widely. Oceanic water enters the Bay at the northern and southern ends of Drink Hartog Island (Fig. 1) and circulates in a counter-clockwise pattern, driven by prevailing SW winds and evaporative loss in the shallow southern embayments. Shallow waters stirred by the winds are responsive to atmospheric temperature changes. The reflective effects of extensive areas of white sand, and the high rate of evaporation, probably also reduce the capacity of Bay waters to store heat. The aridity of the climate, and the sparsely vegetated sandy soils of the surrounding lands, favour radiative heat loss to the night sky and generate a night-time flow of cool air out over inshore waters. Collectively these factors generate a thermal regime in Bay waters which includes an annual reversal of relative temperature patterns. During the summer the warmest waters (25-30° C) are found in the southern and eastern regions. During the winter the temperatures in these areas are the

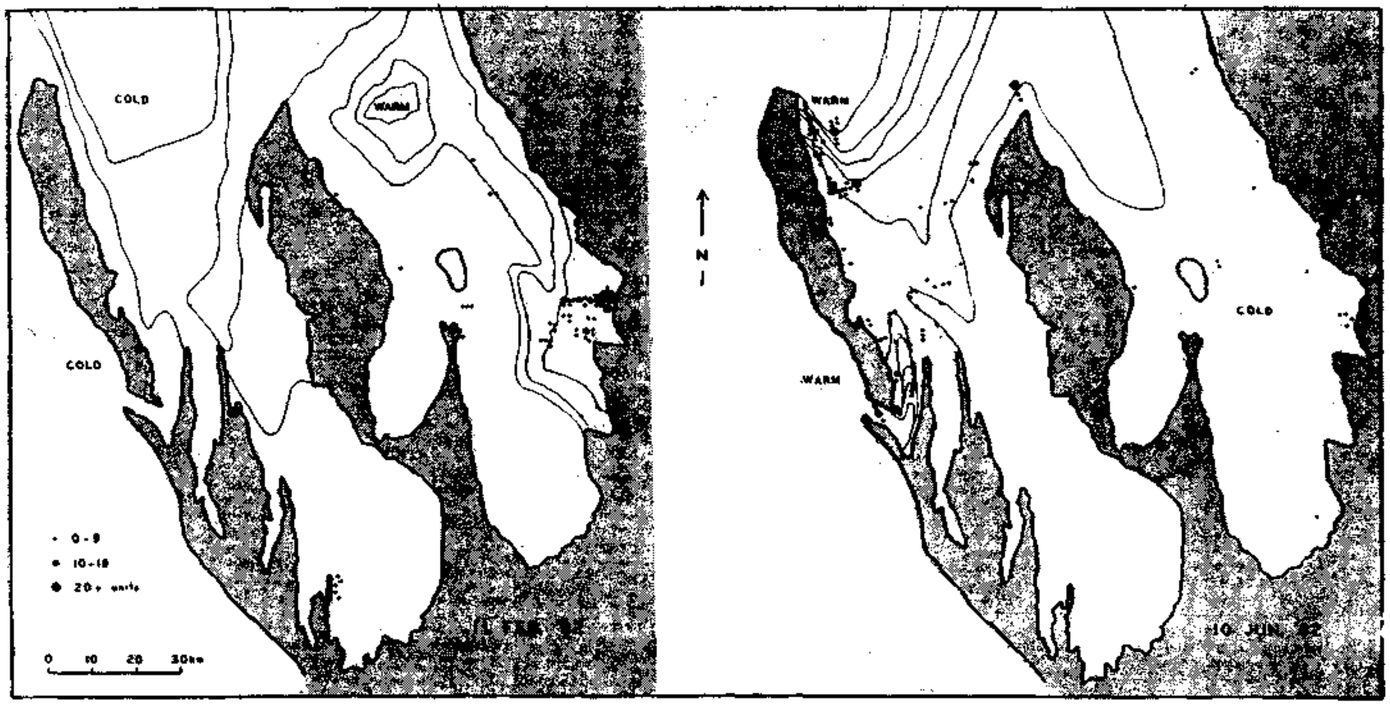

FIG. 2. The distribution of dugong sightings in summer and winter aerial surveys in relation to thermal patterns in Shark Bay. Isotherms drawn from false-colour radiometry transmitted from NOAA satellites. Dots show locations of dugong sightings and size of aggregations. Surveys were flown over identical routes in the two seasons.

coolest, dropping to 16 degrees or lower, and the highest temperatures are in the oceanic inflows from the west, entering about the northern and southern ends of Dirk Hartog Island (Fig. 2).

Temperature and the Seasonal Pattern of Dugong Distribution

Alerted by local reports of seasonal shifts of dugong distribution and the results of initial aerial surveys (Anderson, 1982 a ; Prince, *et al.*, 1981) I carried out a program of periodic aerial surveys over the annual cycle, beginning in October of 1981. Results of this program were examined in relation to thermal maps of the Bay transmitted by radiometers aboard NOAA satellites which were made available to me by the CSIRO Division of Land Resource Management in Perth. As shown in Fig. 2, dugongs concentrate in the winter (late May through mid-August) in tongues of oceanic water which extend northwards and southwards along Dirk Hartog Island's eastern shore. In contrast, between October and April concentrations are located in the eastern Bay. Temperatures in this summer habitat range between 22 and 27°C while those in the winter habitat range between 17 and 24°C. In each season dugong concentration are in the warmest available waters within the Bay.

Seasonal Migration, Seagrass Forage, and Dugong Foraging Behaviour

The temperature-correlated seasonal migration pattern determines what dugongs in Shark Bay eat, and the way in which they forage. In summer, dugong herds are concentrated over the dense strands of *Halodule* which develop on the rich organic sediments of the tiny delta of the Wooramel River. Dugongs feeding on the Wooramel delta dig *Halodule* rhizomes from the bottom, stirring up dense clouds of sediment in the process. As emphasized by Domning (1977) it is this mode to which the dugong foraging apparatus is adapted.

I would like to emphasize four points regarding the dugongs' summer range. First, the area of the dense *Halodule* sward where the dugongs concentrate is very restricted. I suspect this small delta area is a critical resource for the dugong population and that if it were destroyed, or if the dugongs were driven off by disturbance, the carrying capacity of Shark Bay for dugongs would be drastically reduced. Second, the growth of *Halodule* is seasonal. Sampling this vegetation I found that standing crop biomass decreased greatly in the winter months. Third, the foraging method is destructive since rhizomes are being removed and the bottom disturbed. Thus overgrazing may have seasonal, or long-term effects. Fourth, this area is thermally suitable for dugongs only during the summer months. Although the thermal physiology of dugongs is unknown, temperatures in this part of the Bay in winter fall well below the lower critical temperatures determined for other sirenians (Gallivan, *et al.*, 1983 ; Irvine, 1983). Although a few dugongs may be found in this area in June and July, most animals abandon the summer habitat by mid-May.

In winter, as in summer, dugongs concentrate in a limited area. Along the eastern shore of Dirk Hartog Island the sublittoral which supports the main winter concentrations of dugongs is generally 1000 m or less in width.

Seagrass beds in the winter habitat consist almost exclusively of dense strands of the temperate species *Amphibolis antarctica.* This species grows throughout the year, clusters of leaflets are borne on though wirey stems a meter or more in length and reserves are not stored in easily accessible rhizomes. No sediment clouds are raised by dugongs over *Amphibolis* beds, and subsurface observation and photography have shown that they feed, apparently with very low efficiency, by grazing the terminal leaflets of the *Amphibolis* canopy, Over the 1981-82 season periodic samples of seagrasses from summer and winter habitats were taken for analysis of standing crop biomass, digestibility, macro and micro-nutrients and secondary substances (tannins) which might affect the quality of the vegetation as dugong forage. The most significant result of these studies was that the winter diet of *Amphibolis* was low in starch, and therefore in total carbohydrate which could be readily made available to provide energy for thermoregulation.

Water Temperature and Local Movements in the Winter Habitat

On the basis of observations during the winter of 1979 I had anticipated that large numbers normally fed at a location midway along the wintering range where coastal cliffs provided an overview of feeding activity and an excellent opportunity for behavioural observations. In the winter of 1982 this did not occur and animals along this stretch of coast remained well offshore. Daily counts of dugong numbers visible from coastal vantage points showed that low inshore temperatures were paralleled by declines in numbers of dugongs in cooler, shallower inshore areas and that dugongs disappeared from nearshore feeding grounds when water temperatures fell below 10°C. Mean temperature of the water column in areas where dugongs were active during this period was 19.3°C. This is one to three degrees below the lower critical temperature determined for manatees by Gallivan, Best and Kanwisher (1983) and Irvine (1983). Extrapolating, dugongs wintering in Shark Bay must suffer from low-temperature stress.

Aerial survey observations revealed that when dugongs left the preferred inshore areas along the central part of the Dirk Hartog coast, they were distributed in deeper waters, farther north and farther offshore. I believe that these observations indicate that temperatures in the thermal refugium utilized by the Shark Bay dugong herds in winter are marginal to the extent that in cold winters local movements may be dictated by water temperature and dugongs may periodically be forced to move to deeper and warmer offshore waters to maintain body temperature.

Deep Water, Foraging, and Predation

If wintering dugongs are forced by low inshore water temperature to move to warmer, deeper waters offshore, foraging efficiency may be reduced as a result of increased time spent travelling between the surface for air and the bottom for food. Energy expenditure may be increased and intake per unit time reduced.

When forced to forage in deeper waters both the frequency with which dugongs encounter large potential predators, and vulnerability to such predators, may increase. There is surprisingly little literature on non-human predation on sirenians. Dugongs carry numerous scars and I and my assistants have occasionally encountered dugongs bearing clearly recognizable imprints showing they have experienced and survived, attacks by large sharks (Anderson 1981). A significant correlation between aerial sightings of large sharks and the location of larger groups of dugongs was observed in 1979 (Anderson, 1982 a). Dugongs, however, appear to show little concern at the approach of sharks as much as three m in length and although sharks of several species are common in the Bay, shark attacks on dugongs do not appear to be common. Increase in risk from this source in deeper waters remains problematical.

Another source of significant predation, which may correlate with thermally induced movements into deeper waters, has become evident. In June of 1983 two, and probably three, attacks on dugongs by killer whales (*Orcinus orca*) were observed in Shark Bay. There is reason to suspect that in the future killer whale predation may increase and become a significant factor in the dynamics of the Shark Bay dugong population. Killer whales are often reported to travel with migrating populations of humpback and other baleen whales. The once large populations of such whales along the West Australian coasts were severely reduced by the middle of this century, but the number of humpback whales migrating past and entering Shark Bay now appears to be increasing dramatically (Bannister, 1982). Shoal water habitat is probably the dugong's major protection from killer whale predation. Along Dirk Hartog Island there is little such protection and cooling of inshore waters may place dugongs at increased risk. The killer whale attacks observed in Shark Bay in 1983 may have been isolated incidents, but they may also foretell events which will be repeated with increasing frequency. It may be significant that in September of 1983 an aerial reconnaissance showed dugongs to be more thinly and widely dispersed than on any previous survey. One possible explanation of this unexpected dispersion pattern is that it was a response to the killer whale activity.

Reproductive Biology : Intransigent Mystery

In mid-November of 1981 a dead dugong calf, one m in length, washed up on the beach south of Monkey Mia in the eastern half of Shark Bay. A mandible of this animal was salvaged and sent to Dr. Helene Marsh who concluded it was probably less than a month old at the time of death. That record is the one solid fact avaialble regarding the biology of dugong reproduction in Shark Bay.

In contrast to previous observations in Queensland (Anderson and Birtles, 1978) there has been a conspicuous absence of apparent courtship behaviour at Shark Bay during the winter months. Recollections of local fishermen who have worked the Bay for most of their lives are vague or contradictory as to observations of dugongs 'fighting' or copulating and they have been unable to suggest when or where calving takes place.

On the basis of the nutritional and thermal regimes in Shark Bay it is logical to suppose that calving would take place in the spring, perhaps along the migration route or after arrival in the summer habitat, allowing the young to be born into warmer water and allowing parturient females an optimal diet on which to base lactational requirements. On an assumption that warm water lagoons with appropriately shelving beaches remote from habitats frequented by predators would be favoured I have identified several potential sites which I would like to monitor at the appropriate season.

If gestation is 12 to 13 months, mating and calving should occur at the same time in the annual cycle. A limited attempt to test these inferences in September 1983 was largely frustrated by engine problems and the unexpectedly diffuse dispersion of the dugong population at the time. It produced no supporting evidence.

Social Behaviour

While most sightings of dugongs in Shark Bay aerial surveys are of single dugongs or cow-calf pairs, most dugongs occur in groups (Anderson, 1982 a). Attempts to follow the movements of recognizable individuals in 1979 suggested that groupings are not rigid and that individuals may move about with some independence (Anderson, 1982 b).

The cohesive behaviour by dugongs implies communication. To date all my attempts to detect and record subsurface dugong vocalizations in nature have been unsuccessful. Nevertheless, I have observed that groups of dugongs may move away from slowly approaching boats in a concerted fashion, and in an intriguing episode several large dugongs appeared to act to obstruct the harassment of a cow and her calf by a playful dolphin (Anderson, 1982 b).

Summing Up, Major Gaps, and Future Research

At this point the evidence suggests that dugongs in Shark Bay are dependent on two small, but critical, habitat areas : the seasonally productive beds of the tropical seagrass *Halodule* on the Wooramel Delta for summer range, and the narrow sublittoral of Dirk Hartog Island along which inflow of oceanic waters provides a thermal refugium in winter. It also appears that water temperatures in the winter refugium are precariously low, and that forage quality there is poor and foraging relatively inefficient so that in winter dugongs may be both nutritionally and thermally stressed. Temperature declines in cooler winters force dugongs to move into deeper and warmer waters, and a possible increase in whale populations may lead to increasing predation by killer whales, especially during such cool periods.

From a conservation perspective, the message at this point is that the Shark Bay dugong population could be seriously threatened by disturbance of, or in, either of the two seasonal habitats and that industrial or recreational development which could impact either the Dirk Hartog coastline or the Wooramel delta should be viewed with concern.

Disturbance along the migratory route could also be a serious problem. A recently proposed mineral development entails construction of a jetty near the site where large congregations of dugongs have been reported during the spring migration. It will be important with respect to any future development to study the timing and routes of movement between summer and winter ranges and develop a better understanding of factors governing and guiding the annual migrations.

Since trends in whale numbers along the West Australian coast may be very significant for this dugong population, a carefully designed (aerial survey, flown in late June or early July cost of under $1500 annually) should be planned to monitor trends in numbers of both dugongs and killer whales in the Dirk Hartog area and provide a warning of any major increase in non-human predation.

While current knowledge provides some insight into the habitat requirements and possible sources of increased mortality, we remain almost totally ignorant of the reproductive half of this population's demography as well as the nature and importance of social organization. On the basis of my experience to date I believe it is vitally important that studies in these areas be initiated. I also believe that, although such studies are difficult, they can be approached in a practical and reasonably economical way. The basic requirement will be use of a stable shoal-draft sailboat (catamaran or trimaran) to provide a living and research platform from which it will be possible to maintain constant contact with the dugong herds, and to which the dugongs can accommodate. Only by spending long periods of time in this way will there be an opportunity to see, and learn the requirements of, such transient events as courtship, mating, and calving. Patient observation from the mast of such a boat and, given appropriate conditions, from the Dirk Hartog cliffs, will provide a visual window into dugong social relationships. Collaboration with experienced students of marine mammal acoustic communication, based on a boat of this type, should penetrate the world, if any, of dugong vocal communication. I hope to attack these problems in this way in the future.

A Conservation-Oriented Development Plan for Shark Bay

The Underlying Ethic

The last decade has seen a shift away from the environmental concerns prominent in the early 1970's and towards a more exploitive ethic. The shift is understandable in a time of economic recession and frustrated hopes, yet in the long run human well being depends on recognition that wise compromises must be made between immediate economic gain and the survival of a world that has room for biological and social diversity, and for the existence of unregimented human beings, unregimented space, and unconfined, undomesticated, non-human species. All development should be compatible with the ecology of the region in which it occurs, should emphasize quality of human life cver quantity, and should aim at equilibrial states permitting maximum freedom from regimentation and maximum expression of the best in human potential.

Pressures for Development

The present economy of Shark Bay is based on mineral extraction from salt ponds and salt pans at Useless Loop, sheep grazing at several marginal stations, and tourism and commercial fishing at Denham and Monkey Mia. Recent years have seen proposals for mining of beach sands and for gypsum mining on the Peron Peninsula. The highway access is being gradually improved to encourage tourism, and there have been various motel, hotel, marine. and tavern developments proposed. These proposals are attractive to many members of the community, particularly as they might help to underwrite facilities for secondary education and improved medical services. These goals are certainly legitimate, as is the desire for an economy which would encourage younger residents to remain in the area.

Alternatives and Constraints

The attraction of extractive industrial development, such as beach mining or gypsum mining is the promise of immediate, larger scale capital investment. The price of this type of development, however, is likely to be a boom-and-bust economy which leaves, in its passage, a damaged environment, social disruption, and destruction of renewable resources which once had the potential to fulfill the goals that lie burried in the ashes of abandoned enterprises and the spoil heaps of worked out mineral deposits.

The main constraint on development at Shark Bay is fresh water. Most groundwater in the area is too brackish for human consumption and the town of Denham now depends on a small, expensive, desalination system. Further development will almost certainly be dependent upon expansion of this type of facility. This fact alone suggest that development in the area should emphasize quality, rather than quantity.

The true riches of the Shark Bay region lie in its superb winter climate, its potential for commercial and recreational fishing, its role as a nursery for prawns and deep-water fishes, its spectacular scenery, its historical significance, its biological diversity and its existence as a maritime wilderness with room for both individual adventure and lifestyles different from those which fail to fulfill us in ever-growing cities.

Development as a marine wilderness park or reserve, devoted to preservation of wildlife, research, education, and recreation can, I believe, provide a stable economic foundation on which the aspirations of Shark Bay residents can be based.

Proposals

1. I propose that the Shark Bay area be made a marine reserve, to include a national park, reserves for the protection of areas critical to dugongs and other sensitive and threatened species, and maritime wilderness areas set aside for both terrestrial trekking and aquatic adventuring. I believe that such a development is compatible with continuation of such current enterprises as operation of the solar salt works at

Useless Loop, and the traditional beach-seine fishery operating out of Denham, but that the marginal sheep grazing on Dirk Hartog Island and the Peron Peninsula might well be phased out in favour of improving the environment for native plants and animals. Mining and other developments dependent on non-renewable or easily over-harvested resources should not be allowed in the reserve.

2. I suggest that an administrative, training, and service center for this marine reserve system should be established at Denham.
3. I also suggest that as a parallel development, a suitable site in the Denham area be selected for a marine research and educational center, supported by the Commonwealth and/or West Australian Governments, and involving appropriate departments of Western Australian educational institutions. The functions of such a centre should include basic research and research pertinent to management of the area, and education and training of staff for interpretive and management functions at Shark Bay and elsewhere (with preference given to recruitment from among residents of the areas where reserves are established).
4. I suggest that the governments involved undertake, through a program of loans and training grants, to encourage the development of supporting enterprises (such as tourist accommodation, outfitting and guiding services, dive shops, and fishing and boat charters) designed to encourage competent, well informed, and non-damaging utilization of the resources of the Bay.

The biology and preservation of the Shark Bay dugong population, while it is the focus of this paper, is only one aspect of what must be a broad approach to wise management of this spectacular region with its diversity of wildlife, its historical and scientific importance, its scenic and recreational resources, and the opportunity it provides for the realization of those intangible values which hold many of today's residents in Shark Bay communities and will bring others there in the future. The proposal outlined above is designed to lead to establishment of a stable economy that will provide a high quality of life for residents in the area, compatible with environmental constraints, and conserving of the unique resources which make Shark Bay of special value to all Australians and to the world at large.

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AERIAL SURVEY FOR DUGONGS : A REVIEW AND RECOMMENDATIONS

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ABSTRACT

Aerial survey is the only effective method of locating and counting dugongs on a regional basis. Sighting of dugongs from the air was first described from the western Indian Ocean, but aerial survey has since been applied primarily in the Australian region where the only substantial stocks of dugongs known to survive have been located. The fragmentary evidence available suggests that elsewhere populations of dugongs face decimation and that in many areas extinction may be imminent. Responsible conservation requires that a general assessment of dugong status be organized in the near future.

Techniques for dugong survey can be visualized in terms of four levels of objectives. The objectives of first-level surveys are to locate any dugongs in a region, and determine minimum numbers and distribution. Surveys meeting these objectives require only simple techniques (which are outlined) and are not prohibitively expensive. It is first-level survey which is urgently needed over the remainder of the dugong's historical range.

Second-level surveys aim to identify favoured, critical and seasonally utilized habitats, track seasonal movement patterns, identify significant sources of mortality and disturbance and establish approximate frequencies for cow-calf pairs. Current methods are adequate for these objectives; the major need is funding.

Third-level surveys aim to obtain estimates of numbers and cow-calf proportions with sufficient accuracy to allow the determination of population trends. Techniques have yet to be developed which satisfactorily meet these objectives, due in part to the extreme variability of sighting conditions (affected by glare, cloud, wind, turbidity, dugong behaviour, etc.) and in part to unavailability of funds for systematic experimentation.

Fourth-level survey objectives include observation of individual and group behaviour patterns (feeding, courtship, mating and calving, response to disturbance). Efficient aerial observation of behaviour requires aerial platforms which are capable of near-silent and near-hovering flight (lighter-than-air or ultra-light aircraft). The technology is available but the finances are not.

INTRODUCTION

THE surface of the sea is a glass through which we see, at best, only darkly. When we wish to study the numbers, distribution and behaviour of marine mammals we are further handicapped by the lack of elevation from which to view the restless seascape and only a flying carpet can give a perspective from which we can perceive even surface events over a usefully large area. Light aircraft provided the needed perspective and although they have severe limitations, aerial survey is the only effective means of establishing the presence, habitat requirements, minimum numbers, pattern of movement, and status of dugong populations.

The first demonstration that dugongs could be observed from the air took place in the western Indian Ocean in 1970 (Hughes and

Oxley-Oxland, 1971). The scattered and largely anecdotal evidence available to us indicates that this remarkable species is almost everywhere at the brink of extinction, but in the fifteen years since that initial effort only portions of the coastal waters of Australia, Papua New Guinea and the Palauan archipelago have been effectively surveyed. My purpose in this paper is to briefly review the history of dugong surveys, summarize results to date and outline basic methods. My hope is to stimulate aerial surveys over the vast stretches of the dugong's range from which information is desperately needed if there is to be any action to avoid the loss of dugong stocks which may still survive there. Given that aerial survey provides an efficient means of assessing whether such stocks still exist I regard it as somewhat of a disgrace that governments and conservation organizations appear content to allow the dugong to slip quietly into extinction over more than ninety per cent of its historical range.

Historical Review

Western Indian Ocean

Hughes and Oxley-Oxland, in July of 1970, made two one hour flights in search of dugongs in and about the estuary and coast of Antonio Enes, Mocambique. No details of methodology other than time of day were reported (Hughes and Oxley-Oxland, 1971) but a group of six individuals and another of three were sighted on the first flight, and sighting of one, one, two, two and twelve, for a total of eighteen, were recorded on the second. Two of the group of twelve were calves.

Dugongs were being netted in the region, one man reporting a catch of two 'in a good month'. Despite the fact that they had sighted a maximum of 27 individuals the authors regarded the result as indicative of 'a substantial population'. The basis of this optimism is obscure in view of the indication that 10 to 20 might be killed annually by a single hunter. No further surveys have been reported from the area.

The second survey published for the western Indian Ocean is that of Ligon (1976b) in Kenya. In a total of over 12 hours, a grid pattern was flown covering the entire 490 km coastline out to the edge of the continental shelf. It was estimated that 25 per cent of the water surface was scanned. Only eight individuals were sighted in what had been reported to be one of the areas of greatest dugong concentration remaining on the African coast. As a rough indication of the significance of Ligon's findings, her sighting rate under excellent conditions (0.011 dugongs per minute of survey time) compares with a mean of 4.92 dugongs per minute for three surveys flown under similar conditions over the winter range of dugongs in Shark Bay (Anderson, 1982a).

Robineau and Rose (1982) have recently reported on aerial sightings of dugongs from Djibouti. Utilizing a helicopter they were able to locate a total of 32 dugongs. They commented that this was the largest number to have been reported from the region of the Red Sea and Gulf of Aden.

No other surveys have been published for the western Indian Ocean. The only supplementary information (recent events in the Persian Gulf and aerial observations over Palk Strait by Stephen Leatherwood) indicates catastrophic declines and as far as can be determined in our state of near ignorance, a critical situation. The need for aerial surveys in the region is desperate.

Australia

The first attempt to survey dugong populations systematically was initiated by George Heinsohn, Alister Spain and myself on the Queensland coast in 1974. Monthly surveys over a 230 km route were begun in September with a count of 48 individuals; subsequent months produced counts ranging from 16 to 74. A foray to the eastern coast of Cape York in November 1974 produced a count of 171 along a 248 km stretch of coast (Heinsohn, Spain and Anderson, 1976).

These Queensland surveys established a basic framework of technique, described by Heinsohn *et al.*, (1979), for what I will refer to below as firstlevel surveys. Surveys of this type have since been extended from Moreton Bay over the entire Queensland and Northern Territory shorelines (Anderson and Birtles, 1978; Elliott, 1981; Elliott *et al.*, 1979; Heinsohn *et al.*, 1978; Heinsohn *et al.*, 1979; Ligon, 1976a; Marsh *et al.*, 1981). These surveys indicated minimum numbers in excess of 3000 animals along the Queensland and Northern Territory coasts and identified areas of concentration in Moreton Bay, Shoalwater Bay, along the eastern coastline of Cape York and about the Wellesley Islands in the Gulf of Carpentaria. Similar surveys in Western Australia from the De Grey River to the southern limit of the range in Shark Bay revealed major herds in Exmouth Gulf and Shark Bay (Prince, *et al.*, 1981), but left a gap of over 2000 km between the De Grey River and the Northern Territory border which has yet to be filled.

The demonstration that a few thousand dugongs survive in Australian waters was welcome, but may have had the unfortunate effect of inducing unjustified complacency among those concerned with conservation of marine mammals. Recent information suggests that levels of legal hunting by aboriginal people, illegal poaching, kills incidental to fisheries and black market trade in dugong meal may threaten many of the Australian herds. Tourism and other commercial or industrial development may also pose problems. Additional and more precise, survey work is needed to establish baselines from which trends can be followed and to determine the extent of present and future threats.

Torres Strait and Papua New Guinea

As in many other areas, there is here a long and important tradition of dugong hunting among coastal and island peoples. While in the employ of the Papua New Guinea Wildlife Division, Brydget Hudson initiated a program of dugong research and conservation (Hudson, 1981). Part of that effort involved study of the capture and marketing of dugongs in the Western Province. The first aerial survey work reported in conjunction with this program was flown in 1975 and a total of 186 dugongs were sighted in 11 hours of flying over 1200 km of coast and reef (Ligon and Hudson, 1977).

The commercial harvest of dugongs in Papua New Guinea's Western Province declined rapidly from a high of 207 in 1979 (Marsh *et al.*, 1984) and resulting concern was sufficient to generate funding for an extensive survey of the Torres Strait area from which most of the Western Province catch, along with an equal or larger catch by people living on the Torres Strait Islands, is derived. This survey was flown in November of 1983; 223 individuals were counted in 24 hours of survey time (Marsh *et al.*, 1984). As in Kenya this is a comparatively low sighting rate (0.15 dugongs sighted per minute of survey time). In comparison, the sighting rate over winter range at Shark Bay is up to 51 times as high (Anderson, 1982).

Two other features of this survey may be significant. In areas where dugongs are rarely harassed or hunted, aggregations of twenty or more individuals are common and inshore areas are frequented (Anderson 1982a; Anderson and Birtles, 1978; Heinsohn *et al.*, 1976). In Torres Strait, Marsh *et al.* (1984) found most individuals in areas far from mainland or island coastlines and the largest group sighted was six. While feeding grounds may be widely dispersed over the extensive shoals in Torres Strait, the extreme dispersion resembles that observed in Palau (see below) where dugongs are also subject to disturbance (Brownell *et al.*, 1981) and may possibly be a result, and/or a source, of social disorganization due to hunting pressure.

The Torres Strait survey was the first in which an attempt was made to establish confidence limits for an estimate of the total number of dugongs present. The resulting estimate was that 1455+/−276 dugongs were present in the area surveyed. Contrasted with very rough estimates (based on interviews) of the annual legal and illegal catch of dugongs of 400 to 1000, the estimated population is sixteen per cent or less of that required to support the catch suspected (Marsh *et al.*, 1984).

Palau

The Palau group is the only part of Micronesia currently supporting a dugong population. Aerial surveys were flown over the entire Palau area, exclusive of the southernmost island (Angaur) which lacks suitable habitat, in 1977, 1978 and 1983. Data from only the first two surveys have been published (Brownell *et al.*, 1981). Three results are notable. In contrast to other areas dugongs were rarely seen feeding, individuals were widely scattered in small groups as in the Torres Strait survey, and a maximum population of 50 individuals was estimated. As in Torres Strait, interviews suggested an annual kill (illegal, as dugongs are wholly protected) in excess of potential replacement.

Objectives, Methods and Problems in Aerial Survey of Dugong Populations

Survey Levels

Aerial surveys can have relatively simple objectives: to establish that dugongs exist in an area; to follow seasonal patterns of habitat use and identify areas and resources important to dugong populations; to produce estimates of population density, composition and rates and directions of demographic change; or to observe and record aspects of individual and social behaviour. Because these diverse goals require different approaches, different equipment and different levels of expertise and financial support I find it convenient to discuss dugong surveys in terms of four levels of intensity, arranged both in order of practical sequence and of sophistication, cost and difficulty.

First-level Surveys

Over more than 95 per cent of the coastlines along which dugong populations are known to have existed in historical times we know essentially nothing of current status. The immediate need is for aerial surveys intended to provide a rapid overview of potential dugong habitat and locate areas which still contain dugong stocks. Surveys of this type do not require highly trained staff, repeated overflights, or complicated equipment. The essential elements of procedure include preliminary enquiries directed to persons presumed to have local knowledge (perhaps by means of a mail questionnaire as used by Anderson and Heinsohn, 1978) to select areas to be surveyed; contact with officials to obtain any necessary permission for flights; obtaining and examining coastal charts, location of airstrips and making necessary arrangements for refuelling; all followed by flights using a high-wing light aircraft such as a Cessna 182 or equivalent. I believe it advisable, in order to meet the objectives as economically as possible and cover as large an extent of habitat as possible with the limited funds likely to be available, to follow the simple procedures used in the initial surveys in Australia (Anderson, 1982b; Heinsohn *et al.*, 1979). For purposes of evaluation such surveys should be consistent in the following respects:

1. In addition to the pilot, the aircraft should carry a flight-director and a port and a starboard observer. The flight director should be responsible for directing the pilot, keeping track of the position of the aircraft, and marking the route of the flight on a map or chart. He or she should also record the time at which recognizable, charted, landmarks (e.g. headlands, river-mouths, settlements) are passed ; and the number of dugongs sighted and the locations of the sightings. Marine charts designed for navigation are preferable, but topographic maps, or any large-scale map, can suffice if the more expensive marine charts are unavailable. Observers may record their own observations on note pads, but it is my preference that all data be recorded by the flight director since the observers are not then required to divert their attention form the water and the director is at all times informed of what is being seen. The flight director should have a watch and previously prepared data sheets for systematically recording the desired information and he and the two observers should wear polaroid sun glasses to reduce glare from the sea surface.

2. The aircraft should fly at an elevation of about 900 feet (274m) at a speed of 80-100 knots.

3. Flights should take place between an hour after sunrise and an hour before sunset. Time of day, within those limits, is less important than that the sea surface should be calm, the sky cloudless and the water clear. Surface waves, cloud reflections and turbid water greatly reduce the ability of observers to locate and count dugongs. While in many areas clear water cannot be expected, *surveys should be flown only under calm, cloudless conditions if at all possible*. If it can be arranged, aircraft should be held on standby or flights delayed to allow survey under optimal conditions. Wherever practical, flight lines should place the sun behind the aircraft to reduce reflected glare.

4. Where suitable habitat (protected waters less than ten metres deep, with or in the proximity of seagrass beds) forms a zone one or two km wide along the shore, the flight path should parallel the shoreline far enough offshore so that each observer can scan an area of habitat 800 m in width. To aid in estimating the outer boundary of the search zone steamers attached to struts or tape markers on the aircraft windows may be used. An alternative is the periodic use of inclinometers to measure the angle to the outer limit of the search zone. If the survey is to be flown over broad shoals, rather than paralleling a shoreline, transects should be laid out so that the most promising areas can be covered. While it is desirable for purposes of more advanced surveys to lay out transects in such a way that variances can be calculated for purposes of estimating population size, I emphasize here that the purpose of first level surveys is to find as many dugongs as possible, thereby establishing a minimum count of individuals and locating occupied areas of habitat. In my view this purpose is served better by covering as many suitable patches as possible than by having a statistically ideal design.

5. As indicated above, the data taken should include time spent surveying, the location and number of dugongs (adults and cow-calf paris) seen, number of sightings (solitary individuals or cow-calf pairs or groups) and the conditions affecting sightability of dugongs during the survey (sea surface, turbidity, cloud, glare). The data should permit calcula-

tion of the number of dugongs seen per minute of survey time and the range and average of group size.

6. Cow-calf pairs should be recorded as cow-calf units. They are identifiable at the surface and beneath it when turbidity is low, as a larger and a smaller (sometimes not appreciably so) dugong within one dugong length of each other. The two are usually seen side by side.

I assume that first-level surveys are unlikely to be generously funded and that initially, at least, observers are likely to be inexperienced. If, at the start of a survey, there is a nearby area where dugongs can be promptly located, a short training flight followed by an on-the-ground discussion of results and any problems is advisable to acquaint the observers with the appearance of dugongs from the air and standardize scanning and reporting procedures. Alternatively, coloured photographs or transparancies could be used in a pre-flight training session.

It is very important that all results, including negative results, be made available. Since there may sometimes be difficulty in finding avenues for disseminating the results of brief surveys, particularly those in which few or no animals are located I recommend that some individual or institution should be designated to serve as a repository and clearing house for survey reports not published in accessible journals. 'Sirenens, edited by Dr. Daryl P. Domning, Department of Anatomy, Howard University, Washington, D.C., USA 20059 might be a suitable vehicle for this purpose.

Second-Level Surveys

Where a dugong population has been located and a decision has been made to investigate the biology of that population from the viewpoint of conservation and/or basic scientific interest, aerial survey has an important role to play in evaluation of habitat use and management requirements. Whereas a single overflight may serve the purposes of a first-level survey, second-level objectives require that flights be repeated systematically at intervals of a few weeks over two or more years.

The most fundamental problem with second-level surveys is not technical, but financial. Depending on the area, dugong dispersion may be influenced by water temperature, prevailing wind and wave patterns, tides, freshwater runoff, growth and quality of vegetation or by disturbance and attacks by human and other predators. Flight paths must be designed, on the basis of preliminary evaluations to take in areas which dugongs are expected to move to, from and through. The financial commitment must be adequate in amount and duration to permit adequate coverage over an adequate period, preferably with the same staff and provide for the ultimate analysis, summary, and publication of the long-term data.

As second-level surveys should be designed to demonstrate the annual pattern of habitat use, variations in that pattern, and the causal factors behind both the patterns and any variations, requirements include more precise location of sightings and measurement of environmental variables as determined from the surface as well as from the air. Surface investigations of habitat, including examination of seagrass beds and measurements of water depths and temperatures may have to be coordinated with second-level surveys.

In areas where water temperatures may play a role in seasonal migrations (see Anderson, this symposium) strong circumstantial correlations may be demonstrable between seasonal dugong distribution and seasonal temperature patterns through examination of false-colour images transmitted by radiometers carried by NOAA satellites. Facilities for economical production of 35 mm transparencies from satellite signals exist in Perth, Western Australia and enquiries can be addressed to CSIRO Division of Land Resource Management, P.O. Wembley, Western Australia, Australia 6014. These transparencies show relative temperature patterns; actual temperatures must be determined by direct surface measurements. Ideally it would be desirable to coordinate surveys, surface measurements, and satellite passes but in most cases this will not be practical.

Observations of dugong behaviour during second-level surveys can assist in habitat evaluation. Dugongs may feed by rooting rhizomes from the bottom or by browsing on emergent stems and leaves (Anderson 1982b). Rooting animals generate clouds or plumes of disturbed sediment which are evident from the air in all except the most turbid waters. Browsing may be difficult to distinguish from non-feeding activities such as idling (Heinsohn *et al.*, 1979) as no sediment clouds are produced and reliable inference as to browsing requires knowledge as to the seagrass species present as well as observation that the animals are diving to the bottom and moving slowly over a seagrass canopy.

Despite reports in the earlier literature that they spend the day in offshore areas and come inshore to feed only at night, dugongs appear to feed without any evident diet periodicity where they are not disturbed (Anderson, 1982a, 1982b, Anderson and Birtles, 1978). However in the Palau surveys, there was little evidence of feeding, animals were scattered singly or in small groups and most animals appeared to be idling in deeper water or in embayments in coral reefs during the daylight hours (Brownell *et al.*, 1981).

The dispersion pattern, activity and location of dugongs seen in aerial surveys may possibly serve as an index of the amount of predatory or other pressure on a dugong population.

Depending on the precision desired, the location of dugong sightings may be determined by use of an elapsed-time stopwatch to obtain precise timing of sightings and of the aircraft's passage over well defined landmarks, or by carrying large-scale aerial photographs of the area and plotting sightings directly on the photographs or suitable overlays. If the stopwatch method is being used it is advisable to equip the survey with a tape recorder-intercom system, consisting of microphone-earphone headsets for each crew member, operating through a tape recorder. Observers can report sightings through the intercom system and the director can acknowledge receipt of reports by stating elapsed time at the moment of the report. The recorder should be in the hands of the flight director and should have an automatic shutoff when a tape ends. The resulting drop in sound level in the headphones will serve as an alarm indicating the need to change tapes.

Since second-level surveys are intended to elucidate both seasonal dispersion patterns and their causes, the option of flying only when conditions are at their best will not always be available. Sea surface conditions can be reported utilizing the Beaufort Scale and cloud can be reported as cloud type and estimated per cent cloud cover. Wind direction and, if available, wind velocity at the sea surface during the survey period should be recorded.

Tidal movements may be a major factor in dugong habitat use in areas where tidal levels fluctuate widely (Anderson and Birtles, 1978) but may be of little significance elsewhere (Anderson, 1982a). In extensive embayments major differences in tidal level and the timing of tidal flows in different parts of the survey area may make precise evaluation of tidal effects difficult since the state of the tide will vary widely in an area covered over even a brief flight.

The major concern in management of dugong populations is management of human activities such as hunting, netting and boat travel and industrial sources of pollutants such as oil, dredge spoils and other anthropogenic sediments or herbicides which may affect dugongs directly or indirectly through effects on seagrass communities. Boats and nets, oil spills and effluent plumes are detectable from the air and should be recorded.

In theory the mean size of calves and frequency of cow-calf pairs, should vary over the year if breeding is seasonal and spatial distribution of sightings of small calves could provide clues as to times and locations of calving. Size estimation is difficult in the short time animals can be observed during a pass with a fixed-wing aircraft and attempts to record sizes of calves or adults have not produced significant informations to date (Heinsohn *et al.*, 1979).

Third-Level Surveys

Assessments of population size and composition to which some quantitative notion of accuracy can be attached are requisites for monitoring trends, controlling harvests if any, and, perhaps most importantly, presenting both governmental and non-governmental agencies with convincing evaluations of the status and trends of dugong populations. Several factors make such assessments particularly difficult. First, despite the admirable progress which has been made in estimation of life span, age at first reproduction and the frequency of pregnancy in Queensland populations through analysis of data obtained from dugong carcases and tusk sections (Heinsohn, 1972; Marsh, 1980; Marsh, Heinsohn *et al.*, and Channells 1984; Marsh, Heinsohn *et al.*, and Marsh 1984), uncertainty remains as to the seasonality of reproduction and the length of gestation and lactation. Further, there is little to go on in evaluating the degree to which these findings will apply elsewhere. Second, the sampling efficiency of aerial survey varies greatly with the geometry of the habitat (linear along shorelines or broadly two-dimensional); the subsurface, surface and atmospheric conditions (substrate, turbidity, glare, wave action, cloud); and the activity (bottom rooting, canopy grazing, idling or bottom resting) and dispersion (clumped or widely dispersed) of the dogongs. In addition to the variations in type of activity just mentioned, there may be significant variation in the frequency with which dugongs surface (Anderson, 1982, 1984; Anderson and Birtles, 1978). Third, animals directly on the flight path are invisible (see Anderson, 1982a for application of a correction factor) and efficiency of sighting varies in a non-linear fashion as distance from the aircraft increasses. This latter effect has yet to be fully evaluated but preliminary analysis of my own data suggests that efficiency averages less than 50 per cent across the width of an 800 m wide zone scanned by each observer.

To date only the surveys reported by Anderson (1982a) and Marsh *et al.*, (1984) have attempted to evaluate sources of error in enumeration. Anderson reported data for wind speed, qualitative evaluation of turbidity, sea surface, estimated per cent cloud, and overall visibility for a series of counts over the same area in the same season and suggested that cloud cover was especially effective in reducing the number of dugongs sighted. Marsh *et al.*, (1984) used analysis of variance to evaluate observer differences and the effects of glare. Using a block-sampling approach in which equally spaced transects were flown within blocks and statistical methods of estimating population size and variance devised by Jolly and described in Norton-Griffiths (1978), they tested for observer bias (none was found) and corrected for effects of glare, and provided confidence limits for resulting estimates of dugong numbers. While the statistical approach which was used takes into account variance due to spatial heterogeneity plus glare and any observer bias, it estimates only that portion of the total dugong population *visible* to observers at the time the aircraft passes over-head. Since only dugongs seen enter into the analysis, and the proportion of dugongs in the flight path seen is unknown, the estimate is conservative to an unknown extent and the confidence intervals are illusory in the sense of estimating the actual population of dugongs as opposed to that detectable by the survey techniques used under the prevailing conditions.

Many of the difficulties in meeting 3rd-level objectives can be overcome by experimental surveys and modifications of technique. Error levels under various conditions could be estimated by repeated flights over the same area under the same and different conditions, or by using two aircrafts with two teams of observers flying the same route a half hour apart. Development of a satisfactorily quantitative technique for periodically assessing visibility (perhaps moored equivalents of the 'secchi disc' used in limnology) would be especially useful. Lack of adequate funds for such experiments, and for training and maintaining experienced survey teams remains the major obstacle to providing convincing estimates of survey accuracy. Until funding agencies are willing to finance the necessary experimentation they are on dubious grounds in discounting direct enumeration aerial survey results which lack confidence limits.

Fourth-level Survey

As a specialist on benthic macrophytes the dugong is restricted to shallow water environments. Because shoal waters are brightly illuminated and in close proximity to substrates which provide both suspended sediments and nutrients, subsurface visibility is limited to no more than fifteen or twenty m and not infrequently to less than one m. Further, dugongs are both alert, and curious, so that unless they can be accommodated to the presence of an underwater observer it is extremely difficult to observe a range of individual and social behaviours from beneath the surface.

The same shallow water preference that makes subsurface observation of dugong behaviour difficult creates a so far unrealized potential for observation of dugong behaviour from a vantage point above the surface. In the brief moments in which dugongs are visible during the passage of a fixed-wing aircraft occasional glimpses of interactions among dugongs can be seen, but the time is generally too short to allow the nature of the behaviours to be unequivocally identified. Much could be learned about social interaction, courtship, mating and perhaps even calving if it were possible to observe from a stationary aircraft.

Helicopters may offer some advantage, but at very high cost. Further, as dugongs clearly respond to the sound of a circling fixed wing aircraft, the much greater noise of downward-projected helicopter sounds may negate any advantage gained. Robineau and Rose (1982) noted that dugongs dove deeply when the helicopter hovered over them, especially at low altitudes.

The current fad in 'ultra-light' aircraft able to fly at very low speeds offers a possible alternative for aerial study of dugong behaviour. Lighter than air vehicles, for example some of the more recently designed airships, would probably be even more suitable, having the capability of hovering with relatively little disturbance or even anchoring upwind and then letting out sufficient line to hover silently over a group of dugongs. There seems little doubt that current technology can provide the necessary apparatus and that what I have referred to as fourth-level aerial survey could lead to very significant advances in our understanding dugong behaviour. It is perhaps too much to expect that such esoteric activities as the study of marine mammals will be supported to the extent that these lovely toys can be put to use in the near future.

Conclusions

I have tried to present a broad picture of the role I believe that aerial observation can play in efforts to discover dugong populations, to assess their status, to study their biology and contribute to their survival. I believe that the most urgent need for aerial survey, and its most important contribution, lies in the relatively simple task of assessing where, and in what numbers, dugongs persist outside of the Australian region. Without that inforamtion I greatly fear that dugong stocks elsewhere will slip into extinction unnoticed, an eventuality in which we could take little pride.

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USER INVOLVEMENT IN CONSERVATION OF ENDANGERED SPECIES

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Abstract

In order to effectively manage a scarce resource, one must involve the users in research, management, and educational programs. The Great Barrier Reef Marine Park Authority, Australia, has been working with a user group—an Aboriginal community of eastern Cape York in an initial program to ensure conservation of dugong, an endangered species, in the Great Barrier Reef Marine Park. This is a contribution to long-term conservation of endangered marine species and to support Australia's international obligations to the World Heritage Convention.

The Marine Park Authority's Commitment to Conservation of Endangered Species

In 1981, Australia's Great Barrier Reef was nominated to the 'World Heritage List'. The Great Barrier Reef Marine Park Authority prepared the submission which was formally presented by The Australian Commonwealth Government with agreement from the Queensland State Government. One of the criteria that the Great Barrier Reef met was that it provides:

> 'habitats where populations of rare and endangered species of plants and animals still survive.' (GBRMPA, 1981)

In the nomination, the Great Barrier Reef Marine Park Authority was one of the agencies named as being responsible for and being able to make provision for the state of preservation/conservation of the proposed Heritage property.

One of the means by which the Marine Park Authority manages the Great Barrier Reef Region (Fig. 1) is through preparation of Zoning Plans. The *Great Barrier Reef Marine Park Act* 1975 requires that the Authority, when preparing Zoning Plans for Sections of the Marine Park, take into consideration, among other points, the following:

> 'the regulation of the use of the Marine Park so as to protect the Great Barrier Reef while allowing the *reasonable use* of the Great Barrier Reef Region.' (GBRMPA 1975)

The Marine Park Authority, then, has a commitment to conservation of endangered species, where the term 'Conservation' is defined as 'Wise use in perpetuity'.

User Involvement in an Integrated Program for Conservation of Dugong

As described in a background paper prepared for this conference by Dr. Marsh there, is widespread concern about the world's remaining dugong population. It is thought that the effects of over-hunting as a result of improved technology, greater incidental take as a result of increased fishing effort by commercial fishermen in habitat areas, and an expanding shark-netting program have all had their toll on Australia's dugong population (Marsh, 1984).

In a developed country such as Australia, ideas of intentional exploitation of endangered species may not normally be entertained. However, the Commonwealth government has indicated that the traditional pursuits of Australia's original inhabitants—Aborigines and Torres Strait Islanders—cannot be ignored (Sydney Morning Herald, 1983). The dugong is of cultural significance and has long been hunted to supply nutritional requirements. For many of these people, the survival of the dugong represents survival of their culture (Chase, 1980).

Lessons can be gained from the experience of the International Whaling Commission (IWC) in regard to the management of harvesting of the Bowhead Whale in Alaskan waters (IWC, 1982). The value of considering both wildlife science and cultural anthropological aspects of the situation proved essential in resolving conflicts surrounding the Eskimo harvest of an endangered species.

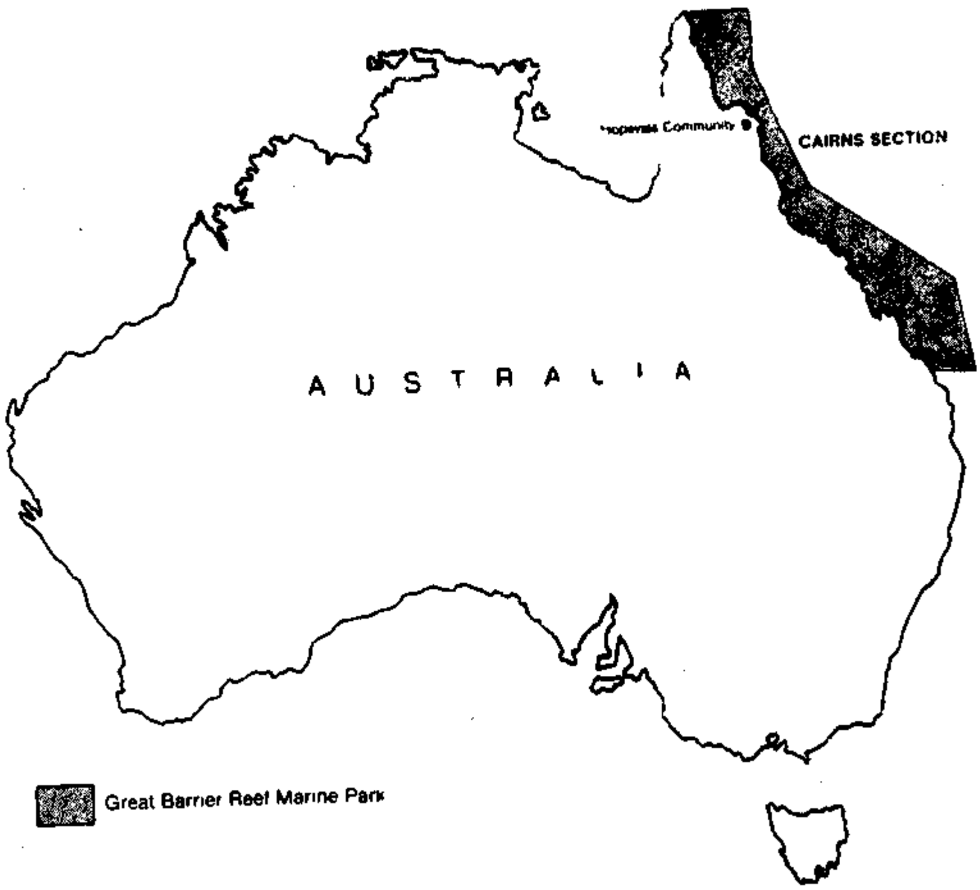

FIG. 1. Location of Great Barrier Reef Marine Park.

However, there is limited information available on the present size of the Australian dugong population, on the actual take of dugong around Australia, and on the cultural significance of dugong. As a result of a need for accurate information and for managing the take of dugong, the Marine Park Authority has initiated an integrated program of research, management, and education on dugong.

To be successful though, any management scheme needs to be acceptable to all parties. Development of a research program and management scheme must adequately include the 'users'. Only through user involvement in an integrated program can the political realities of Aboriginal rights and protection of an endangered species be resolved.

Hope Vale Community

Implementation of user involvement in an integrated program can best be illustrated by the Marine Park Authority's developing program in North Queensland, Australia. To the people of Hope Vale, (Fig. 2) an Aboriginal community on the east coast of Cape York, (with a population 600 or 150 families), the dugong has been an important source of food for many years. It has been estimated (Marsh and Heinsohn, 1982) that the dugong herd adjacent to the Starcke River near Hope Vale is one of the largest in Australia.

A public participation program is an essential part of preparation of Zoning Plans for all Sections of the Great Barrier Reef Marine Park. During preparation of the Zoning Plan for the Cairns Section of the Marine Park in 1982 and early in 1983, Authority staff consulted with the Hope Vale community about the best means of management of the Starcke River area, as a prime dugong habitat. The main hunting season for dugong in the Starcke area occurs during Christmas school holidays. The Council asked that hunting be limited to that season to give all hunters an equal opportunity to take dugong.

In light of a lack of documentation of the community's use of the marine resources, the Marine Park Authority established a study on the marine resources of the area and their use by the community. With the support of the Council and community, the study has now been underway for 12 months. In the meantime, late in 1983 the Cairns Section Zoning plan came into effect, making the Starcke area a Scientific Research Zone. In that zone, traditional hunting of dugong is a permitted activity for those 'traditional inhabitants' who apply for and receive a permit. The objective of the zone and the only other activity permitted in that zone is scientific research.

A number of conditions were proposed to be attached to the required permit for traditional hunting. In conjunction with Queensland National Parks and Wildlife Service, day-to-day managers for the Marine Park, and the Marine Park Authority, the permit conditions were discussed with and accepted by the Hope Vale Council as well as by the dugong hunters. The conditions attached to the hunting permit were as follows :

a. One dugong to be taken per hunter; total quota for the whole community to be 20 dugong;

b. Female dugong with calves not to be taken.

c. No firearms, including spearguns and powerheads, to be used in taking dugong;

d. Catch data sheets to be completed for each dugong taken for collection by Great Barrier Reef Marine Park Authority; and

e. Permit to be available for inspection in the Marine Park;

The permit was issued in Hope Vale and valid for the Marine Park area north of the Endeavour River, between 26 December 1983 and 31 January 1984.

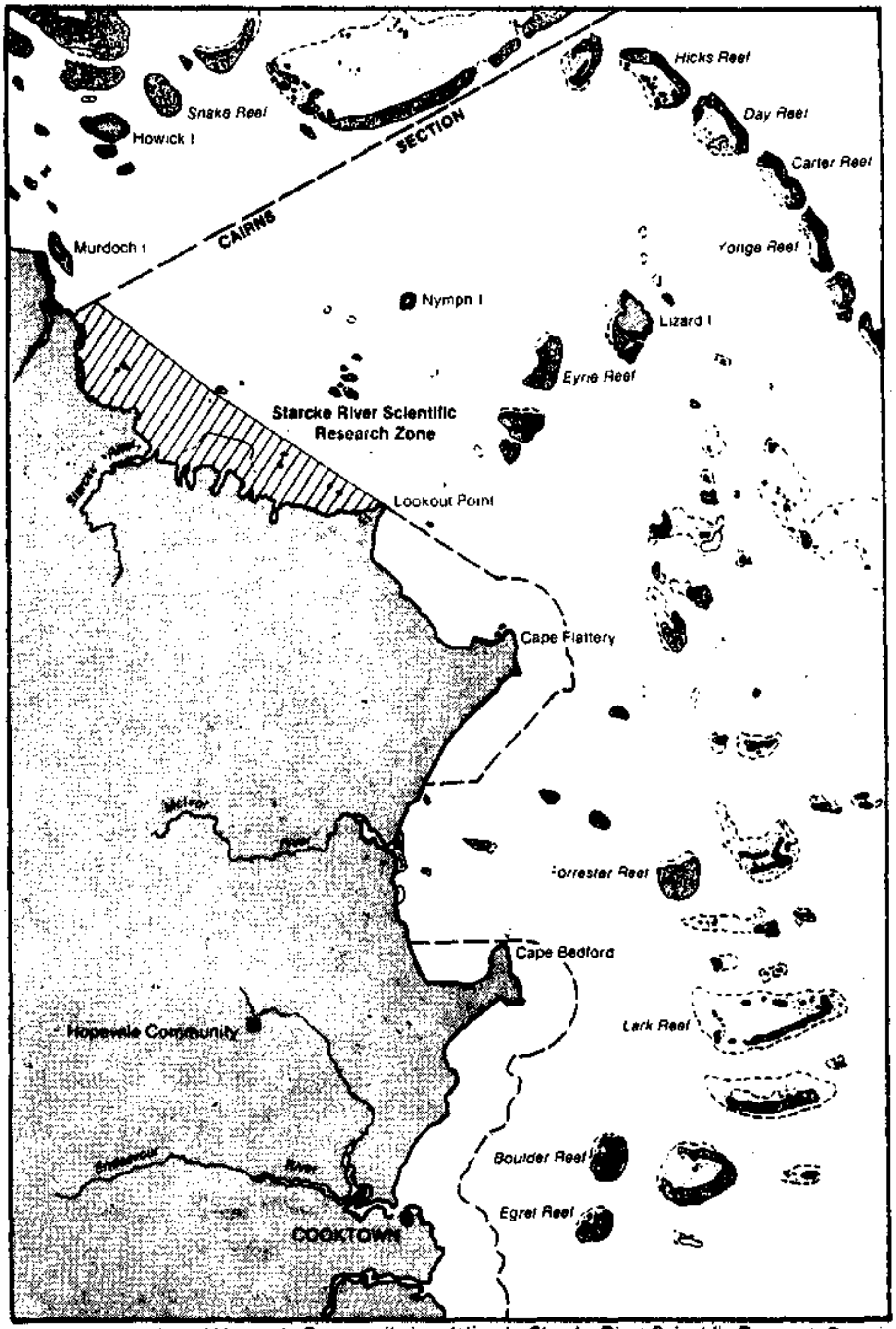

Fig. 2 Location of Hopevale Community in relation to Starcke River Scientific Research Zone

The first time this 'management system' was tried out was in the hunting season of Christmas holidays 1983/84. The permit system was effective to the extent that it controlled and monitored the take of dugong during the hunting season. However, it was apparent that the purpose of, and need for, these new restrictions had not been relayed adequately to the *entire* community, leading to resentment of the recently introduced system. Later discussions between Marine Park managers and the community led to a decision that communication with the entire community had to be improved.

The Great Barrier Reef Marine Park Authority and Queensland National Parks and Wildlife Service have agreed to an educational program directed towards explaining the biology of the dugong and the need for specific conservation measures. The agencies have recently co-produced a video tape in co-operation with the Hope Vale community. It explains why the dugong is vulnerable to extinction, what the various pressures are on the dugong, and the reasons for and the requirements for a permit to hunt. Since many private homes in Hope Vale have video viewers, the video will be available to the Hope Vale community as well as to the local school. It is intended that it will also be used, after adaptations, for discussions with other Aboriginal Islander communities and Marine Park user groups.

Based on the Hope Vale experience, the Marine Park Authority is in the midst of expanding and broadening the integrated program for conservation of endangered species. The following table illustrates the details of an integrated program of research, management, and education as it relates to Hope Vale and is extended to encompass a broader perspective. There is a place for user involvement in each aspect of the program.

Hope Vale	Broader Perspective
Research	
* use of marine resources—East Coast of Cape York	* participation in a proposed national program of Research and Management of Traditional Fisheries
* monitoring and biological sample of dugong catch—Hope Vale—January 1984	* effects of gill netting on dugongs—East Coast Cape York
* aerial surveys and monitoring of the dugong populations—east coast Cape York beginning November 1984	* habitat mapping using Landsat imagery—Great, Barrier Reef Region
Management	
* Cairns and far Northern Sections Zoning Plans	* involvement in a Commonwealth/State Inter-Departmental Committee on take of Endangered Species
* permit system and conditions	* Central and Capricorn Sections Zoning Plans
* possible self-management	

Education

* video tape illustrating dugong vulnerability and permit system
* in-service training for Cape York teachers ; assistance with establishing conservation curriculum and supply of teaching aids.
* poster series on endangered species : dugong (*initial poster*)
* in-service training workshops for teachers adjacent to Great Barrier Reef Region.

This paper has focused on work initiated by the Great Barrier Reef Marine Park Authority with *one* user group—the Aboriginal people of the Hope Vale Community—in relation to *one* resource management problem—conservation of dugong. Only by ensuring user involvement in an integrated program of research, management and education will a management scheme be succesful.

The time-consuming nature of ensuring user involvement in conservation management means that the results of such work will not be available in the short-term. The Marine Park Authority is making a contribution, to long-term conservation of endangered species, to management of the Reef's resources, and to support Australia's international obligations to the World Heritage Convention.

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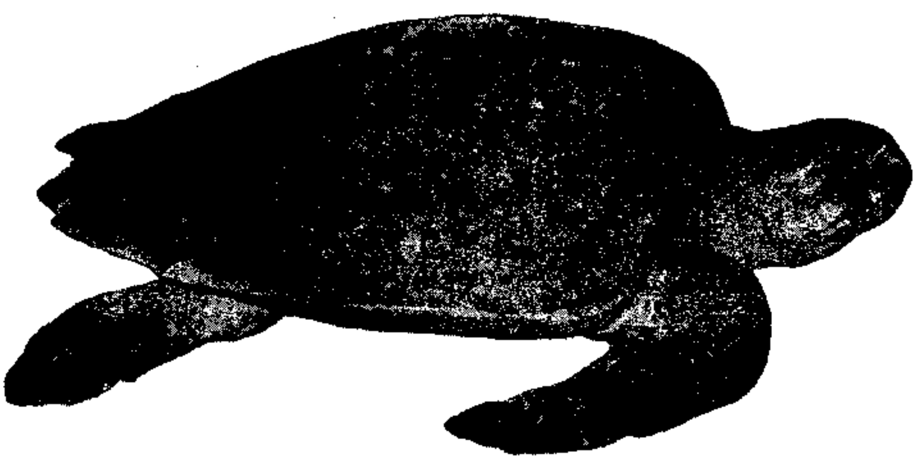
Estuarine and Marine Reptiles



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INDIA'S SEA TURTLES IN WORLD PERSPECTIVE

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ABSTRACT

The importance of sea turtles nesting in India is assessed in the context of the region and the world. Five of the seven traditionally recognised species occur in the northern Indian Ocean, but only the green turtle, hawksbill, olive ridley and leatherback are known to nest on Indian territory. Considered in world perspective the following should be given joint top priority in any comprehensive action plan for sea turtle conservation in India ; (1) the olive ridley population nesting on the mainland east coast, where the *arribada* beaches in Orissa (with the potential for sustainable resource use) are among the three most important in the world and the only mass nesting sites outside the east Pacific, and (2) the Andamans and Nicobars, with moderate numbers of nesting green turtles and olive Ridleys, very good nesting numbers of hawksbills and leatherback, and in addition a unique range of marine, coastal and terrestrial habitats and species.

INTRODUCTION

THE purpose of this paper is to review briefly the distribution and status of sea turtles in India, and to evaluate the significance of these stocks at a regional level—considering the northern sector of the Indian Ocean—and in the overall world context. This provides one criterion by which to assess conservation priorities among the Indian species, although other criteria, notably potential importance as an exploitable but renewable resource, are also appplicable. In fact, as will be pointed out below, the top conservation priority indicated by both these criteria is the same species—the olive riddley *Lepidochelys olivacea*.

One of several drawbacks to sea turtle research in the region and elsewhere is the lack of knowledge of maturation and feeding grounds, and migration patterns between these areas and nest sites. Thus, although sea turtle stocks are typically a resource shared by two or more nations, most of the discussion below will be in terms of nesting sites and numbers and cannot take account of the species' overall life history.

All the world's sea turtles may be regarded as threatened to some extent, the flatback *Chelonia depressa* less so than the remainder and Kemp's Ridley *Lepidochelys kempii* more so. Neither of these species occur in the region under consideration. Of the remaining five species, certain populations are severely threatened and probably the majority of populations are under pressure from one factor or another, or a combination of factors; however, none of the groups of populations currently recognised as species are under immediate threat of effective total extinction. This picture is complicated by the fact that local populations of some species, notably the green turtle, may not interbreed with other local populations and an assessment of world numbers, in terms of the conventional species concept, may thus be unrealistically high.

World numbers are in any case only a partial measure of the survival outlook of these taxa, the low rate of hatchling survival and the rather late age of maturity are among other relevant considerations. The IUCN status categories, which have been traditionally applied to more typical species, are rather difficult to apply in these circumstances; the best way to treat these animals is still under consideration and the temporary categories given in the Red Data Book covering chelonians (Groombridge, 1982) are not repeated below.

SEA TURTLES IN INDIA

The following section will outline the world's sea turtle species, their situation in the world as whole, and in the region of the northern Indian Ocean. For most species is provided (i) a brief statement of world range and status, (ii) a summary of a few important features of the species' biology, (iii) remarks on range and status in the northern Indian Ocean area, and India in particular. Most of these data are taken from the Red Data Book (Groombridge, 1982); more information and references may be found therein. Although still incomplete, the present picture of nest sites and nesting numbers in India is a lot clearer than just a decade ago. No attempt is made to review this material in detail here; much new information is provided by Bhaskar (1984a, b, c) and Kar and Bhaskar (1981) and several items of interest can be found in recent issues of *Hamadryad.*

LOGGERHEAD **Caretta caretta** (TESTUDINES: CHELONIIDAE)

World range and status

This is a circumglobal species but differs from the four other such forms (which are primarily tropical) in nesting mainly in temperate and subtropical waters; except for the Caribbean area almost all nest sites are either north or south of the tropics. Populations are still widespread although some populations are known to have declined and others are suspected to have declined. Most are under pressure, due primarily to incidental capture in trawl nets, loss of habitat due to development and local exploitation. The largest known populations are in Oman, where around 30,000 females nest annually on Masirah Island, and along the eastern seaboard of United States, where about half this number nest.

Biology

A large species, attaining 90-100 cm carapace length, the loggerhead feeds mainly on benthic invertebrates such as molluscs and crustacean. Females may nest four or five times a season and can remigrate at two or three year intervals; mean clutch size in different populations varies between 100-130. The time taken to attain sexual maturity in wild sea turtles appears to be longer than earlier assumed; at one locality (Mosquito Lagoon, Florida) the maturation period for loggerheads has been calculated at between 10 and 15 years.

Regional range and status

Although the loggerhead has it major world nest site in the northwest Indian Ocean—Oman's Masirah Island—the species is only erratically recorded in waters around Pakistan, India, Sri Lanka and Bangladesh. Nesting in the region is poorly documented and apparently very sparse; small numbers certainly nest in Sri Lanka (Dattatri and Samarava, 1983; Wickeremasinghe, 1981) but there is no confirmed nesting in India. Similarly, migration routes and feeding zones are poorly known. There are no confirmed records for Burma (Selter, 1993). The species thus appears to be of very little significance in the Indian context.

FLATBACK **Chelonia depressa** (TESTUDINES: CHELONIIDAE)

World range and status

Largely restricted to the Australian continental shelf where rather widespread and abundant. Nests in Western Australia, Northern territory and Queensland, also on islands in the Torres Straits. Feeding turtles range into waters of Papua New Guinea and Indonesia, in the latter region nesting is suspected on Timor and the species has rcently been confirmed to move as far as the seas around Java (Salm, 1984). There is some subsistence harvest of the species and a significant level of incidental catch, but overall the species appears to be the least threatened of the world's sea turtle species.

Regional range and status

There is no confirmed record of the flatback in the northern Indian Ocean.

GREEN TURTLE **Chelonia mydas** (TESTUDINES : CHELONIIDAE)

World range and status

A circumglobal species nesting on islands and mainland beaches, mainly in tropical and subtropical regions. The East Pacific stocks are sometimes treated as a full species the black turtle *Chelonia agassizii*. Although very many nesting locations are known around the world, most populations appear to be depleted and some local extinctions are known, notably in parts of the Caribbean region. There are currently a dozen or so areas with really large nesting populations (reaching an arbitrary level of 2,000 females nesting annually); these are Ascension Island, west and north Australia, Costa Rica (Tortuguero), Europa and nearby islands in the Mozambique channel, Pacific Mexico (*C. agassizii*), Oman, Pakistan, south Yemen and with large numbers also in Sabah, Sarawak and the Philippines. The stronghold of the species is Australia, where the population, comprising in the region of one hundred thousand females nesting in a typical year, appears to be among the most stable and least heavily exploited. The species is threatened over most of its range by a variety of factors including heavy exploitation of eggs, juveniles for curios, adults for food and other products (such as leather and oil), incidental catch, habitat loss, and possibly pollution.

Biology

The green turtle is a large species, reaching about 100 cm in carapace length, and mainly herbivorous, feeding on sea grasses and algae. A highly migratory species, green turtles typically lay round 110 eggs per clutch, can re-nest three to seven times in a season and have been shown to remigrate at two to four year intervals. There is good evidence from parts of the green turtle's range that the species shows strong philopatry (return to a particular regional shoreline) and site fixity (return to a particular beach) ; such populations tend to be reproductively isolated from other such populations and conservation issues thus need to be considered strictly on regional basis. Maturation period in wild green turtles has recently been estimated at between 25 and 50 years, in Florida and Hawaii (nutrient-poor localities) respectively. Significant captive breeding success has been attained at the Cayman Turtle Farm, where artificial conditions allow rapid growth.

Regional range and status

There are very significant nesting and feeding grounds for green turtles in the northern Indian Ocean region. Three large nesting populations are known around the Arabian Peninsula ; those centred on the Ras al Had area of Oman and the Mukalla area of South Yemen (People's Democratic Republic of Yemen) are amongst the dozen largest in the world, with probably over 5,000 females per year at the former and possibly twice that number (about a decade ago) at the latter (Ross and Barwani, 1981). There are also important sea grass beds, used by feeding green turtles, at several points around the peninsula, apparently of low quality in the Gulf however.

Further to the east, there are reports of sparse nesting along the Makran coast but the beaches at Hawkes Bay and Sandspit on the outskirts of Karachi constitute a further nesting zone of world importance : about 5,000 greens nest here annually. This is suspected to be a largely resident population. The species is uncommon in Bangladesh (Khan, 1982), and relatively so in Burma (Salter, 1983), although it is recorded along much of the coast and nests in places, Thamihla Kyun for example (numbers have declined severely since the last century). Few greens nest on Sri Lanka (Wickeremasinghe 1981) although the species is found quite widely in Sri Lankan waters, and moderate numbers nest in the Republic of the Maldives.

The green turtle has been recorded in waters off many parts of India's mainland coast, but nests at relatively few sites and in rather small numbers, notably between Okha and Okha Madhi in the Gulf of Kutch, also scattered other sites around the Saurashtra peninsula (Bhaskar, 1984a ; Kar and Bhaskar, 1981). However, more significant nesting occurs in the Lakshadweeps (especially the uninhabited Suheli Valiakara) and the Andamans and Nicobars (Bhaskar, 1984c). Feeding green turtles occur in good numbers over the seagrass and coral beds in the Gulf of Mannar. There are suggestions that the turtles nesting on the Burmese coast migrate to do so to and from feeding grounds in the Andamans and Nicobars (Maxwell, 1911) and that some of those nesting at Karachi feed in the Gulf of Kutch (Bhaskar, 1984a).

Overall, although the region supports nesting green turtle populations of great world importance, as well as scattered lesser sites, mainland India is of little current significance in these respects, but it does possess feeding grounds (in the Gulfs of Kutch and Mannar) and notable populations do occur in the island territories of the Lakhshadweeps, Andamans and Nicobars.

HAWKSBILL **Eretmochelys imbricata**
(TESTUDINES : CHELONIIDAE)

World range and status

A circumglobal species, nesting mainly in tropical waters, often on islands but also on mainland beaches. One of the more severely threatened sea turtle species, most populations are known or suspected to be depleted and are under continuing pressure mainly due to international trade in 'tortoiseshell' (the polished scutes of hawkbill, primarily utilized by Japan). Also affected by exploitation for curios (stuffed polished young turtles) and habitat loss : eggs and turtles also subject to subsistence exploitation. Moderate population levels appear to persist around the Torres Straits islands and other parts of northern Australia, in parts of the Solomons Islands, in the Red Sea and Gulf of Aden, a couple of islands in the Persian Gulf, Oman, parts of the Seychelles, and possibly in the Maldives and northwest Madagascar.

Biology

A small to medium size species, reaching approximately 70 to 85 cm, typically associated with coral reefs where it feeds on benthic invertebrates, notably sponges. Often assumed to be a largely resident species, but some extensive migrations are known to occur. Populations exist at rather low density and nesting is typically solitary and diffuse, thus estimates of population size are very difficult to make. Females can lay two to four clutches per season and can remigrate at intervals of three years : clutch size varies with female size, from about 75 to 180 eggs for example.

Regional range and status

The species is widely but sparsely distributed around the Arabian peninsula, with relatively large scale nesting known in South Yemen, with about 1,000 females per year, and Lavan and Shetvar islands in the Gulf, with about half that number. To the east there appear to be no records of hawksbill nesting in Pakistan and very few records for mainland India; recent sites include the Gulf of Mannar. However, there is significant nesting in the Lakshadweeps and the Andamans and Nicobars, possibly 500-800 nest annually in the Andamans (Bhaskar, 1984c). The species is uncommon in Sri Lanka, with probably a few dozen annually (Wickeremasinghe, 1981), also Bangladesh and Burma (although reports exist for much of the coast) (Salter, 1983).

With a species so sparsely distributed, poorly known and heavily exploited as the Hawksbill, even small-scale nest sites assume some significance on a world scale. India's populations in the Lakshadweeps, Andamans and Nicobars are noteworthy in this context, and the coral zones in the Gulfs of Kutch and Mannar may be of similar importance for feeding Hawksbills.

KEMP'S RIDLEY **Lepidochelys kempii**

(TESTUDINES : CHELONIIDAE)

World range and status

The most severely threatened sea turtle, now critically endangered. Nesting numbers have declined from around 40,000 in one day's mass nesting in 1947 to around 200 in the largest group nesting in the early 1980s. Nesting is now virtually restricted to a single 20 km beach on Mexico's Gulf coast, near Rancho Nuevo in Tamaulipas State, northeast Mexico. Feeding and migrating turtles occur around the Gulf shores and along the eastern seaboard of America. The original collapse of the species is attributed to excessive harvest of eggs and adults by man and other predators accidental catch in shrimp trawls and probably pollution from the Mississippi drainage. Accidental catch is the major present problem. An intensive programme of conservation measures is underway, involving relocation of nests, headstrating, captive breeding (recently attained at the Cayman Turtle Farm) and, primarily, development of devices to exclude turtles from trawl nets.

Biology

Kemp's ridley is a small species, of about 65-70 cm carapace length, feeding on benthic invertebrates, mainly crabs. In common with the olive ridley, this species tends to emerge to nest in synchronized aggregations (termed *arribada* in the Pacific, Spanish for 'arrival'), possibly a predator-swamping strategy. Clutch size around 110 · between one and three clutches may be laid per season, with remigrations on a one or two year cycle. In contrast to other sea turtle species nesting is typically diurnal.

Regional range and status

There are no records of the species in the northern Indian Ocean.

OLIVE RIDLEY **Lepidochelys olivacea**

(TESTUDINES : CHOLONIIDAE)

World range and status

A circumglobal species nesting primarily on mainland beaches, not on islands, in the tropics and subtropics. Still widespread and locally numerous although most populations are known or suspected to be depleted, and most are under pressure from heavy egg collection, harvest of adults for food and leather, and incidental catch in trawl nets. Where population numbers are high, females emerge to nest in synchronised aggregations (*arribada*) · possibly a predator-swamping strategy, as with Kemp's Ridley. Large *arribadas* have been known at three sites on the Pacific coast of Maxico, only one of which (La Escobilla) still retains mass nesting, with perhaps several tens of thousands of females annually, and still occur at two sites—Ostional and Narcite beaches—in Pacific Costa Rica. Between

200,000 and 300,000 females participate annually in *arribadas* at each of the Costa Rican sites, both of which are relatively well protected (although there is significant egg predation at Ostional). Elsewhere in the world, only India's east coast rivals the Costa Rican sites in importance, with 300,000 females, or more, nesting in Orissa (see below).

Biology

A small sea turtle, typically 65 to 70 cm carapace length : little is known of the species' biology away from the nest beach. The olive ridley appears to forage mainly in tropical neritic waters, feeding near the surface on larger plankton, including tunicates and jelly-fish, and diving to feed on benthic crustaceans. Some extensive migratory movements are known : for example turtles nesting in the East Pacific move northward to the Gulf of Mexico and southward along Central America to Ecuador. Schools of turtles moving northward, presumably to nest on India's east coast, have been recorded in Sri Lankan waters. Females can nest two or three times a season and remigrate at one or two year intervals. Mean clutch size is around 100 to 115. Hatching success is extremely low at some sites, at Nancite for example, success rate is much less than 1% : estimates for other sites include 23% (La Escobilla, Mexico) and 59% (Eilanti, Surinam).

Regional range and status

A few olive ridleys nest in Oman, and alongside the green turtles outside Karachi, and the species occurs rather widely in coastal waters around the northern Indian Ocean. Nesting occurs in small numbers at several sites around the mainland coast of India, notably Bhaidar Island in the Gulf of Kutch and at several other points around the Saurashtra peninsula in Gujarat, also at several places on all four east coast states, and in the Lakshadweeps, Andamans and Nicobars. Most importantly, the massive *arribada* at Gahirmatha and adjacent beaches in Bhitar Khanika Wildlife Sanctuary in Orissa has been noted above. The species occurs in Bangladesh, with the possibility of a small *arribada* on one of the islands off the southeast corner of the Sundarbans in Khulna District (Whitaker, 1982). Large-scale nesting is suspected to have occurred along the Burmese coast during the last century, but present numbers appear to be much reduced, although precise data are lacking. The suggestion has been made that the olive ridleys nesting in Burma feed around the Andamans and Nicobars. Several thousand nest in Sri Lanka, notably on the southwest coast, especially at Kosgoda (Dattatri and Samarajiva, 1983).

In the world context, Sri Lanka and much of India's east coast are of great importance, but the Orissa *arribadas* represents one of the three largest local populations of olive ridley in the world and the only mass nesting away from the Pacific coast of Central America. In fact the 1984 emergences at Gahirmatha, each with around 400,000 females (Bhaskar, 1984b), may be the largest ever recorded anywhere.

LEATHERBACK **Dermochelys coriacea** (TESTUDINES : DERMOCHELYIDAE)

World range and status

A circumglobal species nesting on beaches of tropical seas, generally on high-energy mainland coasts, and foraging widely and regularly into temperate waters. Although considered on the verge of extinction a few decades ago continuing survey efforts have revealed several previously unknown nest sites and allowed the estimate of the total world population to be revised upward to over 100,000. There is large-scale nesting at Trengganu in West Malaysia (1,000-2,000 females annually), in French Guiana (4,500-6,500), Pacific Mexico (up to 30,000), and along the 'Vogelkop' region of Irian Jaya where, with about

13,000 nests in 1984, numbers may be comparable to those in Malaysia or French Guiana. Although there is no evidence for overall decline in the species' numbers, certain populations are known or suspected to have declined, and the species is under pressure due to egg harvest, habitat loss, incidental catch, and harvest of adults for meat or oil. Marine debris, such as discarded nylon nets and plastic bags, are additional probable threats. However, there is virtually no international trade in Leatherback products.

Biology

The leatherback is by far the largest extant sea turtle, often 150 cm carapace length, sometimes to 180 cm. The species is morphologically unusual among turtles in lacking a properly developed bony carapace and plastron, and cornified scutes, and ecologically unique in having a truly pelagic mode of life. Leatherbacks are powerful swimmers, inhabiting the open seas, but also occur in neritic waters, and make regular migrations into cool temperate waters to feed on seasonal concentrations of jellyfish, the main diet of the species. Females can renest four to six times a season and remigrate at two or three year intervals. Mean clutch size (at Trengganu) is about 84 ; leatherbacks lay fewer but larger eggs than other sea turtles.

Regional range and status

Apparently widespread around the Indian Ocean, but very sparsely recorded and with very few recent nesting records in the northern sector of the region and no regular really large-scale nest sites. A few dozen, probably fewer than 100 in all, may nest in Sri Lanka with similar numbers in the Lakshadweeps. Numbers are somewhat higher in the Andamans and Nicobars where Great Nicobar and Little Andaman constitute the only known important leatherback nest sites in India, with, for example, 160 old nest excavations found at one locality on Great Nicobar (Kar and Bhaskar, 1981) and good numbers in the Andamans (Bhaskar, 1984c). Mainland India is now of little significance to the leatherback.

Discussion

The material summarised above indicates that five of the seven sea turtle species occur in the northern Indian Ocean : the loggerhead, green, hawksbill, olive ridley and leatherback. All but the Loggerhead are known to nest on Indian territory. All these populations are under some degree of pressure, varying locally, from exploitation and habitat modification : most are thought or known to have declined since the last century.

Despite India's relatively good record in sea turtle conservation, particularly in recent years, the finances available for research, conservation and management are clearly not unlimited. In these circumstances it might be advantageous to direct most available funds and research effort toward just one or two top priority projects, rather than spread resources over all possible projects and diminish the chance of success in each. For example, little or nothing can be done to restore numbers of nesting leatherbacks in Kerala.

The relative importance of India's sea turtle stocks in the overall world context is one possible criterion by which to assess the top priority projects. This can be approached in two distinct but interrelated ways. First, in terms of single species, by a direct comparison of populations size (in the case of sea turtles, of annual nesting female numbers), and second, in terms of multi-species assemblages, by an assessment of local species diversity and integrity of habitat.

The first approach indicates that, while India supports nesting populations of green turtles, hawksbills and leatherbacks that are important at a regional level (considering the northern Indian Ocean), only the leatherbacks and hawksbills in the Andamans and Nicobars rank among the world's more important populations of these species. However, the olive ridley population is outstanding; the east coast of India (with Sri Lanka) ranks alongside the Pacific coasts of Mexico and Costa Rica as one of the top three zones in the world for the species, and by far the most important area away from the east Pacific. Within this area the mass nesting sites on the Orissa coast are of critical importance. Indeed, as noted above, first estimates of the two 1984 *arribadas* at Gahirmatha, each with around 400,000 females (Bhaskar, 1984b), appears to be the largest ever recorded anywhere in the world. As also noted above, at present only Nancite and Ostional beaches in Costa Rica compare with Orissa in importance for mass olive ridley nesting.

It could reasonably be suggested that India has a responsibility to the world for conserving the Bay of Bengal Ridley stocks (and with protection of Gahirmatha nesting beaches and recent Coast Guard patrols offshore, India has gone a long way toward discharging this responsibility), but perhaps a more pressing reason is that, as already pointed out by several biologists in India, this immense resource appears to have the potential for some scale of sustainable exploitation. Probably the mildest form of exploitation is to take a proportion of the millions of eggs laid most years (Mrosovsky, 1983); harvest of a certain number of adults may also be feasible, but this is a more contentious issue. Clearly, the two prerequisites for this are continuing and more refined protection of nest beaches and offshore waters, and research directed at the most appropriate form of management. There should be no question of legal utilisation of this resource in the immediate future, but the potential probably exists for India to support not only one of the world's largest olive ridley populations, but simultaneously a valuable nutrient source, in the form of turtle eggs and possibly turtle meat, for communities not averse to these foodstuffs.

The second approach to assessing priorities outlined above indicates that, with the exception of the Orissa olive ridley rookeries noted above and the partial exception of the Gulf of Kutch and the Gulf of Mannar—areas that include the first two Indian marine National Parks — little of the coast of mainland India is a top priority for conservation action. In contrast, the island territories of the Lakshadweeps, and the Andaman and Nicobar groups should be major targets for action. Good numbers of green turtles, hawksbills, olive ridleys and leatherbacks nest and feed in these islands. Whilst different individual islands are favoured by different species, the Andamans and Nicobars stand out by their higher leatherback numbers (one of the few important sites for the species in the entire Indian Ocean) and the apparently higher numbers of nesting hawksbills. In addition, the overall value of the marine, coastal and terrestrial habitats in the Andamans and Nicobars, the relative integrity of the tropical rain forest and mangrove communities widespread in the group, the high number of endemic taxa (of plants, reptiles and birds, among others), and the continuing survival of indigenous tribal communities, all place the Andamans (Whitaker (in press)) and Nicobars firmly among the world's most prominent natural areas, and argue strongly for more effective research and conservation in the group.

Of course there are a great number of very pressing problems in sea turtle conservation in India, and each maritime state will have its own priorities, but the evidence suggests to me that the olive ridleys nesting on the mainland east coast, and the nesting and feeding grounds of the various species in the Andamans and Nicobars, should be the top priority projects in any comprehensive sea turtle action plan in India. As part of the olive ridley project, it would seem desariable for nations around the Bay of Bengal to build up a more complete picture of ridley numbers and movements in the region, largely by cooperative tagging programmes, in addition to their local efforts.

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ESTUARINE TURTLES OF TROPICAL ASIA : STATUS AND MANAGEMENT

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ABSTRACT

Four large riverine turtles *Batagur baska, Callagur borneoensis, Kachuga trivittata* and *Pelochelys bibroni* inhabit estuarine habitats throughout tropical Asia. Due to their large size and prolificacy, they have long been an important protein resource to the region. The stereotyped nesting behavior of the emydids (nesting in large numbers on the same beaches at the same time each year) has made them particularly vulnerable to exploitation. Populations of all four species are presently much depleted but to date Malaysia is the only country actively trying to conserve and manage these turtles.

Malaysia has initiated management programs for both *Batagur* and *Callagur*. Basics of the program include protection of adults, licensing of egg collectors, removing a percentage of the eggs to government-run hatcheries and raising young in captivity prior to release. Similar programs, tailored to local needs and customs, are required throughout the region if estuarine turtles are to remain a viable resource in Asia. Recommended actions include establishing of hatcheries or protected nesting areas, licensing of exploiters, gazetting of sanctuaries, legislating and enforcing closed seasons, and use of captive breeding programs where more natural means fail. Advantages and disadvantages of these techniques are discussed.

INTRODUCTION

CONSERVATION problems concerning sea turtles have been highly publicised and the majority of countries in tropical Asia are making some effort to manage and conserve this resource. These efforts are the subject of several papers at this symposium. However, another economically important group of turtles with similar problems have been largely ignored by most governments of the region. This group is the brackish water species—turtles which inhabit the lower reaches of rivers and estuaries. Like sea turtles, most are large prolific forms which migrate to communal nesting beaches at the same season each year. Such characteristics make these species very vulnerable to exploitation and they must be carefully managed if they are to be maintained as an important resource. Presently Malaysia is the only country of the region with an operating management program for the brackish water turtles.

In terms of human exploitation, the most important brackish water species in tropical Asia are the river terrapin (*Batagur baska*), the painted terrapin (*Callagur borneoensis*), the Burmese roofed terrapin (*Kachuga trivittata*) of the family Emydidae and the Asian giant softshell (*Pelochelys bibroni*) of the family Trionychidae.

This paper concerns these four species. It discusses their ecology, looks at their conservation status, and concludes with a review of existing and needed conservation action to maintain the resource.

Ecology and Conservation Status

The river terrapin—*Batagur baska* (Plate I-B)

River terrapins are large (60 cm shell length) estuarine turtles which inhabit the lower reaches of major rivers over tropical mainland Asia. Specifically they range from the Sunderbans of India and Bangladesh eastward to Viet Nam including the Malay Peninsula and Sumatra.

The species is diagnosed by having four clawed toes on the forefeet and two denticulated ridges on the triturating surface of the upper jaw. The turtles head is relatively small with an upturned snout typical of many riverine species. The shell is deep, massive and heavily buttressed. Both the scutes and bones of the shell fuse together with age resulting in a smooth seamless carapace in older individuals.

Moll (1976, 1978, 1980a) and Siow and Moll (1980) have discussed the biology and exploitation of river terrapins in Malaysia. The following is based on these studies except where otherwise cited.

River terrapins are highly vagile. On Malaysia's Perak River, they move up stream with the rising tide eventually entering small tributary streams where they feed on mangrove fruits, streamside plants and mollusks. They move out of these streams and downriver again with the falling tide.

Males are smaller than females maturing around 40 cm shell length and attaining a maximum size of 49 cm. Females mature at 45 cm and can exceed 60 cm shell length. *Batagur* are seasonally and sexually dichromatic. Females have a brown iris and drab greenish gray or bluish gray colored skin and shell year round. Non-breeding males have a cream colored iris and are somewhat darker than females. During the breeding season, however, their skin and shell become jet black and the iris becomes a pure white.

Nesting occurs during the dry season which falls sometime between November and April in the different parts of the turtle's range. At this time, the riverside sand banks where the turtle nests are exposed and the chances of destructive flooding are least. Females may migrate long distances to nest (up to 80 km on the Perak River) ; males remain in the feeding areas year round. Nesting is nocturnal and occurs enmasse ; in former times coharts of several hundred turtles would nest simultaneously but such aggregations are not known today. Females excavate a body pit with a nest chamber at the bottom. An average of 26 large, oblong eggs (66 × 40 mm ; 6 kg.) are laid per nest in Malaysia. According to Maxwell (1911) Burmese *Batagur* lay 3 clutches over a six weeks period.

There is little reliable information concerning the status of river terrapins. Nevertheless this species is better known than any of the other brackish water species. Still most of the information is anecdotal in nature. The turtle has been long exploited for its eggs and flesh but as no base line data are available it is impossible to accurately assess the degree to which populations have declined. Nevertheless what information is available is indicative of a general drastic decline throughout the range. The river terrapin is listed as endangered by the IUCN Red Data Book (Groombridge 1982) and is an Appendix I species on CITES.

India—the species is known only from West Bengal. River terrapins were formerly abundant at the mouth of the Hooghly River where they were captured in large numbers and shipped to Calcutta markets (Blyth in Gunther 1864). At that time river terrapins were utilized as a substitute for sea turtles in the making of turtle soup (Theobald 1968). Whether due to this exploitation or to alterations of the flow of the Hooghly by extensive water projects, river terrapins no longer are seen at the rivers mouth. Also I found no *Batagur* in the Calcutta and northern West Bengal markets during a recent survey 1982-83. My assistant on this survey Ms. J. Vijaya did establish that the river terrapin was still extant in the Sunderbans of West Bengal. Here she discovered that a number of families near the Bangladesh border were raising this species in small ponds presumably for food. She obtained no direct information on the status of wild populations but people of the area claimed that some nesting still occurred in the vicinity (Moll, In Press).

Bangladesh—Batagur has also been recently discovered in the Sunderbans of Bangladesh (see Khan 1982, Whitaker 1982). During the monsoon season people in the region reportedly catch large numbers of the turtle using strings of hooks baited with mangrove fruits (*Sonneratia*). The eggs are said not to be heavily exploited partly due to the fact that the nesting beaches are frequented by tigers which are not adverse to including humans in their diet. There seems to be a moderate to large breeding population here but to date no census has been made.

Burma—In a 1911 report on turtle resources of Burma by F. D. Maxwell, the numbers of river terrapins were reported to be seriously declining. Although not completely reliable, statistics at the end of the last century showed a 53 per cent decline in egg harvests from 1890-91 to 1897-98. Maxwell concluded that unless the turtles were protected they would soon be extinct. The only recent information comes from a United Nations Development Program team advising the Burmese government on nature conservation. R. E. Salter a wildlife ecologist for the team reported (personal communication), that an 82-83 survey of the Irrawaddy delta located only one small nesting site where 3 or 4 *Batagur* still nested. The large nesting populations described by Maxwell (1911) have apparently disappeared.

Thailand—Known populations occur at Pak Payoon, Phattalung Province, Amphur Ranote, Songkhla Province and rivers in Ranong Province. All of these populations have been heavily exploited and only small remnants of formerly large breeding populations remain (Wirot 1979, Bain and Humphrey 1980).

Malaysia—Islam, the predominate religion in Malaysia, discourages eating the flesh of amphibious animals. Thus Malaysian turtles have received some degree of protection for the five hundred years since the Moslems entered the country. Additional protection is provided by legislation in certain states (*e.g.* Perak, Kedah). Nevertheless some minority groups in Malaysia do eat turtle flesh (e.g., Chinese, Aborigines) and adult *Batagur* are sometimes sold in local markets.

The Islam religion does not discourage eating turtle eggs which are considered a great delicacy having aphrodisiacal properties. *Batagur* eggs are much in demand selling for around three times the price of chicken eggs.

River terrapins are found in the larger rivers throughout Malaysia. The best studied population occurs on the Perak River. The decline of this population has been documented by Loch (1951) Mohamed Khan (1964), Moll (1978), (1980a), and Siow and Moll (1982). Prior to World War II some 375,000 to 525,000 eggs were laid on the Perak nesting beaches annually. As of 1976 only 20,000 to 30,000 eggs were being laid in a good year. The decline began during the Japanese occupation when large numbers of the adults were killed for food. Recovery of the population has since been inhibited by the heavy egg exploitation, and habitat alterations due to damming of the upper Perak and to the polluting effect of riverside tin mining operations. Moll (1980a) estimated the number of nesting females on the Perak River was no less than 401 and no more than 1204. Another *Batagur* populations on the Trengganu River is likely to be negatively affected by the recent completion of a large dam just above the turtles nesting area.

Indonesia—Status is poorly known. A recent report (Anon 1978) indicates the turtles is rare and almost extinct in Sumatra.

Indochina—No recent information is available. Bourret (1941) reported *Batagur* as common in Cambodia and Viet Nam but mentioned that the eggs were much in demand. Pavie (1881) and Tirant (1885) described the Batagur egg harvest in the Kompong Tom for the count of the Queen Mother of Cambodia in the 19th century.

The Painted Terrapin—**Callagur borneoensis** (Plate II)

The painted terrapin another estuarine species, occurs from the southern most provinces of Thailand through West Malaysia, Sumatra and Borneo.

Females attain 50 cm in shell length whereas the males seldom reach 40 cm. The species is similar to *Batagur* but differs in coloration and in having a single denticulated ridge on the upper jaw and five clawed toes on the fore feet. The turtle inhabits tidal areas of moderate to large sized rivers. It seemingly does not have a salt excreting gland and cannot inhabit brackish water in excess of 50% sea water for extended periods (Dunson and Moll 1979). In Sarawak the species is commonly found in Mangrove swamps resting on submerged snags with only the head above water. In peninsular Malaysia, *Callagur* frequently crawls out of the water onto logs or the bank in order to bask. Much of the activity period is directed towards feeding. Juveniles are omnivorous but adults are chiefly herbivorous feeding on mangrove fruits and riverside plants. The turtles commonly scavenge around riverside villages feeding on refuse (especially fruit scraps) thrown into the water (Moll 1980b).

Reproduction is seasonal but dates vary throughout the range. Nesting occurs from June-August on the east coast of Malaysia and from October-January on the west coast (Moll 1980b). Nesting typically occurs on sea beaches at night during low tide within one or two kilometers of the mouth of the home river. However, in mangrove areas lacking sea beaches, the turtles will utilize sand banks within the river. Ten to twelve eggs (average size—70 × 41 mm ; 70 g) are laid per nest in peninsular Malaysia and up to two clutches are laid per season. In Sarawak (Hose in Shelford 1916) 15 to 20 eggs are laid in February and again in March. In Sumatra a gravid female captured in March by J. C. van der Meer Mohr (1933) contained 20 eggs. Hatchlings emerge from nests in around 70 days (Moll 1980b).

Painted terrapins exhibit marked seasonal and sexual dichromatism (Moll *et al.*, 1981). Females are chiefly a dull brown. However, breeding males have white heads with a bright scarlet stripe between the eyes and a cream to pale yellow shell with three prominent black stripes. In non-breeding males the head becomes dark charcoal gray, the head stripe dull orange and the shell dull brown to gray.

The chief threat to this species in Malaysia is overexploitation of eggs for food. Most of the nesting areas on the east coast of Peninsular Malaysia are licensed for egg collection. The harvest is not regulated and almost all eggs laid are taken by the licensee. A survey of east coast rivers by the author and the Malaysian fisheries department indicated that most *Callagur* populations were in a serious state of decline. Only 5 of 17 rivers examined were estimated to have more than 100 nesting females with the largest populations being only slightly over two hundred. On the west coast *Callagur* are still commonly seen in the Perak river but no censuses have been made. No other rivers were examined.

Little can be said concerning the turtles status in other parts of the range. Wirot (1979) reported *Callagur* to be very rare in Thailand. Harrison (1963) considered that they were rare on the Sarawak River but did not mention other parts of Borneo.

The Burmese Roofed Terrapin— **Kachuga trivittata**

Kachuga trivittata is known from the Irrawaddy and Salween Rivers. Theobald (1868) reported it to be very common in the tidal portions of these rivers where there are deep water reaches and where vegetation grows to midwater mark. Smith (1931) stated that the turtle also occurs well upstream of the tidal areas on the Irrawaddy reaching Bhamo.

This turtle is similar in appearance to *Callagur* and according to McDowell (1964) the two are closely related. Both are vegetarian as adults and show extreme sexual dichromatism. Females are uniformly greenish-olive. Males have a pale yellow shell and neck with the head being a deep flesh red except for a black lozenge-shaped plate extending backward across the forehead from the nostrils (Theobald 1868). The sexes also differ in size. Females approach 60 cm shell length but males do not exceed 50. Clutches of 25 eggs (64-75 × 37-42 mm) are laid in January and February on riverside sand banks (Theobald 1868 : Smith 1931).

According to Theobald some of the turtles caught by fishermen are killed and eaten. However, many are purchased by Buddhists who believe that they gain merit by returning the turtles to the water. More important has been the exploitation of the eggs. No recent information is available. In the 19th and early 20th-century egg collecting rights were controlled by the government. Licenses were issued to private individuals which gave them exclusive egg collection rights on specified areas (Theobald 1868 ; Maxwell 1911). As all eggs laid were collected, the government control had little conservation benefit. However, nothing is known of the present population levels of this species.

Asian Giant Softshell—**Pelochelys bibroni** (Plate I-A)

This exceptionally wide spread turtle ranges from India to China on mainland Asia and over much of the Indo Australian Archipeligo including Sumatra, Java, Borneo, the Phillipines and New Guinea. *Pelochelys* appears to be the most salt tolerant of the Asiatic softshells. It inhabits rivers (both above and below the tidal areas) estuaries and contrary to Smith (1931) has been taken at sea (Cantor 1847, De Rooij 1915, Nair *et. al.*, 1975 and Smedley 1932).

This turtle is one of the largest freshwater species attaining at least a meter in length. Constable (1982) reported that a *Pelochelys* preserved in a glass case in a Viet Nam temple is labeled as having a length of 168 cm and 250 kg. A remeasurement of this specimen through its glasscase, however, indicates that the measurement on the label is total length and the shell length is closer to a meter (Constable-personal communication). Wirot (1979) reported fish, shrimp, crabs molluscs and some aquatic plants in the diet of Thai species.

Pelochelys nest on sand banks of rivers or occasionally along the sea. On the east coast of peninsula Malaysia, the nesting season includes February and March and there *Pelochelys* nests along with *Batagur*. Similarly *Pelochelys* in India nest on the Gahirmatha nesting beach of Orissa along with the olive ridley sea turtles (Vijaya 1982). At each site only a few *Pelochelys* nested each season.

PLATE I. A. The Asian giant softshell *Pelochelys bibroni* B. The river terrapin *Batagur baska.*

PLATE II. The painted terrapin *Callagur borneoensis*.

Whether this is coincidence or whether *Pelochelys* nesting times have been selected to reap the predation-glutting benefits attained by these mass nesting species remains to be determined.

Malaysian *Pelochelys* lay 24-28 spherical eggs (30 mm diameter) per nest. Mell (1929) reported that Chinese *Pelochelys* lay up to 27 eggs per clutch but do not lay its entire complement at one time.

Pelochelys though widely distributed is nowhere abundant today. Cantor (1848) reported that they were 'at all seasons plentifully taken in fishing stakes in the Straits of Malacca.' The Chinese relish the meat of this turtle and it is now seen only rarely in Malaysian markets. On our survey of the Subarnarekha River in Orissa India, Ms. J. Vijaya found two shells and was told that these turtles were uncommon but were eaten whenever found. Bain and Humphrey (1980) listed the species as threatened in Thailand and recommended that its habitat should be identified and protected.

In summary all of these Asian estuarine species are being heavily exploited throughout their range which occurs in a chronically protein poor area of the world. The breeding habits of the emydids make them particularly vulnerable to exploitation. Because they return in large numbers to the same nesting beaches at the same time each year, predators including man can key in on the species' breeding schedule and thoroughly harvest the annual reproductive output. If this important protein resource is to be salvaged, governments of the region must take action to rebuild the dwindling populations of these important estuarine species and then control the harvest on a sustained yield basis. The next section will examine the conservation and management programs presently in place and will make recommendations for future action.

Managing of the Resource

History

The most widely exploited of the Asian estuarine turtles over the centuries has been the river terrapin, *Batagur baska*. The exceptionally large and delicious eggs of this species with their reputed aphrodisiacal qualities are to a large extent responsible for the heavy exploitation. As has often been the case with particularly desirable resources, exploitation of the river terrapins in many areas became the exclusive right of kings, sultans, maharajahs and the like. Interesting accounts of the royal harvesting of terrapin eggs appear in Pavie (1881) for Cambodia and Swettenham (in Roff 1967) for Malaysia. Royal control of egg harvests likely provided early conservation benefits, as adults were usually given protection and egg harvests were seldom complete.

Certain foresighted rulers set up still more specific conservation procedures. Swettenham (in Roff 1967) described one such system practiced by the Sultan of Perak in the nineteenth century. *Batagur* on the Perak river typically nested at three distinct periods during the season. All eggs from the first nesting, were removed and delivered to the sultan. Eggs from the next laying were left in place for a royal holiday when the Sultan's court and friends would assemble at the nesting grounds. On this occasion, the women of the party would excavate the eggs in the morning and the remainder of the day would be spent feasting and swimming. Eggs from the third laying were then left in the sand to hatch and replenish the population.

Certain countries under British Rule adopted systems of licensing egg collectors. Maxwell (1911) described one such system devised in Burma for regulating the collection of sea turtles and river terrapin eggs in the Irrawaddi Delta. Malaysia also established licensing to regulate the taking of estuarine and sea turtle eggs. Although it was initiated primarily to bring in revenue to the state, licensing in Malaysia eventually began to serve conservation interests as well. The Malaysian system operates as follows :

1. The nesting area is divided into a number of discrete units.

2. Persons are then given a license to one unit of nesting beach where they have exclusive egg collection rights. In some states (*e.g.* Trengganu) licenses go to the highest bidder whereas in others (*e.g.* Perak) egg collectors apply for a particular site and pay a set fee.

The history of development of a conservation-oriented licensing system for river terrapins has been well documented in the state of Perak (Loch 1950 ; Hendrickson 1961; Mohamed Khan 1964, 1977 ; Balasingam and Mohamed Khan 1969 ; Wycherley 1969 ; Moll 1976, 1978 ; Siow and Moll 1982). Legislation introducing licensing was passed in 1915. The Sultan of Perak still retained his traditional ownership of the terrapins and each licensee had to agree to donate a third of the eggs collected to his ruler. Another third of the eggs were to be reburied in a protected hatchery. The resulting young were to be reared until they reached a size that was safe from most predators and then be released.

The system received a severe test during World War II. Many river terrapins were killed for food during the Japanese occupation of Malaysia and nesting populations plummeted. Following the war the Sultan forbade egg taking for a short period then returned to the former licensing system. By the late 60s, it was obvious that the conservation measures were not working. The river terrapin population continued to decline. Egg collectors would bury a token number of eggs but certainly not the third stipulated. Further, little care was taken in handling the eggs so only a small percentage of those planted actually hatched.

In 1967 the Perak Game Department took over the hatching operation and established a hatchery at Batu Gajah, Perak. From its inception through 1983 some 40,000 eggs have been planted in the hatchery and 16,000 have hatched. Licensees are still required to provide a third of the eggs they collect to the Game Department but the actual numbers provided are always significantly less than this. Hatchlings are not released immediately but are reared in a nursery for a year.

From this beginning the river terrapin hatchery program has been steadily expanding. In 1976, a similar program was started in Trengganu and in 1978 a third was begun in Kedah. Also in 1978 the Perak hatchery was moved from Batu Gajah to a brand new facility on the banks of the Perak river at Bota Kanan, Malaysia.

The Malaysian Fishery Department has set up a hatchery at Mangkok, Trengannu for another estuarine species *Callagur borneoensis* in 1978. In the first year 1,058 eggs were planted and 769 hatchlings were released. Hatchlings were not kept in captivity but were released soon after emergence. In recent years this hatchery project has slowed due to the difficulty of getting egg collectors to bring in eggs. In 1981, 268 eggs were planted and 219 of these hatched. In 1982 only 173 eggs were planted and 139 hatched (Moll 1983).

Although protective laws have been passed in some countries, Malaysia is the only Asian country today with ongoing conservation and management programs for freshwater or estuarine species. The success of these programs remains to be demonstrated. No one knows how long it takes for a large *Batagur* to mature. It may require 25 years or more (Moll 1980) in which case the first females from the Malaysian hatcheries would not return to nest until the 1900s. However, in 1983, the number of nesting females on Perak River beaches increased 1.5 times. If this increase is sustained in future years, it likely represents the first positive results of the Malaysian program.

Recommendations

There are few tried and proven techniques of turtle conservation. Due to the exceptionally long maturation time of larger species (which are typically those most heavily exploited) the effectiveness of turtle conservation programs can usually not be adequately evaluated for decades. Therefore much of the recommended procedures are merely common sense procedures or those worked out for other types of wildlife. Ehrenfeld (1982) has discussed the difficulties of designing a conservation strategy for sea turtles with so many unknowns in their ecology. He concludes that the limited knowledge on the group warrants a conservative approach to conservation action—concentrating on the simplest and least risky techniques of conservation. In Table 1, I have listed several simple conservation actions in order of priority that have the greatest potential for success for the estuarine species of tropical Asia.

As the procedures used will depend to a certain extent on how a species is being exploited, I have divided them into two categories: (1) species exploited chiefly for their eggs · (2) species exploited for their flesh and eggs or flesh alone. The positive and negative features of these techniques are discussed below.

Hatcheries and protected nesting areas

Inasmuch as successful reproduction is key to the survival of any species, this procedure is a highest priority action. Because of its simplicity and relatively low cost it has been the most common initial conservation action for turtles throughout the world.

In a hatchery operation, eggs are removed from natural nests and are transported to another site or hatching. This may be a relatively natural site such as a fenced area of the same nesting beach or it may involve some highly artificial method such as incubating eggs in sand filled buckets, or in cotton in plastic bags etc. Methods for the handling of eggs and the setting up of hatcheries are provided by Pritchard *et al.* (1982). Positive features of a hatchery include the elimination of poaching and most predation. Costs are low. A beach hatchery would require fencing initially. Thereafter the major expense would be man power to collect and guard the eggs. Employment would be temporary. For example, *Batagur* has a three month nesting season and all eggs hatch within three months of laying hence personnel would only have to be employed for one half year.

TABLE 1. *Recommended conservation actions for brackish water turtles of tropical Asia.*

Procedure	*A*	*B*
Hatcheries and/or Protected Nesting Sites ..	++++	++++
Licensing of Exploiters ..	++++	++
Sanctuaries ..	++	+++
Farming and Captive Breeding ..	+	+
Closed Seasons ..	—	+++
Education Programs ..	++++	++++

Category A—species exploited chiefly for their eggs (e.g. *Batagur* and *Callagur* in Malaysia/Category B—species exploited for their flesh and eggs or flesh alone. (e.g. *Batagur* and *Kachuga* in India and Burma, *Pelochelys* throughout its range). Pluses are used to indicate the priority of the action with 4 pluses being the highest priority.

On the Negative side hatcheries require considerable manipulation of eggs. If not done carefully and soon after nesting, decrease in hatching success can result. Another serious problem with some hatcheries is that if temperatures are kept too high or low, the sex ratio of hatchlings can be greatly skewed. (Mrosovsky and Yntema 1982 : Morreale *et.*

al. (1982). This is a particular problem of artifical hatcheries using plastic buckets or styrofoam boxes. In many species of turtles including sea turtles and most emydids that have been studied, the sex of hatchlings is determined by the incubation temperature of the eggs. When temperatures are cool (below 30°C) males usually result. Warmer temperature (above 30°C) produce mostly females. As temperatures of eggs kept in indoor hatcheries and styrofoam boxes are typically lower than those on the nesting beaches such hatcheries may produce males alone which would not benefit the conservation of the species.

Headstarting (raising hatchlings in captivity prior to release) is an integral part of the Malaysian Game Department's *Batagur* hatchery. The idea to raise hatchlings to a size that they will be safe from most predators is logical. However, the procedure is considerably more expensive than a hatchery and largely unproven. We do not know how a years captivity may affect the instinctive processes which are important to the survival and eventual return of these turtles to the nesting sites. Inasmuch as there is yet to be a proven return of a head started turtle to its nesting beach (Ehrenfeld 1982) this procedure must be considered chancy at best. I concur with Pritichard (1979) that headstarting should be considered an experimental procedure only and never be used in exclusion of the direct release of hatchlings at their nest sites.

Protected nesting areas are cheaper than hatcheries (no fencing needed, less presonnel). Handling of eggs is minimal if required at all. In some areas the eggs are left in the natural nest and the beach is regularly patrolled to reduce predation. Screen or hardware cloth cages may be placed over nests. Alternatively nests can be transplanted a few feet from the original site. Experiments have shown that transplanted eggs have significantly lower predation rates than natural nests (Stancyk 1982).

Licensing of Exploiters

While not a conservation technique itself, licensing can be an important tool in a conservation porgram. For example in a situation where eggs are being exploited, conservation benefits could be achieved from licensing through the following actions :

1. Licensing can be a source of revenue for conservation action.
2. By restricting the number of licenses provided each year, a certain percentage of the nesting beaches would always remain productive. For example by withholding one third of the licenses each year, beaches could be productive once every three years. A negative feature of this plan would be that guards have to be hired to prevent poaching. Funds obtained from licenses could be used for this purpose.
3. By requiring that a certain percentage of the eggs collected be turned over to a hatchery program, annual recruitment can be maintained. Problems with this action would include determining howmuch recruitment would be needed to sustain the yield and how to keep egg collectors from cheating on their quota. In reference to the latter, Malaysia pays collectors market prices for eggs to be used in the hatchery to prevent this problem. Again funds from licensing could be used for this purpose.

Sanctuaries

Sanctuaries should be totally protected refuges where no hunting, fishing or egg collecting is allowed. Ideally the sanctuary should include optimum nesting and feeding habitats for the species of concern. The object is to protect a breeding nucleus of the species which can continually supply recruitment to the population both in and out of the sanctuary.

The benefits of sanctuaries in freshwater turtle conservation are exemplified well in India. In 1982-83, I conducted status surveys of freshwater turtles on many of Indian river systems (Moll, In Press, Moll 1984).

Two situations where I regularly found an abundance of turtles and a variety of species were in crocodile sanctuaries and in religious sanctuaries associated with Hindoo Temples along certain rivers. While not designed specifically for turtles most of India's crocodile sanctuaries prohibit hunting, fishing, and egg collecting actions thus benefitting turtles as well as crocodiles. Similarly the religious sanctuaries we visited usually provided protection to all species of the river. Fish, turtles and water birds often abound in such situations.

On the negative side, sanctuaries are expensive to set up and usually require a permanent staff to enforce the rules. Hence I have assigned this a lower priority than cheaper and simpler methods.

Captive Breeding and Farming

Captive breeding or husbandry is here recommended as a low priority action to be used when attempts to increase population utilizing natural reproduction techniques fail are insufficient. Captive breeding and rearing is expensive, man power intensive and includes many of the same problems discussed for 'head starting'. Nevertheless husbandry is an integral part of India's crocodile breeding program (Bustard 1982) and seems to be working well thus far. Crocodilians which are raised in captivity are being used to restock the 11 sanctuaries which have been gazetted as part of the project. If this restocking ultimately proves successful, it can be given further consideration for turtles. In the mean time the techniques for captive breeding various species should be studied so that they can be utilized if the need arises.

Farming of turtles is here defined as raising animals throughout their life history in captivity for commercial gain. In Asia this practice has chiefly been used with softshelled turtles which are a particularly popular food among the Chinese and Japanese. Whether or not such operations can be used to relieve the market pressure on wild populations is open to question. A similar issue concerning sea turtles has recently been the subject of much debate (Brongersma 1980, Dodd 1982, Ehrenfeld 1982, Mrosovsky 1983 and Reichart 1982). I will not rehash these arguments here but will simply state that under certain conditions turtle farming has potential to be of benefit to conservation. A case in point is India.

Turtle meat is little favored throughout most of India but is very popular in West Bengal and Assam. The regional demand is so great that turtles are shipped by rail from over much of India to fill this demand. Considering the costs of shipping and the numerous turtles which die enroute, it seems possible that a large farming operations in West Bengal could provide turtles to the markets more economically. If so pressure on wild stocks would be relieved (Moll In Press).

Closed Seasons

This action is again aimed at maximizing recruitment by protecting a species during its reproductive season. This would be chiefly used for species being exploited for their flesh. Female turtles are most vulnerable to capture at this time and many species are known to lay multiple clutches of eggs. Therefore by protecting turtles during the nesting season, exploitation levels drop while recruitment increases. Moll (In Press) has previously recommended a plan for India involving two closed seasons which would benefit most of the commercially exploited species.

Education Programs

The long term success of any conservation program requires trained personnel and the support of the public. Education programs are important to producing both of these.

The Indian Crocodile Breeding Project is a model example of the former. Besides establishing sanctuaries and a captive, breeding program, it provided for a training centre to train the personnel for the program (Bustard 1982). Moll (In Press) found that a major problem preventing the enforcement of the laws protecting endangered species of turtles in India was that few wild life officers could identify the species involved. Here education in reptile identification is needed to make enforcement work.

From the standpoint of public co-operation education is also necessary (IUCN 1980). A turtle fisherman is far more likely to abide by the law if he understands that closed seasons, sanctuaries, and hatcheries are designed to benefit him by increasing the numbers of turtles. Wildlife departments might well employ public relations personnel to inform the public of the need for conservation actions and laws and how they can benefit. Mass media, environmental education units in school curricula and on-site visits to local villages in key areas should all be utilized to get the message across.

Not all of the techniques and actions mentioned will be suitable in all societies or for all species. For example *Batagur*, *Callagur* and *Kachuga* nest in large numbers on ancestral nesting grounds at the same time each year. Hatcheries and protected nesting areas work well for species like these. *Pelochelys*, however, nest singally or in small numbers. No large concentrations have been reported for any Asian beach. A hatchery would be much less suitable for a species with these habits.

Each country needs to decide which actions are most suitable to their situation. It must be reemphasized, however, that time may be very short for the brackish water turtles and unless some effective conservation action is taken Asia will have lost a unique and potentially very important resource.

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SEA TURTLES AS POSSIBLE DISPERSAL AGENTS FOR FISH OTOLITHS

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ABSTRACT

Captive loggerhead turtles, *Caretta caretta*, fed 57 species of fishes, within 23 families, passed sciaenid fish otoliths intact through their digestive tracts in about 18 hours. Chemical composition of the other species' otoliths may account for their digestibility and absence in the fecal matter. The fact that sea turtles can eat a fish and then deposit the otoliths far from where the fish was eaten suggests that caution should be exercised when attemtping to explain wide disjunct fish distributions, based on the occurrence of otoliths in geological strata.

INTRODUCTION

OCCURRENCES of marine fish otoliths in fossil deposits disjunct to the presently known geographic distribution of the species have long been perplexing and often gone unexplained (Fitch, 1964, 1968 Fitch and Lavenverg 1971, 1983). Disjunct distributions could be explained by water currents carrying a dead fish or fish predator, such as a cetacean (Schafer, 1972), far from its natural range prior to its becoming part of the fossil record, but that avenue of dispersal is not very plausible because decay would have set in before the currents could have carried it very far. Another hypothesis would have the predator eaten by a second predator, i.e. a deep sea fish eaten by a surface feeder who was in turn eaten by a porpoise that carried both far afield (Robison and Craddock, 1983). Other than vastly changing world climatic conditions that drastically changed a fish's overall distribution range, predation by large sharks, cetaceans, whales, sea birds and seals, etc seems the most plausible explanation for disjunct fish otolith distributions.

Could it be that fish otoliths eaten by cetaceans, marine birds, marine mammals or sea turtles passed through the predator's digestive system while being carried far afield and later become part of fecal deposits in geologic formations elsewhere? Such actions could possibly explain the disjunct distribution of fishes, based on otoliths we encounter today in modern sediments (Fitch and Lavenberg, 1983).

Finding that otoliths of some fishes pass through the digestive tracts of sea turtles now presents yet another avenue by which otoliths could be carried and deposited in areas far removed from a fish's natural range.

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TEST OBSERVATIONS

Captive loggerhead turtles, *Caretta caretta*, hatched and reared for six and 15 years at the Institute of Marine Sciences, Morehead City, North Carolina, were fed a variety of locally captured foods. The majority of foods were fishes of the families : Clupeidae, Engraulidae Synodontidae, Gadidae, Cyprinodontidae, Atherinidae, Syngnathidae, Serranidae, Pomatomidae, Carangidae, Gerridae, Haemulidae, Sparidae, Sciaenidae, Ephippidae ; Mugilidae, Sphyraenidae, Trichiuridae, Scombridae Stromateidae, Triglidae, Bothidae, and Cynoglossidae (Table 1). All fishes except syngnathids (Schwartz and Carter, 1984) were readily accepted and eaten. Eighteen hours usually elapsed between time of feeding and defecation.

Feeding at all times, was to satiation. This amounted to 9 kg of mixed fishes being fed twice weekly during indoor feedings versus 18 kg during daily outdoor feedings. Indoor storage was necessary between November and March since sea turtles will die in water colder than 10°C (Schwartz, 1978). Inside tank waters were either heated above 10°C or were ambient. Outside storage of the turtles occurred once water temperatures exceeded 10°C.

Otoliths

Hundreds of sciaenid otoliths passed intact through the digestive tracts of the captive study young and subadult loggerhead turtles. Plate 1 compares otoliths of banded drum (*Larimus fasciatus*), Atlantic croaker (*Micropogonias undulatus*), weakfish (*Cynoscion regalis*) and spot (*Leiostomus xanthurus*) that have passed through loggerhead turtles with similar otoliths removed from fresh fish. In almost every case the otolith was intact and exhibited few effects of digestion. On rare occasions a few vertebra also passed through the turtle and were usually within the fecal pellet.

DISCUSSION

Loggerhead turtles, *Caretta caretta*, are considered omnivores (Ernst and Barbour, 1972). Although Brongersma (1972) believes that fishes are not preferred food of sea turtles, they do eat fishes if available (Frazer and Schwartz, 1984 ; Grassman and Owens, 1982 ; Limpus, 1973 ; Schwartz, 1961).

McLellan and Leong (1980) noted, during radiological observations of a barium sulfate suspension and food passage through a hatchling loggerhead, that 4-5 days was necessary to pass food through their systems. This long digestive time was perhaps extended by the natural drying action of the barium sulfate which was used as a means of tracking food through the digestive tract. This contrasts with the 18 hr digestion time observed herein. Also, since sea turtles are known to travel 0.7 km/hr (hatchling) (O'Hara 1980) to 15-90 km/day (adult) (Carr *et al.*, 1978 : Meylan, 1981), fecal material could then be spread over a considerable area. Currents could also enhance the distance travelled.

Fitch and Brownell (1968) reported fish otoliths from the stomachs of bottlenose dolphins. These were referrable to *Menticirrus undulatus* and *Bairdiella*. Fitch (1971) noted drum otoliths from *Seraphus politus*, *Menticirrus* sp. and *Mhcrodon ancylodus* in the stomach of the cetacean *Pontoporia blainvillei*. *Bairdiella icistius* otoliths have been found in Gulf of California harbor porpoises, *Phocaena sinus* (Fitch and Brownell 1968).

Fitch and Brownell (1968) speculated that otolith occurrences in cetaceans were accumulations that resulted following several days of feeding.

The otolith structure and shape (Schmidt, 1968) of various American sciaenids has been described by Chao (1978) and Mohsin (1981). Note agreement in structure and shape of the otoliths (Plate 1) with those described by Chao or Mohsin. None have been reported previously from sea turtles.

Note in Table 1 that otoliths from fishes comprising 22 families were absent in the study of turtle fecal deposits. This may reflect

TABLE 1. *Families (23) and species (57) of fishes fed captive loggerhead turtles.* (Species whose otoliths passed through the turtle intact and undigested are denoted by an asterick. Species rejected as food by**)

Clupeidae	Sparidae
Brevoortia tyrannus	Lagodon rhomboides
Engraulidae	Sciaenidae
Anchoa hepsetus	Bairdiella chrysoura*
Anchoa mitchilli	Cynoscion regalis*
Anchoa nasuta	Larimus fasciatus*
Synodontidae	Leiostomus xanthurus*
Synodus foetens	Menticirrhus americanus*
Gadidae	Menticirrhus saxatilis*
Urophycis regia	Micropogonias undulatus*
Cyprinodontidae	Ephippidae
Fundulus heteroclitus	Chaetodipterus faber
Fundulus majalis	Mugilidae
Atherinidae	Mugil cephalus
Menidia beryllina	Mugil curema
Menidia menidia	Sphyraenidae
Membras martinica	Sphyraena guachancho
Syngnathidae	Trichiuridae
Syngnathus fuscus**	Trichiurus lepturus
Syngnathus louisianae**	Scombridae
Serranidae	Euthynnus alletteratus
Centropristis ocyurus	Stromateidae
Centropristis philadelphica	Peprilus alepidotus
Centropristis striata	Peprilus triacanthus
Pomatomidae	Trigilidae
Pomatomus saltatrix	Prionotus carolinus
Carangidae	Prionotus salmonicolor
Caranx crysos	Prionotus scitulus
Caranx hippos	Prionotus tribulus
Chloroscombrus chrysurus	Bothida
Selar crumenophthalmus	Ancylopsetta quadrocellata
Selene setapinnis	Citharichthys macrops
Selene vomer	Citharichthys spilopterus
Trachinotus carolinus	Etropus crossotus
Trachinotus falcatus	Paralichthys dentatus
Gerreidae	Paralichthys lethostigma
Eucinostomus argenteus	Scophthamus aquosus
Eucinostomus gula	Cynoglossidae
Haemulidae	Symphurus plagiusa
Orthopristis chrysoptera	

differences in chemical composition and stability of the otoliths. Otoliths are usually composed of aragonite, but some are composed of vaterite and calcite (Carlstrom, 1963; Fitch and Lavenberg, 1983; Mugiya, 1972; Palmork *et al.*, (1963). Palmork *et al.* (1963) even speculated that the fish's living environment may inhibit the metabolism of calcium and thereby change the structure of the otolith. Degens *et al.* (1969) and Morris and Kittleman (1967) have noted aragonite composition may vary widely between species.

FOSSIL RECORD

The fossil record for sea turtles and cetaceans is incomplete, yet their fossils have been found in recent geological strata throughout the United States and the world (Cope, 1867, 1896; Frizzel and Dante, 1965; Hay, 1908; Shikama, 1956). Fossil remains from the New Jersey-South Carolina seaboard have been studied by many (Emmons, 1969; Leriche, 1942; Weems, 1974). Weems (1974) reported that the most common Miocene chelonians of the region were *Syllomus aegyptiacus*, *Procolpochelys grandaeva*, and *Psephophorus calvertensis*, with *S. aegyptiacus* having a cosmopolitan distribution. Zug (manuscript) found a *Caretta caretta* skull and fragments of *Chelonia* and *Procolpochelys*, *Syllomus*, and *Psephophorus* turtles in the Lee Creek mine deposits of North Carolina. Although additional fossil loggerhead remains are presently unknown inland in the Coastal Plain of the Carolinas (Weems, pers. comm.), they do occur far inshore in various marine deposits in nearby states. Therefore, the present lack of turtle fossils in the Carolina Coastal Plain cannot be construed to mean that they were never present, because the fossil record remains very incomplete for many geographic areas and geological strata.

Fitch and Lavenberg (1983) studying the 'death assemblage' otoliths from the Lee Creek Mine near Pamlico River, Aurora, North Carolina (Yorktown Formation: Pliocene) recovered otoliths comprising 45 species of fishes from 17 teleost families. Seven species of drum otoliths (*Cynoscion nebulosus*, *Equetes umbrosus*, *Leiostomus* sp., *Micropogonius* sp., *Pogonius cromis*, *Sciaenops ocellatus*, and Sciaenid sp. A) were among the deposits. Likewise, otoliths of offshore species such as the tilefish, *Lopholatilus chamaeleonticeps*, fawn cusk-eel, *Lepophidium cervinum*, Atlantic tomcod, *Microgadus tomcod*, white hake, *Urophycis tenuis*, offshore hake, *Merluccius albidus* bearded brotula, *Brotula barbata*, stargazer, *Kathetostoma* sp. were within the diggings. All of the drums are shallow water fishes common to North Carolina coastal estuaries or Carolinian Shelf, whereas the other species rarely are found in waters less than 12 meters deep. It should be noted that 12 of the 17 families with recognizable otoliths found in the Lee Creek Mine deposits (Fitch and Lavenberg, 1983) were different from those fed the study turtles. The Lee Creek Mine deposits now lie 42 m below the surface and 70 km inland of the sea (McLellan, 1983). Even when the sea was at higher elevations and extended inland as far as the Fall Line, the offshore deep water forms would have rarely or barely resided in the area of the Lee Creek Mine. While deep water oceanic intrusions are known for the North Carolina Shelf (Atkinson *et al.*, 1980; Blanton *et al.*, 1981; Hofman *et al.*, 1981) and could have carried an occasional *Brotula* inland (live *Brotula* have been collected in the Cape Fear River estuary (Schwartz *et al.*, 1982)) such events still do not adequately explain such widespread disjunct fish otolith distributions. The same is true for the otoliths of 14 fish species within 8 families noted by Huddleston and Savoie (1983) from the Severn Formation of Maryland.

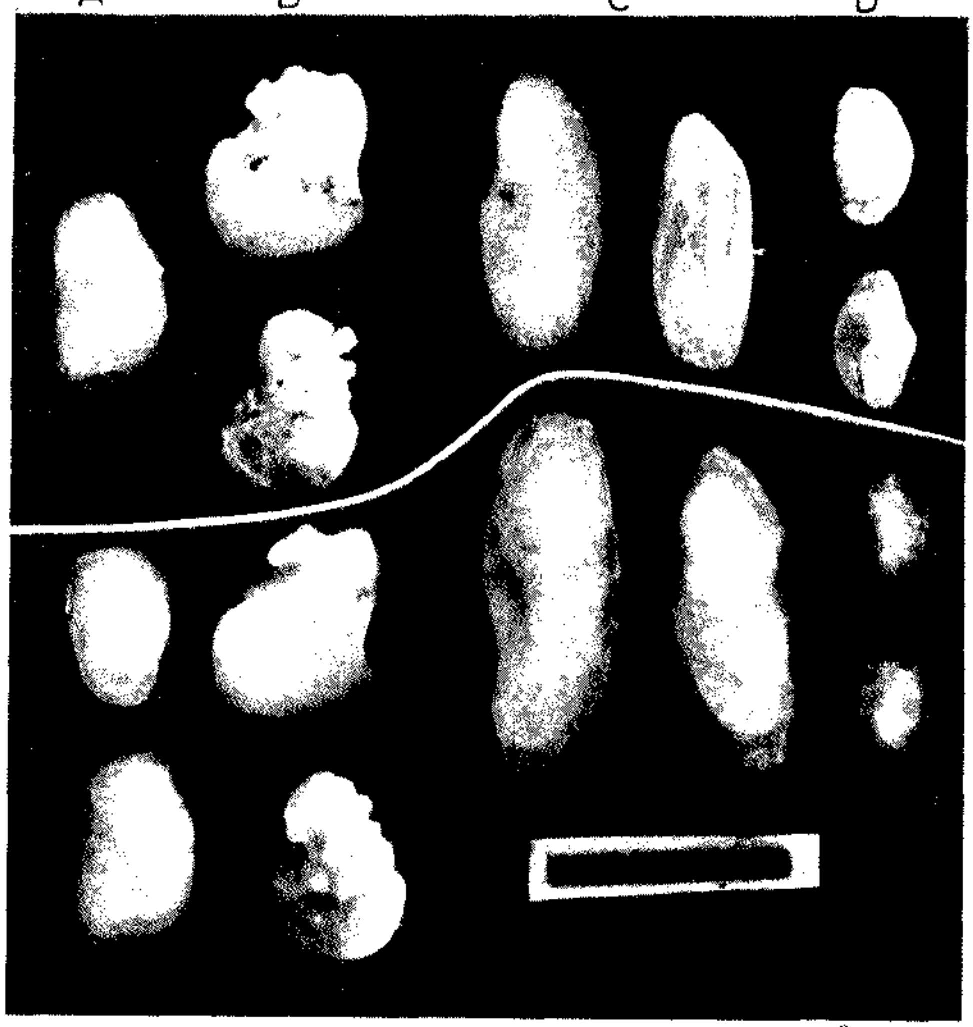
Turtle Behavior and Distribution

The present and fossil distribution of loggerhead turtles suggests that sea turtles could have penetrated vast areas of coastal and inland seas during past geologic periods. Sea turtles are known to penetrate waters with salinities as low as 10 ppt. They have been found in the lower Rio Grande River (Neck, 1978) and the freshwater Chowan River of North Carolina (pers. obs.) for extended periods of time. Inland intrusions of saline waters have long been documented for many parts of the United States (Gunter, 1942, 1956; Schwartz 1981); avenues that could have served for turtle dispersal. Past higher sea levels could also have helped inland penetration by sea turtles.

In North Carolina (Chowan River) and elsewhere loggerhead turtles have occasionally remained in freshwater for six or more weeks with no ill effects. Neck (1978) commented that loggerhead turtles are able to survive such conditions by reducing their sodium loss to such an extent that at least 20 days survival in freshwater is possible even though no sodium is extracted from the external medium.

Thus, it would be a simple matter for a sea turtle to eat a slow swimming, live, sick or dying fish, digest it, and then during its subsequent migration or movement deposit fecal matter containing the otoliths in areas far from where the fish was eaten. In this way the fish did not have to originally range at all into the area in which their otoliths were later found. Caution should therefore be used in explaining disjunct or unexpected

Otoliths recovered from faecal matter



Freshly dissected fish otoliths

PLATE I. Sciaenid otoliths (upper row) that have passed through loggerhead turtle *Caretta caretta*, compared to freshly dissected otoliths (lower row). From left to right the otoliths are of A. banded drum (*Larimus fasciatus*), B. Atlantic croaker (*Micropogonias undulatus*), C. weakfish (*Cynoscion regalis*) and D. spot (*Leiostomus xanthurus*). Black bar = 1 cm.

fossil fish distributions only on the basis of fish migration patterns. Even in India, the disjunct occurrences of fossil clupeid, silurid, sciaenid, and other fishes or fish otoliths may be better explained by knowledge of the fossil and present day distribution of sea turtles and fishes (Gowda, 1968 ; Gupta, 1972 ; Kar and Bhaskar, 1981 ; Menon, 1959 ; Pillai and Yazadani, 1976 ; Satsangi and Mukhopadhyay, 1975 ; Seshagiri, 1976 ; Silas, 1964 ; Talwar and Sen, 1968 ; Tilak, 1964 ; Vashishat *et al.*, 1978), rather than simply assessing their occurrence as the result of massive continental drift tectontic transport.

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ON THE SECOND MASS NESTING OF THE OLIVE RIDLEY *LEPIDOCHELYS OLIVACEA* AT GAHIRMATHA, ORISSA DURING 1984

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ABSTRACT

Observations carried out on the second mass nesting of the olive ridley along the Gahirmatha beach towards the end of March 1984 are recorded here. The mass nesting occurred in general along the same stretch where the first mass nesting had earlier taken place from 25th January to 6th February 1984, with a peak activity along about one kilometre of the stretch of the beach. Maximum destruction to earlier nests and emerging hatchlings was noted in this area of overlap. Some observations made during this phase on emerging hatchlings of the first mass nesting are also reported here.

INTRODUCTION

The annual arribada of the olive ridley *Lepidochelys olivacea* (Eschscholtz) along the Orissa Coast has been reported by Biswas (1982), Bustard (1974, 1976), Bustard and Kar (1981), Davis and Bedi (1978), FAO (1975), Kar (1980, 1982), Kar and Bhaskar (1982), Kar and Dash (1984), Kar and Whitaker (1984), Silas *et al.* (1983), Whitaker (1984) and Whitaker and Kar (1984). A detailed account on the first mass nesting of the olive ridley during the 1984 season at Gahirmatha has been reported by Silas *et al.* (1984). We are reporting here a second arribada which took place during the same season at Gahirmatha from 24 March, 1984 to 29 March, 1984, sixty days after the first mass nesting which commenced on 25 January, 1984 and lasted until 6th February, 1984. On 24 March, 1984 about 7,000 turtles emerged for nesting. The intensity increased to about 1,00,000 turtles on 26 March, 1984 and thereafter decreased. The mass nesting lasted for about a week and on 29 March, 1984 hardly about 1,000 turtles nested (Table 1). It is roughly estimated that about 2,00,000 turtles would have emerged for nesting during the second mass nesting. Kar and Dash (1984) observed that the first arribada is very intensive every year when compared to the second one. The first mass nesting of 1984 lasted for about 13 nights during which period about 3,00,000 turtles visited Gahirmatha beach for nesting (Silas *et al.*, 1984).

A significant feature of 1984 mass nesting is the occurrence of such a large number of olive ridley for nesting in the second season. The second mass nesting of 1984 season may be the largest one among the second arribada witnessed in the recent past. The total nesting females for both the mass nestings in 1984 is estimated to be roughly about 5,00,000. However, we have absolutely no information whether the 2,00,000 turtles or a part of this number represent females nesting for the second time during the same season. The modal sizes of the intraovarine developing eggs seen in slaughtered animals indicate distinct modes pointing

TABLE 1. *Details of nesting females during second arribada at Gahirmatha in 1984 season*[1]

Period of nesting		Area-Beach stretch (km)	Estimated number of nesting females	Number of nesting females per 100 metres (Mean in Parenthesis)
24-3-1984 to 25-3-1984 1900 hrs—0600 hrs	..	2.5	7,000	100—500 (350)
25-3-1984 to 26-3-1984 1800 hrs—0500 hrs	..	3.0	25,000	300—1200 (800)
26-3-1984 to 26-3-1984 0800 hrs—(Day) 0600 hrs	..	5.0	45,000	300—1500 (900)
26-3-1984 to 27-3-1984 0700 hrs—0600 hrs	..	3.5	1,00,000	1000—5000 (3000)
27-3-1984 to 28-3-1984 1900 hrs—0600 hrs	..	4.0	10,000	70—500 (220)
28-3-1984 to 29-3-1984 1800 hrs—0600 hrs	..	0.7	2,000	60—600 (300)
29-3-1984 to 30-3-1984 1800 hrs—0600 hrs	..	1.0	1,000	600 metres-60/100 Metres 200 metres—20/100 Metres 200 metres—10/100 Metres
30-3-1984 to 31-3-1984 1800 hrs—0600 hrs	..	1.0	25	——

[1]Also corraborated with Orissa Forest Department Records.

to a definite possibility of the females nesting in the first arribada also renesting atleast once more during the season.

The first mass nesting occurred at Gahirmatha in a 5 km stretch of beach from Ekkula to Ekkula Nasi with the peak intensity in the stretch of 3 km south of Ekkula Nasi. The second mass nesting was also from Ekkula to Ekkula Nasi but the intensity was highest over a stretch of 3 km north of Ekkula which resulted in a heavy overlaping of the nesting area in a stretch of about 1 km. Besides, in the entire stretch of 5 km, large number of nests of the first arribada were destroyed during the second mass nesting. The intensity of damage was high in the area of overlap where a large part of the incubating eggs of first mass nesting which had not hatched out were destroyed. As in the first mass nesting a number of abnormal females were also encountered (Silas *et al.*, 1984).

We wish to express our sincere thanks to the Conservator of Forests and Wildlife and the Chief Wildlife warden, Government of Orissa and Shri S. K. Misra Deputy Conservator of Forests, Chandbali and his staff for all the help and co-operation extended to us during the period of study.

Length Frequency of Nesting Females

During the second mass nesting, the carapace length of 85 nesting females measured (curved measurements) from 58 to 74 cm (mean 69 cm). The carapace length of first mass nesting females ranged from 63 to 75 cm with modes at 64 to 65 and 70 to 71 cm (Silas *et al.*, 1984).

CLUTCH SIZE AND WEIGHT OF EGGS

In a few clutches examined the number of eggs was between 74 to 160 which is comparable to the observations (70-159) made during the first mass nesting (Silas *et al.*, 1984). The depth of the nest varied from 45 to 52.5 (48.7) cm which is also comparable to the earlier observations made by Silas *et al.*, (1984) from the Madras Coast.

Weight of individual eggs from three clutches were taken during the second mass nesting. The eggs were wiped off adhering mucus before weighing in a balance. The weight of individual eggs in gm ranged from 26.5 to 32.0 in clutch I, from 22.5 to 30.0 in clutch II and from 27.5 to 33.0 m in clutch III. Silas and Rajagopalan (1984) also observed variability in the individual egg weight within a clutch as well as between clutches. In the three clutches observed, eggs were collected as and when the nesting turtle was laying eggs. The eggs were collected in three batches, the first batch contained eggs dropped at the beginning of oviposition, the second batch towards the mid-phase and the third batch those eggs dropped towards the end of oviposition. This was done to study the possible difference in weight of the eggs dropped at different times of oviposition. Little variability was seen in the three batches as earlier observed by Silas and Rajagopalan (1984) along the Madras Coast.

STUDIES ON THE HATCHLINGS OF FIRST MASS NESTING

Hatchling success of eggs laid

The second mass nesting almost coincided with the emergence of hatchlings of the first arribada. The emergence of hatchlings commenced on 22nd March, 1984, about 58 days after the first mass nesting. In the area of mass nesting it was observed that about 6,000 hatchlings emerged from 53 nests located in a 100 metre stretch on the night of 22nd March, 1984. On the next day about 13,500 hatchlings emerged from 120 nests in a 100 metre stretch. On an average about 113 hatchlings have emerged from each nest. This high intensity of emergence occurred along a distance of about 3.4 km along the shore from 22nd March, 1984 to 24th March, 1984. When the second arribada commenced on 24th March, 1984 there was severe damage to the earlier nests as well as hatchlings emerging thereafter which would have accounted for a loss of roughly about 75% of the remaining egg/ hatchlings. In the urge for nesting the females of the second arribada devastatingly dug up pits in the same stretches of the beach especially in the 'core' area of overlap with the first mass nesting. Silas (1984) has estimated that over 30 millions eggs are annually laid at Gahirmatha with a survival at hatchling stage of only 25% due to heavy predation, renesting and resulting damage, unfertilised eggs and arrested development. With this magnitude of damage to the eggs and loss of valuable protein, there are suggestions that part of the eggs should be harvested for human consumption. Mrosovsky and Yntema (1982) have remarked on such utilisation. Pritchard (1978) also has suggested that the logical method of exploiting olive ridley would be to permit egg collection from the first arribada. But we feel that this suggestion should be evaluated in light of information about the temperature regimes at Gahirmatha during the two mass nesting seasons since temperature plays a vital role in deciding sex ratio of hatchlings of successive arribadas. At Gahirmatha some preliminary temperature measurements made in the nests during the first mass nesting (about 25 to 45 metres away from the high water mark) during morning hours (0900 to 1030 hrs.) and during the second mass nesting (about 40 to 50 metres away from the high water mark) in the evening hours (1700 to 1800 hrs.) on April 1984 indicates a rise of mean temperature values from 26.0°C to 34.0°C.

Pivotal temperature where the sex ratio would be 50.50 needs determination. Hatchlings developing at the lower temperature from the eggs laid during the first arribada may mostly be males and those at relatively higher temperature during the second arribada predominantly females. Could this be nature's way of maintaining a balance? Thus any excessive collection of eggs in an arribada may result in imbalance in the sex ratio which will become evident several years later and could have an adverse effect on the breeding population of occurrence of disproportionately large numbers of males or females.

To study the hatchling success of eggs in the nests 20 clutches were examined. In each case the number of eggs laid, live hatchlings which emerged, those in the pipping stage, dead hatchlings in the pit, those dead in the pipping stage and spoilt and unfertilised eggs were noted and details are given in Table 2.

The percentage of live hatchlings emerging from natural nest varied from 51.4 to 95.2 with an average of 74.5%. The percentage of live and dead in the pipping stage varied from 0.6 to 22.8 (mean 3.9) and 0.9 to 39.0 (15.0) respectively. The percentage of dead hatchlings and spoilt and unfertilised eggs varied from 0.9 to 8.1 (2.7) and 1.9 to 11.8 (3.6) respectively. It could be observed that mortality occurred (to the level of 15%) mainly during pipping stage of the hatchlings. Break-

TABLE 2. *Details of live hatchlings emerged, live hatchlings in pipping stage, dead hatchlings encountered in the pit, dead hatchlings in pipping stage and spoilt and unfertilised eggs observed (percentage in parenthesis) during April 1984 based on the observations made by the authors at Gahirmatha*

	Clutch size	Live hatchlings emerged	Live hatchlings in pipping stage	Dead hatchlings in pit	Dead hatchlings in pipping stage	Spoilt and unfertilised eggs
1-4-1984 ..	110	94 (85.45)	4 (3.6)	1 (0.9)	8 (7.8)	3 (2.7)
,, ..	99	86 (86.80)	2 (2.6)	—	7 (7.0)	4 (4.0)
,, ..	114	81 (71.00)	2 (1.8)	1 (0.8)	27 (23.6)	3 (2.6)
,, ..	76	48 (63.10)	5 (6.5)	—	19 (25.0)	4 (5.2)
,, ..	149	105 (70.50)	5 (3.4)	34 (22.8)	2 (1.3)	3 (2.0)
,, ..	94	84 (89.30)	4 (4.2)	—	4 (4.2)	2 (2.0)
,, ..	105	79 (75.20)	2 (1.9)	21 (20.0)	1 (0.9)	2 (1.9)
,, ..	133	69 (51.80)	3 (2.3)	2 (1.5)	52 (39.0)	7 (5.2)
,, ..	86	59 (68.60)	7 (8.1)	2 (2.3)	9 (10.4)	9 (10.4)
,, ..	130	109 (83.80)	2 (1.5)	11 (8.4)	5 (3.8)	3 (2.5)
,, ..	133	120 (90.20)	2 (1.5)	2 (1.5)	6 (4.5)	3 (2.2)
,, ..	149	128 (85.90)	2 (1.3)	1 (0.6)	16 (10.7)	2 (1.3)
,, ..	139	122 (87.70)	7 (5.0)	—	7 (5.0)	3 (2.1)
2-4-1984 ..	127	87 (68.50)	2 (1.6)	5 (3.9)	29 (22.8)	4 (3.1)
,, ..	101	53 (52.40)	3 (2.9)	3 (2.9)	30 (29.7)	12 (11.8)
,, ..	104	99 (95.20)	—	—	3 (2.9)	2 (1.9)
,, ..	105	54 (51.40)	3 (2.8)	2 (1.9)	42 (40.0)	4 (3.8)
,, ..	147	114 (77.50)	2 (1.4)	2 (1.4)	27 (18.3)	2 (1.3)
,, ..	112	73 (65.10)	5 (4.5)	2. (1.7)	30 (26.7)	2 (1.7)
,, ..	107	62 (61.30)	1 (0.9)	2 (1.9)	25 (24.7)	11 (10.8)
Total ..	2314	1726 (74.5)%	63 (2.7%)	91 (3.9%)	349 (15.0%)	85 (3.6%)

ing the egg shell and merging from the egg is perhaps a crucial stage. In the hatchery system at Kovalam, Tamil Nadu, Silas and Rajagopalan (1984) observed that the hatchling success of olive ridley eggs was about 65.8% which is less than the hatchling success (74.5%) in natural nests observed at Gahirmatha, during the 1984 season.

measurements) of the 10 clutches ranged from 35.7 to 39.7 mm.

The percentage frequency of carapace length, carapace width and weight for 335 hatchlings collected randomly along a stretch of 5 km beach has been studied. A higher percentage of hatchlings was in the size range of carapace length 37.1 to 39.0 mm carapace width 31.1 to 34.0 mm and the body weight 15.1 to 17.0 gm. Both in carapace length and weight, these observations are almost similar to the earlier observations made by Silas and Rajagopalan (1984) on the hatchlings collected from the hatchery system of transplanted

TABLE 3. *Variation in the size in mm and weight in gm of olive ridley hatchlings from 10 clutches (mean in parenthesis) at Gahirmatha examined by the authors in 1984 season*

Clutch No.		Carapace length	Carapace width	Plastron length	Plastron width	Weight	No. of lateral scutes
1.	.. N = 20	34.4-38.2 (36.7)	30.2-33.6 (31.3)	28.7-31.2 (30.3)	26.0-28.5 (27.3)	14-15 (14.6)	6-7 (6.1)
2.	.. N = 20	38.7-41.2 (39.5)	31.6-36.4 (32.4)	30.1-34.3 (32.2)	27.2-32.5 (29.9)	17-20 (18.9)	5-7 (6.4)
3.	.. N = 20	37.4-41.0 (38.9)	33.1-38.3 (35.0)	33.0-35.3 (33.5)	28.0-31.2 (29.1)	16-18 (16.3)	6-7 (6.4)
4.	.. N = 20	30.5-35.2 (33.5)	29.0-32.7 (30.5)	27.0-29.4 (28.3)	25.4-27.5 (26.6)	9.5-12 (11.3)	6-7 (6.7)
5.	.. N = 20	35.4-38.4 (37.2)	31.3-35.6 (33.9)	28.7-33.0 (31.4)	27.5-31.5 (29.3)	15.5-17 (16.1)	6-7 (6.5)
6.	.. N = 20	36.5-40.0 (38.4)	30.4-38.2 (33.0)	29.0-33.6 (31.5)	26.9-29.9 (28.5)	16-18 (17.3)	6-8 (6.6)
7.	.. N = 18	35.3-38.9 (37.3)	32.0-35.6 (33.5)	30.0-34.3 (32.1)	26.7-30.5 (28.5)	15-17 (15.9)	5-7 (5.9)
8.	.. N = 20	34.7-37.7 (35.9)	31.2-37.4 (33.3)	29.5-32.5 (29.8)	27.4-30.8 (28.9)	15-17 (15.4)	5-6 (5.9)
9.	.. N = 20	34.1-38.9 (35.7)	31.4-35.2 (33.9)	31.2-34.2 (33.3)	27.0-30.4 (29.5)	16-18 (16.9)	6-7 (6.6)
10.	.. N = 20	35.7-38.6 (37.0)	31.0-34.4 (32.6)	30.4-33.1 (31.7)	27.0-29.8 (28.4)	15-17.5 (15.7)	6-7 (6.7)

Variability in hatchlings

Variations were observed in the carapace length and weight of emerging hatchlings in 10 clutches examined. About 20 hatchlings from individual nests were randomly collected and measurements taken as detailed in Table 3. The mean carapace length (Straight line clutches. But there was a noticeable difference in the carapace width of natural (Gahirmatha) and hatchery reared (Kovalam, Madras) hatchlings, the modal carapace width being 22.34 mm and 27.28 mm respectively.

Time of emergence and orientation

At Gahirmatha the hatchlings were seen to emerge from the nests from 1700 to 0700 hrs. with the peak activity from 0400 to 0700 hrs. The emerging hatchlings have no difficulty in orienting towards the sea. At Gahirmatha an interesting event was also noticed. Hundreds of hatchlings emerging from the nests near Ekkula Nasi entered the adjacent estuary. We have observed the hatchlings in the Rana hansa and Patsala rivers on our way from Gahirmatha to Chandabali. Hatchlings were found floating and moving swiftly into the estuary in freshwater about 7 to 10 km away from Gahirmatha beach. Whether this movement upstream is fortuitous or not, and whether the hatchlings return to sea calls for further observations.

Movements of hatchling from nest to sea

An attempt was made in quantifying the time taken by the hatchlings to reach the sea from the nests. The distance from the individual nest to the water mark, the number of flipper movements in crossing the dry and wet sand area and the time required for the same were noted. The hatchlings required 10.5 to 32.0 minutes to travel 23.0 to 84.0 metres and reach the wet sand and 2.5 to 18.0 minutes to cross 5.0 to 24.0 metres strip of wet sand (Table 4.). The speed of the hatchling over the dry sand varied from 0.32 to 0.68 metre/minute (0.51) and in the wet sand varied from 0.50 to 0.80 metre/minute (0.66). The hatchlings after undertaking a few movements stopped for short durations before continuing their crawl. The movements and a subsequent stop over is termed as a 'stage'.

TABLE 4. *Details of number of 'stages', speed (metre/minute) observed in emerged hatchlings of olive ridley at Gahirmatha in March* 1984

	DRY SAND				WET SAND			
Sl. No.	Distance in metres (from nest to high water mark)	Time taken (min.)	Speed (Metre/ min.)	Number of 'stages'	Distance in metre (from nest to high water mark)	Time taken (min.)	Speed (Metre/ min.)	Number of 'stages'
1. ..	25	15.0	0.60	75	5.0	2.5	0.50	30
2. ..	25	16.0	0.64	142	10.0	8.0	0.80	57
3. ..	22	15.0	0.68	135	8.0	4.6	0.57	22
4. ..	23	10.5	0.45	103	4.0	3.1	0.77	12
5. ..	—	—	—	—	17.0	10.2	0.60	95
6. ..	—	—	—	—	17.0	13.0	0.76	117
7. ..	84	32.0	0.38	292	13.5	8.0	0.56	33
8. ..	38	12.5	0.32	172	24.0	18.0	0.75	109

Entry of hatchlings into the sea

Observations were also made on the entry of hatchlings into the sea. Some of the hatchlings entering into the sea during hightide were washed back again on the beach and reentered with subsequent retreating waves.

On 28th March, 1984 at about 0600 hrs. we observed about 125 hatchlings entering into the sea in a 100 metre area 2 km north of Ekkula. The hectic activity of hatchling movement from shore to sea was noticed near Ekkula Nasi also. In an area of beach about 1.8 to 2 km we observed around 0530 hrs. on 31st March, 1984, 300 hatchlings per metre stretch area entering the sea in one hour. The intensity and concentrations of hatchlings was uniformly dense throughout the length of 2 km beach. In two hours it was roughly estimated that about 1.2 million hatchlings would have entered the sea on that day in this 2 km stretch. Continuous observations are, however, necessary in different stretches of the beach simultaneously to arrive at reliable estimates of the total number of hatchlings entering the sea.

We collected information from the Coast Guard Vessel on the migratory movements of thousands of hatchlings. During the last week of March 1984 the hatchlings which had entered the sea off Gahirmatha were seen off Paradeep and moving towards the south. Besides the hatchlings a large number of adults were also seen moving southward indicating the direction of movement of spent adults after the second mass nesting at Gahirmatha. Silas *et al.*, (1984) reported mass movement of adult turtles during December 1983 towards Gahirmatha. At that time the turtles were reported migrating northward and mass northward movement was seen off Pondicherry, and within three weeks large concentrations of mating pairs were seen off Orissa Coast.

Predation of hatchlings

Since the hatchlings at Gahirmatha emerged and reached the sea also during day time, predation by sea gulls, crows and vultures was intense during the early morning hours. The hatchling face danger from the time they emerge from the pits, until they reach the sea. The birds turn the hatchlings upside down and peck on the ' umblicus area ' of the plastron making a hole and eat the contents. For every one metre about 10 dead hatchlings with such damage on their plastron were noticed along a stretch of 2 km near Ekkula Nasi in the last week of March 1984.

Beach Erosion

Kar and Dash (1984) and Silas *et al.* (1984) have reported severe beach erosion in Gahirmatha every year. In 1984 also, beach erosion was noticed near Ekkula immediately after the first nesting was completed. Due to this, large number of eggs were destroyed. Since beach erosion and accretion are regular phenomean every year, the impact of this natural phenomena on the egg loss, success of hatchling and recruitment needs further study at Gahirmatha.

Tagging of Nesting Females

During the 1984 season we have tagged about 85 nesting females from the second arribada with monometal tags bearing the numbers 0001 to 0085 and with the inscription reading :

PLEASE RETURN TO
CMFRI, P.B. 1912
COCHIN, INDIA

Tagging was done after the nesting process is completed and on the trailing edge of anterior left flipper. While tagging on 29th March, 1984 we have encountered one nesting female with carapace length 67 cm and width 57 cm bearing the number 12791, tag of Chief Wildlife Warden, Bhubaneswar indicating remigration of the animal for nesting.

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THE OCCURRENCE AND CAPTIVE REARING OF THE TURTLE *LEPIDOCHELYS OLIVACEA* ESCHSCHOLTZ, IN SUNDERBANS

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ABSTRACT

Reports on the presence of the ridley in the fishermen's catches during December to March every year and its egg poaching indicate a sizeable population and number of nesting beaches along the Sunderban coast. The present investigation has indicated a number of ridley nesting grounds. Comparisons of the physiographic data with other nesting beaches indicate the width of the ecological niche. A 39% rearing success in the first year and a 100% rearing success in the second year suggest guidelines for captive rearing programmes. Growth statistics are provided to gauge the success of captive rearing technique, as a faster growth reduces cost of rearing. Experiments conducted on the feeding behaviour of sub-adults showed a marked preference for crabs such as *Uca* and *Sesarma* over fish and prawns. The successful treatment of a fatal skin ailment with dilute $KMnO_4$ solution, but its persistent recurrence creates scope for discussion and further investigation.

INTRODUCTION

Information on the status and distribution of the olive ridley in the Sunderbans was not available, when the first batch of 600 eggs of the ridley arrived at Bhagabatpur for artificial incubation in March, 1983. Their presence in this estuarine area being indicated by ridley catches in fishermen's nets, brought to Raidighi and Kakdwip during December to March every year. Statistical analysis on the number of ridleys caught is difficult to compile as the trade is done underground. Turtle shells can, however, be found lying by the roadside at market places near any one of these centres during the period under study. 90 ridleys were found held captive in a pond in Kakdwip in January 1984 (Nandi *pers. comm.*). Other reports on this clandestine trade suggests an overall operation, large enough to indicate a population of enough magnitude along the estuarine beach, to call for management measures. The present paper summarises the information gathered in the course of a preliminary reconnaissance of the area and results obtained in captive rearing of the turtle.

Ridleys are caught while floating at the surface during the breeding season. As this overlaps the nesting season February-March in the Sunderbans, some are also caught in fishermen's net while coming to the shore to nest. The principle decimating factor is however, the poaching of eggs by man and nest predation by boar (*Sus scrofa*), monitors lizards (*Varanus* spp.) and cats, as was indicated during this study.

The author acknowledges with thanks the help received from Dr. A. K. Lahiri, Conservator of Forests, Central Circle, West Bengal, Shri U. Dasgupta and Shri A. Roy, Divisional Forest Officers, 24 Parganas Division, for providing valuable advice and guidance in the preparation of the present report.

Nesting Ground of Ridleys in Sunderbans

Mass nesting of ridleys in West Bengal have been reported earlier (Biswas, 1982). In Sunderbans, the Lothian seaface and Sagar Islands have been mentioned as areas where ridley eggs and hatchlings have been found (Biswas, 1982). During the present study, nesting grounds have been located in course of ridley egg searching for turtle rearing projects in Sunderbans under the Forest Dept., Govt. of West Bengal in Kanak Island (Banerjee, 1984). Some eggs and nests have been located in Mechua and at Chaimari locally known as 'Cadna'. A predated ridley nest was found in Halliday Island Sanctuary. One ridley hatchling measuring 4.08 cms. carapace length and 3.35 cm carapace width, weighing 17 gm recently hatched (Biswas 1982, Banerjee 1984) was recovered from the Northern face of Lothian on 27th May 1984. This appears to support reports by fishermen that the olive ridley nests on Bakha beach and along the southern shore of Lothian.

Natural History and Biology of the Ridley

In Sunderbans, sea turtles are commonly called 'Katha,' 'Kachim', refers to the fresh water form, while 'Kachhap' is the general term for the reptile. The most commonly occurring marine turtle in the Sunderbans is the olive ridley. Other species have, however, been identified. Some loggerheads (*Caretta* sp.) were rescued from a market near Kakdwip in January, 1984 by the Forest Department Officials. They were later released in the sea 9 km off Bakhali beach. (Ed. *Comment:* Could be a misidentification for *L. olivaeea*) Descriptions of the hawksbill (*Eretmochelys*) and the leather back (*Dermochelys*) have also been obtained from local fishermen.

Some Notes on Weather and Physiography of the Nesting Beaches

The regularity of the occurrence of the ridley and its nesting along the Sunderbans Coast suggests favourable ecological conditions for inducing seasonal ridley migration and nesting.

Rainfall

The annual rainfall data (1964-1974) along the Orissa Coast where mass nesting of ridleys is an annual phenomenon shows a minimum average rainfall of 0.03 mm in December and a maximum average rainfall of 322.68 mm in September (Biswas, 1982). The annual rainfall in Sagar (1982-1983) show a minimum average rainfall of 4.30 mm in December and a maximum average of 634.45mm in August (Table 1).

TABLE 1. *Annual rainfall in Sagar (mm)* 1982-1983

Months	Year 1982	1983	Average
January	0.00	26.20	13.1
February	39.80	36.10	37.95
March	52.40	64.80	58.60
April	58.90	1.00	29.95
May	0.80	69.50	35.15
June	216.30	335.20	275.75
July	370.30	178.20	274.25
August	691.80	577.10	634.45
September	81.90	377.30	229.60
October	207.00	277.10	242.05
November	32.20	10.40	21.30
December	0.00	8.60	4.30

Source: Alipore Meteorological office.

Temperature

Since temperature plays an important part in the biology of a reptile, data for the average monthly air temperature in Sagar for 1982 to 1983 are presented in Table 2 (Biswas, 1982).

TABLE 2. *Average monthly air temperature (°C at Sagar)*

Months		Year 1982		1983	
		Min.	Max.	Min.	Max.
January	..	17.6	26.2	16.6	24.7
February	..	19.6	27.0	19.1	26.2
March	..	22.7	28.4	23.9	29.6
April	..	26.1	30.6	26.6	32.5
May	..	28.4	32.7	26.8	32.0
June	..	27.0	32.0	28.2	32.7
July	..	27.2	31.4	27.4	31.2
August	..	26.3	30.3	26.8	30.3
September	..	27.3	31.3	26.9	30.6
October	..	25.7	31.8	25.8	30.1
November	..	21.7	28.4	20.7	28.2
December	..	17.3	26.1	16.2	24.9

Source : Alipore Meteorological office.

Salinity

Salinity recorded at Chandipur base showed an increase from 22.8‰ in December, 1971 to 34.6‰ in May, 1982 (Biswas, 1982). At Sagar the average salinity varied from 15.07‰ in November, 1982 to 26.00‰, in May, 1983 (Table 3).

TABLE 3. *Salinity fluctuations at Sagar*

Months		Year	Average salinity (ppt)
November	..	1982	15.07
December	..	1982	15.07
January	..	1983	19.56
February	..	1983	22.65
March	..	1983	24.21
April	..	1983	25.82
May	..	1983	26.00

Source ; Project Report Mangrove Ecosystem of Sunderban. Dept. of Science and Technology, New Delhi.

BREEDING BEHAVIOUR AND NESTING ECOLOGY

In Sunderbans, mating of the ridleys are generally observed to begin from the first week of December and continues upto February. A marked increase in the number of copulating pairs are observed when the sea is relatively calm. Average carapace length of the catches during this season was 65 cm. Laying of eggs coincides with the high tide, a drizzle and a strong on-shore wind.

Ridley nests were located in Kanak Island in 1983 after a night of light storm and rain. The high tide facilitated the nesting of ridleys. The nesting ground in the Sunderbans consist of fine silica sand. Beaches with silt depositions are not visited by the ridleys for purpose of nesting as the soil turns heavy and hardens on exposure, thus becoming difficult to excavate. Hatchlings would also find it difficult to emerge through such nests as was observed in the case of eggs hatched artificially at Bhagabatpur. The beaches associated with good mangrove vegetation and relatively undisturbed are found to be favoured by them. The vegetation forms a basis for the production of plankton and neritic fauna. The period immediately after the ridleys hatching is found to coincide with the occurrence of large number of small pelagic fish and crustaceans and with the hatching of river tern (*Sterna*). The birds are found to lay on the same nesting beach as the ridley at Kanak Island.

Natural ridley nests are found 50 to 75 metre away from the maximum high tide water mark and at an average elevation of 1.35 metres. The average early morning nest temperature recorded was 30.5°C and the noon temperature 31°C, while the air temperature varied between 28°C to 32°C. The upper layer of the eggs were found at a depth of 45 cm in the nest laid in a cluster and touching each other. The nest cavity resembled a laboratory flask with a narrow neck of 30 cm and a width of 60 cm. The total nest depth measured 50 cm. Number of eggs per clutch varied between 96 - 120.

Captive Rearing

Studies involving the rearing of olive ridley begun at Bhagabatpur Crocodile Project, Sunderbans in March 1983, when the first batch of 600 eggs were brought from Kanak Island, a newly sedimented land rising above the waters, at the mouth of river Matla (Banerjee, 1984). Eggs were marked in the conventional manner on the animal pole before transferring to the transportation box and carriage. 4 nests were opened. Each clutch being marked with a separate colour. These were transferred to the hatchery at Bhagabatpur were simulated nests were prepared.

Hatchery technique

Simulated nests were prepared using some amount of parent soil and collected estuarine sand, in a trench of size 2.90 m × 0.80 m with a gradually deepening depth from 0.75 m to 0.90 m. The bottom slope was provided to facilitate prompt drainage. Nest cavity were scooped out resembling the original and eggs were placed in separate clutches as collected, touching each other. A hollow bamboo pipe was inserted at the centre of each egg chamber. A thermometer inserted through the pipe in order to record the nest temperature at 2 hours interval. The sand covering the nest was tightly packed. The entire hatchery was located in a partially shaded patch and fenced off.

Hatching

Eggs were found to start hatching from the 61st day, the average nest temperature being maintained at 29°C. Hatching continued upto the 6th day. 117 numbers hatched at a total hatching rate of 19.5%. Several eggs were found to be infertile (Table 4).

Hatching behaviour

First hatching took place on 17-5-1983 at about 5.15 p.m. when 28 hatchlings were observed running about on the hatchery floor. Hatching continued from the same nest and altogether 34 hatchlings were obtained upto 11.15 p.m.

Hatchlings emerged one at a time through a single opening in the nest, sometimes from the centre or through the periphery of the neck of the pitcher shaped nest. Complete emergence took place in 15-25 minutes, for each individual. After emergence the hatchlings slowly move on their flippers and then scurry forward towards the sea.

TABLE 4. *Hatching results of olive ridley at Bhagabatpur*

Date		Nest (1)	(2)	(3)	(4)	Total
17-5-'83	..	34	30	—	—	64
18-5-'83	..	5	3	—	—	8
19-5-'83	..	3	11	4	—	18
20-5-'83	..	—	1	2	—	3
21-5-'83	..	—	—	—	8	8
22-5-'83	..	—	—	—	16	16
					Total	117

Release

Twelve days after hatching, 99 hatchlings were selected at random and released at the original nesting site, in sandy creeks on the island. On 27th May, 1983 over a thousand river tern (*Sterna*) were observed nesting on the same island. Fine meshed fishing nets cast at the site, caught a large quantity of minute crabs, fish and prawns.

Rearing

Hatchling were kept in plastic basins 63 cm diameter and 20 cm depth in a water depth of 2.5 cm. After a fortnight these were transferred to a masonry tank 3 m × 3 m × 0.75 m. Water was filled to a depth of 25 cm. Necessary basking and resting place was provided by filling sand above the water line at the corners. The hatchling climbed up onto these and remained for some time before clambering down into the water. The water in the plastic basin was changed twice daily and in the masonary tank once daily in each case changing being done after feeding. Saline estuary water was used for rearing experiments.

Food and feeding behaviour

Ridley hatchlings were not found to feed on the first day after emergence. Hatchlings were offered minced prawn ground to bite-size. The feed was dropped in the water filled plastic basins. These were picked up by the beak and gulped down under water and some times with the beak thrust out of the water line. Live fish, prawns, pond weed and algae were offered but no ingestive behaviour was noted.

The masonry tank bottom had to be covered by a sand layer as the hatchling were found to injure their beaks and carapace. After the completion of a year the feed schedule (Banerjee, 1984) was experimented with live fish, prawns, crabs and weeds, since a change in feeding from the carnivorous to the harbivorous behaviour was stated by Biswas (1982). Kar (1982) and Hughes (1983) opined it to be carnivorous, while Murthy and Menon (1976) stated they were omnivorous. Crab was preferred as food while the vegetative matter was not accepted (Table 5).

Growth and health

The growth rate of the hatchling are found to also depend on temperature, maximum growth being observed in July-August and levelling of totally during December-January. During the monsoon a skin infection was observed in 1983 and 1984. Infection appeared on the neck, flippers and carapace joints. Feeding was stopped and animals turned lethargic. Whitaker (1978) reported this to be fatal. However, successful treatment with 5% KMn O_4 solution twice daily, helped with a daily dose of 4% solution of teeramycin Anti-germ—77, checked and healed the infection. A dilute solution of electral powder was fed two drops per individual.

TABLE 5. *Feeding behaviour of ridley*

Date	23-6-1984	
Water temperature	— 30.5°C	
Water depth	— 20.00 cm	
Tank size	— 3 m × 3 m × 0.70 m	
Specimen *L. olivacea*		
Age	— 395 days	
Carapace length	— 27.8 cm	
Carapace width	— 25.26 cm	
Weight	— 2.795 kg	
Numbers	— 10	
Live feed offered	*Average Size*	*Nos*
Prawns	6 cm	112
Fish	2.5 cm	46
Crabs (*Sesarma*, *Uca*)	3.5 cm	52
Boleopthalmus sp.	15 cm	12
Weed	20 cm	
Grass	20 cm	
Recovery		
Prawns	— 103 Nos	
Fish	— 39 ,,	
Crabs	— Nil	
Boleopthalmus sp.	— Nil	
Weeds	— Total	
Grass	— Total	

This helped to induce activity and feed intake. No mortality was observed. The infection again appeared during the monsoons of 1984. The treatment removed the infection but it reappeared after a week and was found to persist. The hatchlings were feeding normally. No mortality was observed among the 1984 hatchlings. Infantile mortality in captive ridleys at Bhagabatpur have been reported (Banerjee *et al.*, in press). In a year the infantile mortality rose to 8 numbers (*i.e.* 44%). 3 hatchling died owing to developmental abnormality and one owing to an accident. Thus in effect the infantile mortality was 4 Nos. (22%) for the 1983 hatchling after the first year. To date, 7 nos are surviving (39%). 5 hatchling are being reared from the 1984 batch and no mortality has been observed.

Financial implications in 1983

It is essential in any attempt at exploitation or rehabilitation of a species that husbandry cost be kept at the minimum required level. High expenditure may compel to abandon a programme prematurely. The figures given relate to the fiscal year 1983.

	Rs.
Cost of egg collection	
1. labour charges	120.00
2. Boat hire	200.00
Preparation of nest	105.50
Release	
1. Boat hire	200.00
Maintenance cost (Food, cleaning pen etc. for 1 year)	
Labour @ Rs. 285 p.m.	3420.00
	4045.50

After the second year the turtles will have to be stocked in big ponds or in suitably enclosed creeks, protected from predation.

Turtle meat is sold at Rs. 12/kg at the local market. The eggs are considered a delicacy. The much needed protein for the rural population can be met from turtle farming.

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CAPTIVE REARING OF HATCHLINGS OF OLIVE RIDLEY *LEPIODCHELYS OLIVACEA* AT POINT CALIMERE, TAMIL NADU

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ABSTRACT

The growth of hatchlings of olive ridley *Lepidochelys olivacea* has been studied from emergence to five months under captive conditions. The morphometric characters were studied during growth. Internal anatomy confirmed that there is no indication of development of sex organs. Sexes could not be identified externally.

INTRODUCTION

THE growth of olive ridley *Lepidochelys olivacea* in captivity has been reported by a few authors (Deraniyagala, 1939 ; Whitaker, 1979 ; Rajagopalan, 1984). The present paper reports on the growth of *L. olivacea* under captive conditions for a period of five months.

The authors express their sincere thanks to the chief wildlife warden, Forest Department, Government of Tamil Nadu for the implementation of the scheme at Point Calimere, Thanjavur District.

MATERIAL AND METHODS

A batch of 102 emerged hatchlings were collected from the hatchery at Point Calimere, Thanjavur District along the east coast of India. For the first three days, hatchlings were fed with hen's eggs thoroughly mixed in sea water. Once the food was consumed the hatchlings were transferred to another polythene tub of diameter 70 cm containing fresh seawater. Hatchlings were maintained for three days in the polythene tub and were transferred to a cement tank (Size 6' x 3' x 4') constructed inside the hatchery. During the growth of hatchlings different types of food such as sea grass, prawns, *Sepia* sp. and marine fishes were offered as food thrice a day. After food was consumed, the water was also changed. Growth characters such as carapace length, width, plastron length width and total weight of hatchlings were recorded at the end of every week.

RESULTS

The relationships of various morphometric characters were recorded. A simple regression $y = a + b x$ has been fitted to understand the relationship between variables (Table I). All these characters show a linear relationship.

The 'a', 'b', and 'r' values for the relationship between the growth characters and the age are presented in the Table 2.

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TABLE 1. *Values of a, b, and r for different growth characters of* Lepidochelys olivacea *(N ; 102 Individuals)*

Characters		"a"	"b"	"r"
carapace length and carapace width :	..	—1.5345	1.0372	0.9945
carapace length and plastron length :	..	1.2288	0.6848	0.9374
carapace length and plastron width :	..	—0.2544	0.7767	0.9966
carapace length (Log) & Total weight :	..	5.4748	0.0228	0.9632

TABLE 2. *Values of "a", "b" and "r" for different growth characters against age of* Lepidochelys olivacea *(N ; 102 Individuals)*

Characters		"a"	"b"	"r"
135 Days Age and carapace length	..	4.9926	0.5055	0.9465
,, Age and carapace width	..	3.4455	0.0526	0.9979
,, Age and plastron length	..	4.3828	0.3675	0.9951
,, Age and plastron width	..	3.4733	0.3935	0.9988

The mean carapace length and width of just emerged hatchlings of *Lepidochelys olivacea* were 43.8 mm and 34.3 mm. At the end of 1st month the carapace length was increased to 56.8 mm and further increased to 72.6 mm at the end of 2nd month, 87.8 mm at the end of 3rd month, reached 101.8 mm at the end of 4th month and 110.9 mm at the end of 5th month. The corresponding mean values for carapace width were 47.3, 62.2, 78.5, 92.3 mm and 105 mm respectively.

The mean body weight of freshly emerged hatchlings was 16.6 grams. It increased to 34.31, 77.97, 153.5, 215.73 grams, and 328 grams at the end of 1,2,3,4, and 5 months respectively.

DISCUSSION

The carapace length and width of hatchlings have been studied under captivity conditions. Deraniyagala (1939) measured the carapace length of one animal at about 6 months as 74 mm and its weight as 76 grams. Whitaker (1979) recorded the carapce length of the same age group as varying from 83 to 95 mm with a mean at 89 mm and the weight varying from 100 to 175 grams. Rajagopalan (1984) observed for a similar period and recorded that the carapace length varied from 102.4 to 119.2 mm and mean weight was 280 grams, (1981 group) and further extended the study for a period of 22 months and registered a growth of 3,300 gms in 1980 groups and 7,800 gms in 1981 group as compared to the recorded value of 2,100 grams (Whitaker, 1979). In the present study at the end of the 5th month the olive ridley attained 328 grams in weight with 110.9 mm carapace length, and 105 mm breadth. Sexes could not be identified externally, and internal anatomy did not indicate the development of sex organs at the end of five months.

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RECOVERY PLAN FOR OLIVE RIDLEY *LEPIDOCHELYS OLIVACEA* AT POINT CALIMERE, TAMIL NADU

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ABSTRACT

A recovery programme for olive ridley *Lepidochelys olivacea* was started by the Department of forest, Tamil Nadu Government in 1982. During 1982-83 and 1983-84 a total number of 30,046 and 30,771 eggs were incubated and the maximum percentage of hatching were 81 per cent and 83.69 per cent respectively. The field study indicated that Vanavanmahadevi at Thanjavur District has favourable environment for nesting and conducting artificial hatchery programmes.

INTRODUCTION

CONSIDERABLE literature exists on the various conservation methods of sea turtles (Bjorndal, 1981), with particular reference to Indian seas (Jones and Fernando, 1968 ; Bhaskar, 1978, *a, b, c, d, e*, 1979 ; Kar, 1980 ; Biswas, 1981 ; Bhaskar and Whitaker, 1983 ; Silas *et al.*, 1983, a, b, c.). Studies indicated that the number of eggs in a clutch markedly differ in olive ridley, nesting in different geographical areas (Deraniyagala, 1939 ; Carr, 1952 ; Schultz, 1975 ; Biswas *et al.*, 1977 ; Rahaman *et al.*, 1983 ; Silas *et al.*, 1984). The present paper reports on the recovery plan of the olive ridley along the east coast at Point Calimere, Thanjavur District, Tamil Nadu between 1982-'84.

The nests were located at 10 and 30-40 meters away from the high water mark. However, the nests located at the distance of 10 meter have an elevated sand bar, which the turtle crawls over for nesting. Normally the nests were found at a distance of 30 to 40 meters away from the high water mark. The crawl marks were useful in the location of the nests. The size of the nests were mearsured while collecting the eggs. From each nest, size of the clutch was recorded. While taking the eggs care was taken, not to disturb the eggs. With a sketch pen, a dot was marked on the top of the eggs, when the eggs were removed from the nests, to facilitate correct position while transplanting the eggs in the hatchery.

The width of the nest varied from 27 to 39 cm (35 cm) at the widest part of the nest chamber, and 12-18 cm at the neck region and the depth of the nest varied between 30-45 cm.

Nesting Season

Nesting season commences from the last week of November to the end of March, with a peak in the middle of January. Nesting of olive ridley usually was observed between 1.00 to 3.00 a.m. on most of the occasions. In January 1984, a number of carcasses of olive ridley were washed ashore at Vizhundamavadi, near Point Calimere. The reason could not be confirmed.

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During nesting season, average atmospheric humidity and temperature were recorded (Table 1). Temperature ranged between 29°C to 34.5°C (Maximum) and 22.5°C to 34.5°C (Minimum) and the humidity ranged between 60% to 76% during 1982-83. In 1983-1984, the variation in temperature was 28.5°C to 34°C (Maximum) and 23°C to 25°C (Minimum) and humidity 61% to 78%.

Clutch

The eggs in 255 nests during 1982-1983 and 249 nests in 1983-1984 were collected and transferred to the hatchery. The clutch size varied from place to place. However, at Vanavanmahadevi average clutch size was 124 and 131 during 1982-1983 and 1983-1984 respectively (Table 2). When compared to the other observations, Vanavanmahadevi recorded maximum clutch size and the range of clutch was narrow when compared to other places (Table 3). During the 'Turtle Walk' about 25 turtles were observed nesting and the morphometric characters are given elsewhere (Kumar, *Per. Comm.*). The diameter of the

TABLE 1. *Average Monthly Humidity and air Temperature* 1982-'84

	Average Humidity (%)		Temperature (°C)			
			Minimum	Maximum	Minimum	Maximum
	1982-83	1983-84	1982-83		1983-'84	
December ..	76	78	22.5	29.0	23.0	28.5
January ..	73	75	23.0	30.5	23.5	30.0
February ..	70	73.5	23.0	32.0	24.0	31.0
March ..	67	70	23.5	33.0	24.0	32.0
April ..	65.5	65.5	24.0	33.5	24.5	33.5
May ..	60	61	24.5	34.5	25.0	34.0

TABLE 2. *Clutch size variation and number of nests in different areas at Thanjavur District, Tamil Nadu*

Place	Year	Number observed	Average Clutch Size
Point Calimere ..	1982-83	90	119
Vanavanmahadevi ..	1982-83	87	124
Arcotthurai ..	1982-83	78	111
Point Calimere ..	1983-84	91	115
Vanavanmahadevi ..	1983-84	78	131
Vizhundamavadi ..	1983-84	80	125

During the months of December 1983 and January 1984 the entire area under study had unusual rain 869.6 and 135.2 mm respectively and the field observation indicated that there was no nesting of the turtle during the rainy days.

TABLE 3. *Clutch size variation in different nests in the Thanjavur District, Tamil Nadu*

Place & Year		*Total Number of nests in which less than 100 eggs were observed*	*Total number of nests in which 100 to 120 eggs were observed*	*Total number of nests in which 121 to 140 eggs were observed*	*Total number of nests in which 141 to 160 eggs were observed*	*Total number of nests in which more than 160 eggs were observed*
1982-'83						
Point Calimere	..	11	36	32	11	—
Vanavanmahadevi	..	11	26	30	20	—
Arcotthurai	..	21	29	20	8	—
1983-'84						
Point Calimere	..	13	34	35	8	1
Vanavanmahadevi	..	9	7	29	32	1
Vizhundamavadi	..	10	12	38	20	0

egg varied from 28.2 to 32.1 (Average : 31 mm). In a single clutch of 120 eggs, the diameter of the eggs did not vary much. (Average : 31 mm). In the present study, variability in the weight of a single clutch and between the clutches were not significant. While recording the weight of an egg, the sand particle adhering to the shell were removed with the help of camel hair brush with least disturbance to the eggs.

Predation of eggs

During the 'Turtle Walk' at night, stray dogs and pigs were often seen to disturb the nests. This may be due to the smell of the albumen like mucus coated on the freshly laid eggs. In some instances, raw eggs were consumed by the local people and at one instance it was noticed that eggs were taken and mixed with cattle feed and given to the cows. It was also observed that the eggs were mashed with water and filled in a feeding bottle and forcibly given to the goats. Exact data on the predators are wanting.

On one occasion the locals used fire crackers such as '*Venkaya vedi*' (Onion shaped fire cracker) to frighten the stray dogs from consuming the eggs. However, this method is abandoned in the sanctuary at Point Calimere. Further local people use the goat fat to cover the fire crackers (*Venkaya vedi*) and dry them in shady place and use this as fake food. This method is used to kill the fox, which predates on turlte eggs.

Hatchery

The forest department of Tamil Nadu government had constructed three hatcheries in 1982-1983, at Point Calimere, Vanavanmahadevi and Arcotthurai. In 1983-1984 the hatcheries functioned at Point Calimere and Vanavanmahadevi and instead of Arcotthurai, Vizhundamavadi was chosen for erecting the hatchery as it provided favourable environment.

In 1982-1983 out of 30,046 eggs incubated, 24,501 eggs were hatched and the percentage of hatching was 81%. In 1983-1984 out of 30,771 eggs incubated 25,755 were hatched and the percentage of hatching was 83.69% (Table 4). The field study indicate that Vanavanmahadevi is the ideal place for conducting hatchery programme, since at minimum 45

TABLE 4. *Showing total number of eggs incubated and total number of hatchlings released*

Place of Collection		*Total number of eggs incubated*	*Total number of eggs hatched*	*Average days for incubation*	*Total number of hatchlings released*	*Total number of eggs unhatched*	*Percentage of hatching*
				A (1982-'83)			
Point Calimere	..	10,630	8,556	50	8,256	2,374	80%
Vanavanmahadevi	..	10,723	8,925	45	8,925	1,797	83%
Arcotthurai		8,693	7,020	46	7,020	1,663	80.75%
Total	..	30,046	24,501		24,201	5,834	81%
				B (1983-'84)			
Point Calimere	..	10,511	8,429	52	8,304	2,082	80%
Vanavanmahadevi	..	10,240	8,798	49	8,798	1,442	85%
Vizhuthamavadi	..	10,020	8,528	48	8,528	1,492	85%
Total	..	30,771	25,755		25,630	5,016	83.3%

days of incubation, a maximum of 83% of hatching was achieved. Balasingam (1965-1966) reported that the eggs of leathery turtle when buried in sand in batches of 50 instead of their natural clutches (Average 84 eggs) found the hatching rates are better. In the present study entire clutch was buried, irrespective of clutch size, the hatching rate was found to be better. It suggests that the clutch size and the better hatching are independent. Other factors such as temperature, sand particle size and diffusion of gases might operate in the artificial hatchery for a better percentage of hatching. However, the percentage of males and females in such commercial method of hatchery remains to be worked out under altered temperature and other environmental conditions.

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PRESENT STATE OF MARINE TURTLE CONSERVATION AND MANAGEMENT IN WEST BENGAL

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ABSTRACT

Surveys on the catch of olive ridley turtle *Lepidochelys olivacea* (Eschscholtz) were made during 1983-84 season in West Bengal. A total of 19,636 turtles have been captured during November to February period from Digha and Jambdwip (Sundarbans). Of these, 5,180 and 3,266 were consumed by the local people of the Districts 24 Parganas and Midnapore respectively while the remaining 11,190 turtles were transported to Calcutta and other markets during the period. Since the West Bengal Forest officials are keeping constant watch at almost all the active centres for this nefarious trade, the turtles were transported through the creeks to landing centres located in the interior. As the turtle trade provides additional support to the economy of fishermen the management programme should take this into account.

INTRODUCTION

A LOT has been written about the mass nesting of the olive ridley *Lepidochelys olivacea* in the recent past. The focus has also been on the illegal trade in this species in the market in West Bengal. Ganguly (1978) made an appeal to save the olive ridley from mass killing in West Bengal and Orissa, while Silas *et al.* (1983 a, b, c) and Silas (1984) repeatedly discussed on this aspect and expressed their views regarding conservation and management of sea turtles occurring in India. Though central government as well as state government authorities and other agencies are trying to stop turtle poaching and marketing, the present state of conservation and management of this species is far from adequate. In the present paper an attempt has been made to focus the state of turtle trade in West Bengal during 1983-84 season with some suggestions for meaningful conservation and successful management.

Turtle fishers and sites of fishing

The olive ridley turtles are fished by the fishermen at Digha, Midnapore District and Jambudwip of Sundarbans, 24-Parganas District, West Bengal. The fishermen are used to operate over a hundred fishing units from these two Districts of coastal West Bengal. They are known to perform their traditional fishing of commercial fishes and prawns. But a few units sometimes arrange organised capture of marine turtles along West Bengal and Orissa Coasts. There are 206 villages comprising 59,056 fishermen in these two Districts. They belong to fishing (*Jalia Kaibarta*) as well as non-fishing castes, both scheduled (*Tanti, Dom, Hari, Suri, Muchi*) and general (*Raju, Mahesya, Kayastha*). The educational status of most of the fishermen is of primary standard and mostly they have no alternate source of income. Finding no other job, even those with secondary level of education have joined with the other members of their family/community in fishing pursuits. However, out of 59,056 fishermen, 13,869 are engaged in actual fishing, either full-time or part-time or occasionally as per estimate of the Central Marine Fisheries Research Institute (CMFRI), Cochin (Anon, 1981).

In West Bengal, though there is no vessel or boat exclusively meant for turtle fishing, the fishermen of the Midnapore and 24 Parganas Districts do not spare turtles from their trade. This is particularly pronounced during lean periods when the fish catch is low. At such times a switch-over from incidental catches in the gill net fishery to directed capture of turtles may occur. During mating, the olive ridley is extremely sluggish and can be hauled aboard easily by hand or nets. However, three nesting sites are located in the Sundarbans namely, Mechua, Sainmari and Kanak island between the Latitude 21°31′ N-22°30′N and longitude 88°10'E—89°51′E (Sanyal, 1983 ; Saha, 1984) which are presumed to be free from human interference. Through inquiry and survey among fishermen and traders, it is estimated that a total of 19,636 turtles have been captured during November-February from Digha and Jambudwip in 1983-84 season. Of these, about 90% of the total catch was from Digha.

Landing centres and trade network

The turtle fishing is normally restricted to winter *i.e.* November-February and it reaches a peak at the end of December. Live turtles captured at fishing grounds are clandestinely despatched by mechanised boats through the creeks to landing centres located in the interior and away from the vigilance of Forest officials. Thus, from Jambudwip, turtles are brought directly to Ukilbazar and Kakdwip instead of Namkhana to avoid the watch of Namkhana Forest officials. The important landing centres from Digha source are Chouddamile, Bankshalghat, Samudrapur, Angariaghat, Jaldha, Junput and Rasulpur. From Digha turtles are transported to south 24-Parganas markets via Kakdwip and Uttar Chandannagar *ca* 2 km west of Nischintapur on Diamond Harbour-Namkhana Road. From these landing centres turtles are delivered by Rickshaw-van and Matador-van to the different road-side markets since the police personnel are not alerted about the imposition of the Wildlife (Protection) Act 1972 on ridley turtles.

Like fish trade, the turtle trade is also controlled by the middlemen known as Aratdars (Godown owners). But, the fishermen who own fishing crafts and tackle in the Midnapore and 24 Parganas Districts form fishing units, employing 50-150 unit members on 'contract basis' for the season. The remuneration beside the provision of food, is settled for the season as per their skill to a maximum of Rs. 5,000.00 for the Majhi (head crew of the boat). The fishermen (unit owners) take loan from the Aratdars on hypothecation of their catch. The Aratdars also employ 20-50 persons with 4-8 boats and a launch or a trawler to collect catches off-shore. The principal Aratdars are stationed at Digha and Kakdwip. They are known to instruct fishermen to catch sea turtles when the fish catch goes down. The Aratdars usually sell turtles to Paikers or Fores (also middlemen) who transport turtles to suburban and urban markets as well as to Howrah wholesale markets. The suburban markets are located on the arterial routes from Digha and the Sundarbans to Calcutta. However, sometimes small fishing units of 6-8 persons with 1 or 2 boats resort to turtle fishing as and when they feel it is profitable.

Turtle markets and turtle economics

Although the turtle fishery is a supplementary one, the selling of turtle meat in the local markets along coastal areas of West Bengal is now-a-days very common. Tables 1 and 2 represent the list of markets and other relevant information in connection with the selling of turtle meat and eggs in 24-Parganas and

TABLE 1. *Sea turtle markets along Diamond Harbour—Namkhana Road, Data on sale proceeds (per week) from November to February*

Markets		No. of turtle sold/week	Price/kg	No. of seller
			Rs.	
Diamond Harbour	..	10-20	3.00-6.00	1-2
Kulpi	..	10-15	3.00-6.00	1-2
Karanjali	..	10-15	3.00-6.00	1-2
Nischintapur	..	40-50	3.00-5.00	5-6
5 No. Hat	..	15-20	3.00-5.00	1-2
Kakdwip	..	20-30	4.00-6.00	1-2
Ukilbazar	..	35-40	3.00-6.00	3-4
Interior markets (Sagar, Pathar, Namkhana)		60-100	3.00-6.00	10-15

Eggs sold at Rs. 2.00-3.00 per kg. Of the total consumption 80% of the turtles comes from Digha landings and 20% from Jambudwip.

Total sale (per week) = 210-300 turtles

Total sale (November-February) = 4,500-5,000 turtles

TABLE 2. *Sea turtle markets in the coastal belt of Midnapore District*

Markets		No. of turtle sold/week	Price/kg	No. of seller
			Rs.	
Deuli	..	6-8	4.00- 6.00	2
Depal	..	3-4	4.00- 6.00	1-2
Sapua	..	3-4	4.00- 5.00	1-2
Kanpoyrahat	..	2-4	4.00- 6.00	2
Mirgodagunge	..	2-5	5.00- 8.00	2
Mirzapur	..	4-8	6.00- 9.00	2
Ramnagar	..	2-5	3.00- 4.00	1-2
Kalinagar	..	2-5	6.00- 8.00	1-2
Khejuri	..	3-6	7.00- 9.00	1-2
Haldia	..	10-15	10.00-12.00	2-4
Khakurda	..	3-8	6.00- 8.00	1-2
Belda	..	8-16	6.00- 8.00	2-4
Narayangarh	..	5-9	6.00-10.00	1-2
Nayagarh	..	4-7	6.00-10.00	1-2
Paniparul	..	2-3	3.00- 6.00	1
Mohanpur	..	1-2	3.00- 6.00	1
Keshiary	..	4-6	6.00- 8.00	1
Khakurda	..	6-16	6.00-10.00	2
Interior markets	..	28-35	6.00-10.00	2-4

Eggs sold at Rs. 2.00-6.00 per kg.

Total sale (per week) = 98-166 turtles

Total sale (November-February) = 2,200-2,500 turtles.

Midnapore Districts respectively'. It is estimated that about 5,180 turtles have been consumed by the local people of 24-Parganas District. Of the total local consumption 80% comes from Digha source while only 20% is captured from Sundarbans at Jambudwip. However, apart from the listed markets, turtles are sent to certain parts of Purulia, Bankura and Midnapore Districts as per prior contract of the buyers. The remaining turtles were transported to Calcutta and sometimes to Jamshedpur markets.

The selling price of turtles varies from place to place. In the sea, the fishermen sell a turtle at Rs. 30.00 to Rs. 50.00 depending on the weight of the individual. The fishermen may earn about Rs. 10.00 or more if they bring it to the Aratdars ashore. The Aratdars sell it at Rs. 70.00 to Rs. 130.00 to Fores or Paikers. The fishermen though selling turtles at sea earn at least Rs. 800.00 to Rs. 1200.00 per season. The boat collecting turtles at sea earn about Rs. 10,000.00 in one season.

TABLE 3. *Net income from a turtle of 30 kg weight at different stages of trade on its way to Calcutta market.*

Stage	Income
	Rs.
Fishermen in the sea	25.00
Boat owner	5.00
Aratdar at shore *or* Collecting boat	45.00
Labourer (for loading and unloading)	3.00
Truck owner	10.00
Paikers at Digha (by selling to Howrah Aratdar)	20.00
Howrah Aratdar	160.00
Tempo owner *or* Thelawala (for carrying the turtle to different markets)	20.00
Salesman (in Calcutta market)	85.00*

* Sometimes this amount increases upto Rs. 150.00 depending on the market conditions and this is why the selling rate varies with the market in Calcutta.

The profit gained at various levels from a turtle of 30 kg in course of its transport to Calcutta market has been shown in Table 3. In Calcutta, at Thakurpukur market the turtle meat is sold at Rs. 23.00 per kg these days while at Beliaghata market it is slightly less *i.e.* Rs. 18.00 per kg and at Sealdah it is still cheaper *i.e.* Rs. 15.00 per kg.

Turtle conservation and research

There are only two turtle rearing centres in West Bengal. Both the centres are located at Sundarbans one at Bhagabatpur Crocodile project and the other at Sajnakhali Forest Office, 24-Praganas District. As a part of their conservation and management programmes, these centres are used for collection of eggs from Mechua, Sainmari and Kanak Island of Sundarbans. The eggs are incubated in the beach hatcheries. Sanyal (1983) obtained 51% hatchling success from the Sajnakhali hatchery while Saha (1984) got 30 hatchlings (22%) out of 137 eggs incubated at the same hatchery. However, Banerjee (1984) obtained 117 hatchlings (19.5%) from 600 eggs collected from 4 nests at Kanak Island in 1983 of which 99 hatchlings were released at their original nesting sites (creeks). The rest has been retained for further scientific study. Both egg and hatchling mortality have been revealed in addition to skin infection among hatchlings of ridleys (Banerjee, 1984; Banerjee *et al.*, in press). The following conservation strategy has already been adopted in West Bengal for better conservation and management.

(i) Artificial rearing of turtle to keep the population normal.

(ii) Promulgation of Indian Wildlife (Protection) Act 1972.

(iii) Training of turtle project staff in India and abroad.

The coastal West Bengal supports an unique aquatic ecosystem along with luxuriant mangroves. The Sundarban biosphere reserve is recently declared as a National Park which may offer protection to ridley resources of West Bengal. A proper management programme has to be developed suitable for the areas including trained adequate field as well as scientific staff for implementing proper conservation and management measures.

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TEMPERATURE DEPENDENT SEX DIFFERENTIATION IN THE OLIVE RIDLEY *LEPIDOCHELYS OLIVACEA* AND ITS IMPLICATIONS FOR CONSERVATION

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Abstract

Temperature is a controlling factor that has important effects on sex differentiation in embryos of most turtle species. In general, females are produced at the higher end of the range, and males, at the lower. The sex is determined by their temperature during the middle third of development. The effect of three temperatures, 26-28°C, 29-30°C and 31-32°C showed that *females* only were produced at the high incubation and *males only*, at the low, with *both sexes* developing at the intermediate temperature. Both Studies on a transplanted beach nest showed that *only* females were produced in the nest. Both laboratory and field studies have important implications for the conservation of the endangered sea turtles in general.

Introduction

Most turtle species that have been tested are without recognizable sex chromosomes. Furthermore, they are temperature-labile as to sex differentiation. The temperature of incubation during the middle third of embryonic development is apparently critical as to whether an embryo differentiates as male or female. Males are produced at the low and females, at high, with both sexes developing at an intermediate temperature, termed as the pivotal temperature. So far three of the eight species of sea turtles have been found to confirm to the same general pattern : the loggerhead *Caretta caretta* (Yntema and Mrosovsky, 1980) ; the green turtle *Chelonia mydas* (Miller and Limpus, 1981 ; Morreale *et al.*, 1982) ; and the olive ridley *Lepidochelys olivacea* (Dimond and Mohanty-Hejmadi, 1983 ; McCoy *et al.*, 1983).

Furthermore, a common practice for conservation of sea turtles has been to move eggs from natural nests to beach hatcheries or styroform box incubators and then the release of hatchlings into the sea as they emerge. This exercise is an attempt to improve the hatching success and thereby increase the chances of survival of the population. This method is popular and is practiced in many parts of the world. At present, in India thousands of hatchlings from beach hatcheries are being released into the sea (Silas and Rajagopalan, 1984). But this practice has increasingly been criticised because of the temperature-labile sex differentiation. It is opined that many eggs at a single temperature may lead to distortion of sex ratios and instead of survival may destroy a population (Pritchard, 1980 ; Spotila *et al.*, 1983 ; Mrosovsky, 1983). What is even more distressing is that we do not have much idea regarding the sex ratio under natural conditions to evaluate this method especially for olive ridley.

We would like to thank the Chief conservator of Forests, Government of Orissa for the help and encouragement provided for the study. Special thanks are due to Shri

U.N. Sarangi, now Chief Conservator of forest; Shri S. Mahapatra, Chief Wild Life Warden; and Shri S. K. Mishra, D. F. O., Chandbali; for their help in collection and transportation of eggs from Gahirmatha to the laboratory. This work was supported in part from the American Philosophical Society as a grant-in-aid to Dr. Dimond.

Materials and Methods

For laboratory studies, clutches of eggs were removed from nests in 1983 and 1984 at Gahirmatha, Bhitar Kanika Sanctuary, Orissa; a few hours after laying and transported to the laboratory at Utkal University within two to three days. The eggs were placed either between two layers of moist cotton or buried in sand in enamel pans. Eggs were incubated at three temperature levels: cool (26°-28°C); 'room' (fluctuating from 1° to 5.5°C per day, with mean ranging from 28.1° to 31.7°C which was recorded with a dual control thermistor, (Fig. 1); and warm (31°-32°C). Eggs were candled at regular intervals and dead embryos were removed from the clutch. At certain times normal embryos were removed and fixed for staging and histological studies.

In order to study the sex ratio in transplanted beach nests, a clutch of 104 eggs were taken from a nest in the hatchery at Gahirmatha on day 24 of transplantation, coded as to their position in the nest and brought to complete development at room temperature in the laboratory at Utkal University. By day 24 of development *i.e.* before transport to the laboratory, the embryos had passed Yntema's stage 22 when sex is probably determined (Yntema, 1968; 1979). After hatching, the hatchlings were sacrificed, their gonads were examined morphologically and then processed for histology.

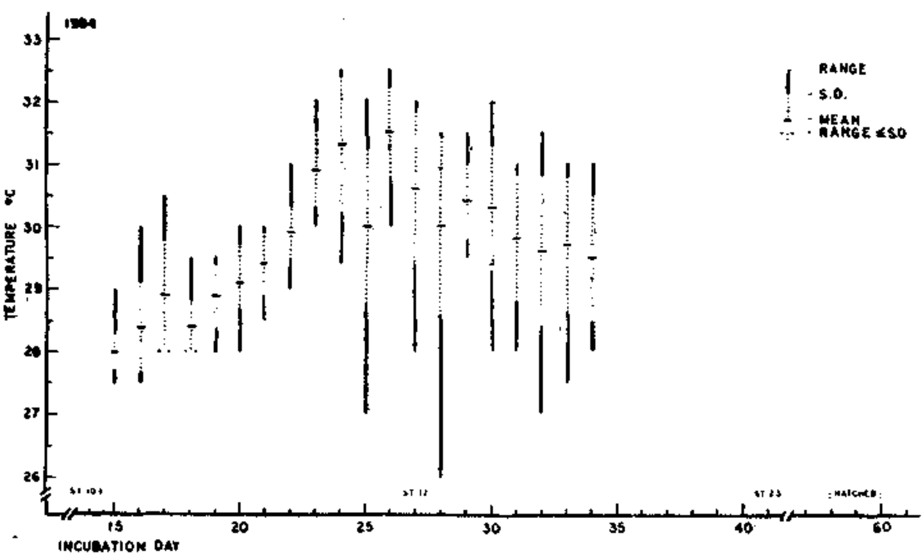

Fig. 1. Daily temperature record, with mean, standard deviation and range based on continuous recording for eggs of *Lepidochelys olivacea* at 'room' temperature. Day 1 of incubation was 12 February, 1984. At day 14, the day previous to the start of continuous monitoring, the embryos were at Yntema's stage 10. Temperature recording was discontinued after day 34. Hatching occurred between days 58 and 60.

Results and discussion

The temperature of incubation affected the rate of development (Table 1). By 19 days of incubation, the warm temperature embryos had reached stage 19; the room temperature ones stage 16 and the cool temperature ones stage 12. Hatching occurred accordingly; at a shorter period at warm, at an intermediate period at room and at a longer period at cool temperatures.

TABLE 1. *Effect of temperature on development and sex ratio of* Lepidochelys olivacea

Temperature (°C)		Number of days for hatching	Sex (%)
26.5	..	76 (75-78)	Males (100)
28.0	..	75 (72-75)	Males (100)
29.5	..	58 (58-60)	Males (40) Females (60)
30.0	..	55 (54-55)	Females (100)
31.0	..	51	Females (100)
31.5	..	45 (45-46)	Females (100)

An examination of gonads by gross examination followed by histological examination revealed that females only were produced at 30°C or above and males only were produced at a temperature of 28°C and below (Table 1t) Both males and females were produced at 29.5°C indicating that this probably represents the pivotal temperature at which both sexes can develop. These results confirm the observations of McCoy *et al.*, (1983) that at the higher range of temperature only females and at lower range only males were produced, although there is a difference between the critical temperatures in their work and ours. This is probably due to the fact that we have used eggs from a different population than theirs.

As said earlier, it is advantageous to produce as many males and females according to the need, in any conservation effort. Therefore, this work has far reaching implications for the conservation of the olive ridley.

The results of the beach nest showed that transportation of 24 day embryos with a well developed circulation, did not adversely affect the survival. The hatching success was 69% (72 out of 104 eggs) which is within the range of hatching percentage under laboratory and natural clutches. The time of hatching was remarkably synchronous, all hatching between 48 to 50 days. All the hatchlings were females indicating that the temperature in the beach hatchery was above the pivotal temperature. This result indicates that the concern expressed by several workers that beach hatcheries may produce hatchlings of predominantly one sex may be justified. Therefore, it is planned to examine more nests in the beach hatcheries at Gahirmatha in the coming nesting season to determine if the sex ratio of the particular nest studied holds good for others. In the meantime, it is necessary to examine the sex ratio of hatchlings in other areas in India where transplantation of nests to other hatcheries is being practiced for improving hatching success.

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SEA TURTLE BODY-ORGAN WEIGHTS : THEIR RELATIONSHIPS DURING GROWTH AND RESPONSES TO THE ENVIRONMENT

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ABSTRACT

Autopsy examination of 12 body-organ weight relationship of 56 hatchling, six month old, subadult, and adult loggerhead turtles *Caretta caretta*, from Bogue Banks, North Carolina, USA, collected in 1979, 1980, and 1981, revealed hypermegalistic growth for the liver, digestive tract, kidney, flippers, carapace, and plastron. Little change in yearly body-organ weight occurred in the remaining 'organs' studied. Statistically body-organ weight regressions were most abberant in 1980. Similarly, May-August water temperatures, a result of a prolonged heat wave in 1980, were statistically different. Supportive data suggested that the 1980 turtles had responded to and reflected poor food and ecological conditions of areas to the north of North Carolina. Pursuit of body organ weight data will contribute to the scientific data base regarding sea turtles and permit all to better protect, manage, and utilize their sea turtle resources.

INTRODUCTION

SEA turtles are considered rare, endangered or threatened animals worldwide. Attention to this plight is magnified by the fact that 87 nations of the world are signatures of the 1973 Cites Convention agreement wherein each nation pledges to protect sea turtles from poaching, importation of their meats or use in the ornament trade. In spite of these well meant intentions, decimation and human utilization of sea turtles continues almost unabatted. Such actions result in enormous numbers of carcasses left rotting on the beach, if only the eggs, meat or shell is taken by the poacher or manufacturer of ornaments. More importantly this wanton destruction of sea turtles eliminates much valuable basic biological information concerning the turtle's growth, health, and condition, aspects essential to the scientific community and the biologists, administrators or officials who are responsible for the management and welfare of sea turtles within their country's waters.

While the external physical state of a sea turtle can be noted by the presence of barnacles (Schwartz, 1960), parasites (Schwartz, 1974), body erosion from a mange-like disease or jaundice, little information exists in relation to body-organ weight relationships in sea turtles, other than carapcae length body weight. See Caldwell (1962), Hirth (1982), Frazer and Schwartz (1984) and many others in this regard. Papers by Milson (1975), Pathak and Dey (1956), Friar (1977), and Friar and Shah (1982) are the few that treat sea turtle lung, fat, red blood and serum protein data. This woeful lack of data on organ growth of turtles, whether they are sea, freshwater or land turtles, also holds true, to an even greater extent for most reptiles. This is inconsistent to the many studies on other vertebrates. I therefore report on 12 different body-organ weight relationships, determined in 1979, 1980 and 1981, following autopsies of new born, six month old hatchlings, and recently stranded freshly killed subadult and adult female loggerhead turtles *Caretta caretta*, from Bogue

Banks, North Carolina, USA. These relationships are compared with prevailing seasonal ocean water temperatures to determine if they influenced or could explain the aberrant and normal body organ weight relationships noted.

Paul Robinson, Bel Air, Maryland, reviewed early versions of the manuscript and provided helpful suggestions. Institute of Marine Sciences personnel who helped were: G. Safrti performed the autopses, J. Chapman ran the statistical analyses, V. and H. Page produced Fig. 1, and Jane Garner typed the text.

METHODS

Autopses of twenty-two (15 in 1979, 7 in 1981, none were available in 1980) 37-43 mm carapace length CL (measurement was straight line length in mm) recently hatched or sex month old dead hatchlings (50-94 mm CL) were measured with dial vernier calipers and weighted to the nearest gram (g) on a Mettler 3000 balance. Thirty subadult to adult female leggerhead turtles (150-194 mm CL) were likewise autopsied following external feature measurement or weighing on hanging or platform balances.

The heart, liver digestive tract, lungs and trachea, kidneys, fat, spleen, muscle and bone, left front flipper, right rear flipper, carapace, plastron, head and tail were dissected out, and depending on size weighed on platform or Mettler balances. The heart was cut open and flushed of any clotted blood prior to weighing. Muscle and bone weights included all flippers and internal muscles but not the attached ribs. The ribs were left intact and attached to the carapace. Flipper weights were of the entire severed flipper. This comprised the area from its proximal humeral or femoral junction with the body. Carapace and plastron weights were those devoid of all extraneous tissues, muscle and fat. Weight of the head, severed at the supraoccipital base, included the enclosed bone, muscles, eyes, and brain. The tail was that organ projecting beyond the rear of the body.

All body-organ weight relationships were best expressed by log linear regressions of $\log y = a + b \log x$, where x was body weight and y was organ weight, rather than by curvilinear or sigmoid growth curves.

The combined hatchling and larger turtle body-organ weight relationship slopes (b's) were analyzed between years by analysis of variance (ANOVA) comparisons. Similarly, organ-weight slopes (b's), following removal of the hatchling data, were compared by ANOVA's to ensure that any bias caused by the lack of hatchling data in 1980 was removed from the original comparisons. Organ data (except for fat and spleen) for 26 (1979), 16 (1980) and 12 (1981) turtles were used in the overall slope (b) comparison analyses, whereas 11 (1979), 16 (1980) and 5 (1981) turtles comprised the sample data, following removal of the hatchlings, in the revised slope ANOVA comparisons. Yearwise comparisons of ocean water temperatures were also tested by ANOVA.

Bristol thermographs continuously recorded daily and hourly water temperatures. Vagaries in the temperature data, influenced by tides, winds, currents or seasons, were average weekly (Fig. 1) and further smoothed by three week moving averages. ANOVA analyses compared between years data for the 1 May-30 August period, intervals that best reflected periods when sea turtles frequented Bogue Bank waters. Bogue Bank is situated near the middle of the North Carolina coast between 34°41'N and 76°40.5'—77°06'W.

RESULTS

The liver, digestive tract, kidney, flippers, carapace and plastron data, exhibited hypermegalistic growth. There was little change, yearly, in body size and organ weight regressions for the remaining organs (Table 1). The most drastic variations (note low correlation coefficients, Table 1) occurred in 1980 and were reflected by the heart, kidney, flippers and tail data.

Statistically (Table 1) good correlations existed (most were 0.9) for 12 body-organ relationships determined in 1979 and 1981 for the combined hatchling and larger turtles hatchling data produced similar overall and between years significances, except for 1979 *vs.* 1981 data. Again 1980 data stood out as the aberrant data.

Similar between years ANOVA analyses of the 1979, 1980, 1981 water data produced significances that pointed to an 1980 aberrant water temperature condition as well. Water temperatures in 1979 were below expected

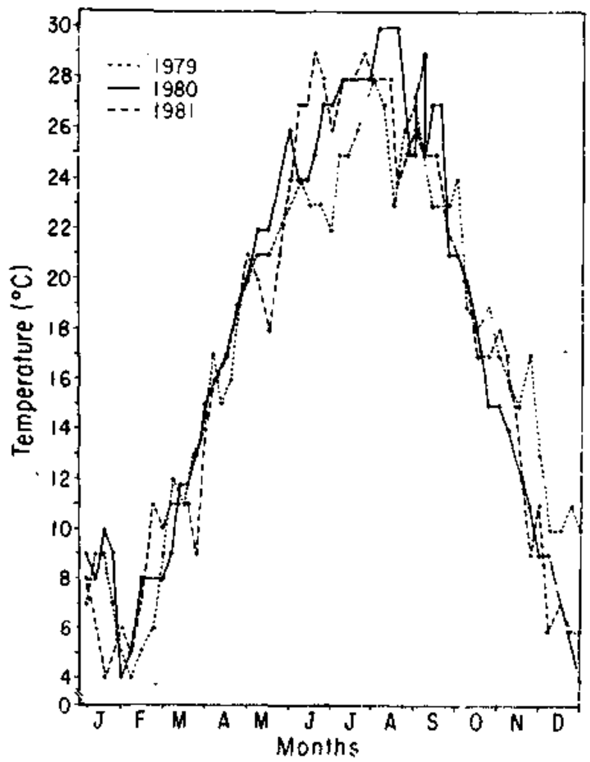

Fig. 1. Mean weekly ocean water temperature (°C) during 1979, 1980 and 1981 off Bogue Banks, North Carolina.

data. This was not the case in 1980. ANOVAs of the overall between years slopes (b's) for hatchling and larger turtle body-organ relationships were significant (Table. 2). Analyzing 1979 *vs.* 1980, 1979 *vs.* 1981 and 1980 *vs.* 1981 data separately yielded significances indicating that the 1980 data was the cause of the significances noted. Removal of the (Cooke 1979; Quayle 1979). This condition persisted into 1980. A July-August 1980 heat wave produced water temperatures of 1-2°C above normal or above 30°C for several weeks (Elms and Quayle 1980). A dense winter 1979 concentration of the dinoflagellate *Ceratium tripos* occupied the Western Atlantic Ocean from New Jersey to Cape Hatteras and

TABLE 1. *Regression intercept (a) slope (b) and correlation (r) data for recently dead or stranded young and large (combined) loggerhead turtle body-organ weight data collected in 1979, 1980 and 1981. Strandings occurred on Bogue Banks, N.C. U.S.A.*

Organ		1979 (N = 25)			1980 (N = 14)			1981 (N = 12)		
		a	b	r	a	b	r	a	b	r
Heart	..	—1.9284	0.9962	0.9921	1.1256	0.3165	0.2976	—1.7985	0.9186	0.9921
Liver	..	—1.7132	1.0884	0.9947	0.7146	0.5509	0.7923	—1.6017	1.0502	0.9995
Digestive tract	..	—1.2891	1.0622	0.9953	0.7064	0.6235	0.8069	—1.8737	1.1862	0.9981
Lungs & Trachea	..	—1.7316	1.0280	0.9983	0.4621	0.7185	0.8692	—2.0956	1.0999	0.9990
Kidneys	..	—2.2322	1.0575	0.9967	0.6390	0.4197	0.4211	—2.4561	1.0877	0.9991
Muscle & Bone	..	—0.6234	0.9827	0.9901	—0.7970	1.0648	0.7722	—0.6465	1.0234	0.9998
Lft. Front Flipper	..	—1.5614	1.0280	0.9978	2.341	0.1743	0.3029	—1.8778	1.2344	0.9908
Rt. Rear Flipper		—1.8470	1.0525	0.9974	1.4929	0.3169	0.3403	—2.0399	1.2112	0.9896
Carapace	..	—0.9316	1.0654	0.9988	—0.5659	0.9761	0.8732	—1.2243	1.1133	0.9994
Plastron	..	—1.3477	1.0769	0.9989	—0.1286	0.7981	0.9706	—1.5403	1.0875	0.9999
Head	..	—0.7048	0.9081	0.9989	0.6573	0.6007	0.8561	—0.6782	0.8947	0.9990
Tail	..	—2.0356	0.9181	0.9960	0.8916	0.3175	0.2400	—2.3070	1.0108	0.9935
Spleen*	..	—1.2615	0.1993	0.5606	—1.8535	0.8285	0.5886	—3.3889	1.1342	0.4939
Fat*	..	—3.7148	1.9949	0.6256	—1.9589	1.1315	0.7407	10.3339	—1.6566	—.4779

* Not used in ANOVA analyses

TABLE 2. *ANOVA comparisons of slopes (b's), overall and between any two year combination, for turtles collected on Bogue Banks, N.C.****

	d.f.	Sum. Square	Mean Square	f
		Overall Comparison		
Total	35	2.8527		
Year ..	2	1.8312	0.9156	30.3179**
Organ ..	11	0.3566	0.0324	1.0728 n.s.
Individuals ..	22	0.6649	0.0302	
		1979 vs. 1980		
Total ..	23	2.2073		
Year ..	1	0.9983	0.9983	36.70**
Organ ..	11	0.9756	0.0887	3.26*
Individuals ..	11	0.2991	0.0272	
		1979 vs. 1981		
Total ..	23	2.7720		
Year ..	1	0.2624	0.2624	1.2640 n.s.
Organ ..	11	0.1255	0.0114	1.000 n.s.
Individuals ..	11	2.2841	0.2076	
		1980 vs. 1981		
Total ..	23	2.9789		
Year ..	1	1.5203	1.5203	16.4892**
Organ ..	11	0.4449	0.0404	0.4382 n.s.
Individuals ..	11	1.0137	0.0922	

* — Significant 5% level
** — Significant 1% level
*** — Fat and spleen data not analyzed
n.s. — Not significant.

TABLE 3. *Regression intercepts* (a), *slopes* (b) *and correlations* (r) *for adults only loggerhead turtles collected on Bogue Banks, N. C.* 1979, 1980 and 1981.*

	1979 (N = 11)			1980 (N = 14)			1981 (N = 5)		
Organ	a	b	r	a	b	r	a	b	r
Heart ..	—2.9462	1.2253	0.6901	1.1256	0.3165	0.2976	—16.7274	4.2676	0.9703
Liver ..	—1.7523	1.0963	0.8006	0.7146	0.5509	0.7923	—4.2653	1.4679	0.8826
Digestive tract ..	—1.8259	1.1799	0.7890	0.7064	0.6235	0.8069	—5.1578	1.9233	0.6902
Lungs & Trachea ..	—0.3063	0.7123	0.7566	0.4621	0.7185	0.8692	0.5820	4.9919	0.8708
Kidney ..	—1.2257	0.8120	0.7398	0.6390	0.4197	0.4211	—1.8899	0.9608	0.5014
Muscle & Bone ..	—1.4814	1.1734	0.4889	—0.7970	1.0648	0.7722	1.5061	0.5404	0.7819
Lft. Front Flipper ..	—0.5218	0.7983	0.8742	2.2341	0.1743	0.3029	—4.5863	1.7601	0.4025
Rt. Rear Flipper ..	0.4979	0.6465	0.6780	1.4929	0.3169	0.3403	—4.7109	1.7271	0.3837
Carapace ..	0.7199	0.6165	0.9176	—0.5659	0.9761	0.8732	2.4655	0.2854	0.2422
Plastron ..	0.6580	0.5357	0.9140	—0.1286	0.7981	0.8706	—1.8087	1.1475	0.9620
Head ..	1.0113	—1.1613	0.9657	0.6573	0.6007	0.8561	2.7455	0.1265	0.1248
Tail ..	0.6479	— .8162	0.7467	0.8916	0.3175	0.2400	6.2964	—2.6030	—.8463

* See text for explanation for deletion of fat and spleen data.

persisted into the spring of 1980 (Esser *et al.* 1980). Water temperatures were nearly normal in 1981.

Discussion

Knowing the body-organ weight relationship of an animal has many useful applications. For example, changes in the relative weight of various organs, in a turtle subjected to different environmental conditions, provides insight into the general physiological state of the turtle. Variations in organ-body weights could also signal pathological responses to various external or experimental procedures (Robinson *et al.* 1960; Wilbur and Gilchrist 1965). Internal examination may even uncover information that sea turtles possess blood and organ vessel aneurysms (this study).

Most body-organ weight relationships are either hypomegalistic, where the organ grows less and less with increasing body size, or hypermegalistic, where organ growth rate is greater than the body as a whole (Robinson 1966; Robinson *et al.* 1960; Wilbur and Gilchrist 1965; Wilbur *et al.* 1961). Sea turtles autopsied in 1980 were definitely different from those examined in 1979 or 1981 (Tables 1-4). Differences in the way the 'organs' were dissected and weighed did not account for the different weights noted, for all but six of the 56 turtles studied were dissected by the same technician. Coupled with the aberrant 1980 seawater temperatures, I can only conclude that the 1980 sample turtles had been affected by the high water temperatures of 1980 or they represented turtles from else-

TABLE 4. *ANOVA comparisons of overall years and between years adult only loggerhead slope (b) body-organ weight data*

	d.f.	Sum. Square	Mean Suqare	f
		Combined years		
Total ..	35	2.8525		
Year ..	2	1.8314	0.9157	29.63**
Items	33	1.0211	0.0309	
		1979 vs. 1980		
Total ..	23	3.8750		
Year ..	1	1.2090	1.2090	9.98**
Items ..	22	2.6660	0.1212	
		1979 vs. 1981		
Total ..	23	0.1800		
Year ..	1	0.0178	0.0178	2.41 n.s.
Items ..	22	0.1622	0.0074	
		1980 vs. 1981		
Total ..	23	2.5022		
Year ..	1	1.5203	1.5203	34.1**
Item ..	22	0.9819	0.0441	

* — Significant 5% level

** — Significant 1% level

n.s. — Not signifiecant.

where, such as Gulf Stream or the north Atlantic Ocean, where drastically different food or water temperatures prevailed. High late summer water temperatures, off Bogue Banks in 1980, apparently caused an absence of the jellyfish *Stomalophus*, usual summer food for North Carolinian loggerhead turtles.

Seasonal movement and distributions along the western Atlantic United States coast confirm the conclusion that the 1980 turtles obtained from Bogue Banks were alien to those that usually frequented the area. In May 1979, most nesting and non-nesting loggerhead turtles occupied waters north of Cape Hatteras. Warming waters induced movement into southern North Carolinian waters (from Cape Lookout southward) in July and August. Conversely, in May 1980, loggerhead turtles occupied coastal waters off Bogue Banks and south of Cape Lookout, it was late June before they frequented waters north of Cape Lookout. Shoreward movements south of Cape Lookout occurred in May 1981, while areas north of Cape Lookout were not occupied until June. The late poor body-organ weight relationships (Table 1) of the 1980 Bogue Banks turtles definitely suggested that they were turtles that had spent the winter or spring of 1979-80 in food poorwaters north of North Carolina.

Thus, body-organ weight data provide us with an enhanced way of detecting what is happening to a sea turtle as it grows and frequents an area's waters. They also hint that different populations of sea turtles may occur in the sea and they visually reflect the turtles responses to varying or different environs, foods, and ecologies. I urge biologists, managers and governments to seek out such data which, in turn, will better help them manage or conserve their sea turtles resources.

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MANAGING FLORIDA SEA TURTLE POPULATIONS

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ABSTRACT

Florida, as an urbanized State with significant populations of sea turtles, has many conflicts between human uses of the coastal areas and sea turtle survival. In this paper, various impacts and techniques being used to mitigate harmful impacts are discussed.

INTRODUCTION

SINCE the time in 1956 when Robert M. Ingle, retired Director of Research for the Florida Department of Natural Resources' predecessor agency recognized the potential value of giving hatchling sea turtles a 'head start' by raising them in captivity until they were large enough to avoid most hatchling predators, the department has developed an increasingly strong research and management program. Presently, the program is actively supported by Dr. Elton J. Gissendanner, Exceutive Director and his administrative and research staff. The co-operation provided by the federal agencies, the National Marine Fisheries Service and the Fish and Wildlife Service, is essential to the success of our work. The many individuals and organizations who contribute so significantly to the success of the State's program are greatfully acknowledged anonymously. Space limitations make it impossible to list them all.

The State of Florida has approximately 800 miles (Anon., 1971) of sandy beaches that are suitable for sea turtle nesting. More than eighty per cent of Florida's population lives in coastal countries (Morris, 1983). There is a substantial amount of residential, commercial and recreational usage of beaches which results in varying degress of adverse impact upon nesting turtles and their hatchlings. To assure the greatest degrees of survival for the state's sea turtles,mitigative measures are adapted to meet particular conditions on various sections of the beaches.

While the most apparent problems are associated with beaches, the state's more than 8,000 miles of coastal and lagunal waters (Cooke, 1983) have substantial populations of juvenile, sub-adult and adult turtles that are adversely affected by such things as industrial water intakes, propellers of high speed boats, oil spills and, possibly, artificial means of altering the marine environment.

DISCUSSION

One very obvious alteration associated with coastal development is the ubiquitous use of artificial lighting. Such lighting lengthens the number of hours that lighted areas may be used for human activities. In addition, some law enforcement agencies believe that the lights are a deterrant to crime. The lights range from single bulb fixtures to installations having multiple high intensity flood lights.

Both humans and nature litter the beaches. Nature provides the flotsam of biological material—mostly seaweeds, and humans provide an almost indescribably varied supply of jetsam. While humans are responsible for the trash of glass, plastic, metal, paper containers and spilled chemicals, another segment of the human population desires that the beaches be cleaned regularly of the flotsam and jetsam so that they are not offended by its presence during their time on a beach. Beach cleaning may be done by hand, but, most often it is done by heavy tractors equipped with rakes.

Over the years, much residential, commercial and recreational development has occurred in the coastal zone of the state. In earlier days little concern was shown for the possible deleterious effects of beach dune destruction. In some cases highways were built where they resulted in dune damage. In other cases, residential, recreational or commercial development destroyed the dunes in order to have 'better' access to the beach. With the inevitable beach erosion (Anon., 1971), upland property owners' concern for the possible loss of buildings has led to various efforts to 'stabilize' beaches. Seawalls, revetments of concrete, rocks and plastic bags, groins and plastic seaweed have been tried to halt erosion. Most such installations have failed outright, or have not yet proven to successfully control erosion. In any event, hard structures on beaches limit accessibility by humans. In recent years there has been an increasing interest in restoring beaches by 'renourishment'. Renourishment of beaches involves rebuilding them with sand obtained from offsite.

There are indications that, at times, foot traffic of humans and other animals (Monn, 1977) can be harmful to sea turtle nests. Since the female turtle firmly packs the beach sand on the top of the newly laid nest, it is unlikely that foot traffic will cause any harm to such a nest. However, the emerging hatchlings become particularly vulnerable as they are working their way toward the sand surface. At that time, a single unfortunate footstep may collapse the loosened sand and crush the hatchlings.

Americans have a fascination with motor vehicles and significant numbers of drivers like the off-the-road vehicles for recreation. These come in various styles, from light weight, large tired, aircooled engine powered tricycles to heavy, diesel powered, four wheel drive trucks. While the light weight vehicles may not be harmful, the heavier vehicles do dig deep ruts, which may act as traps for seaward bound hatchlings, and could collapse the sand into nests of emerging hatchlings. Heavy beach cleaning equipment creates the same negative impact.

Florida has some industrial plants, mainly electrical generating facilities, that take seawater from the ocean or lagoons to cool their steam generators. While the facilities in lagoons only occasionally entrap a sea turtle, one large nuclear generating plant, with an intake in the ocean, regularly entrains significant numbers of turtles. Since the generating plant started operation in 1976, over 900 turtles have been removed from its intake canal (Wilcox, 1984). While most of the turtles have been loggerhead *Caretta caretta*, green turtle, *Chelonia mydas*, and leatherback *Dermochelys coriacea*, Kemp's ridley *Lepidochelys kepmi* also have been removed from the system. It is believed that all of the species except *D. coriacea* attempt to use the ocean intake structure, with its large water control fixtures, as a reef for resting. When these turtles attempt to rest under the velocity caps of the intake system, they are entrained in the intake water and delivered into the large cooling canal. The *D. coriacea* are believed to be feeding on jellyfish when they become entrapped in the water intake.

Maintenance dredging of shipping channels is done by either U. S. Army Corps of Engineers owned or contracted hopper type dredges. Hopper dredges are designed to suck silt and sand from channel bottoms by means of huge dredgehead intakes. These intakes, under some conditions, appear to trap sea turtles. For several years the Corps of Engineers has had a Dredging/Sea Turtle Task Force studying means of reducing, or eliminating harm to sea turtles from such dredging operations.

While sea turtles are from time time caught by hook and line fishermen, commercial netting operations catch considerable numbers of turtles. The main source of concern in Florida is with shrimp trawling. At times, particularly at the beginning of the nesting season, turtles appear to concentrate in waters where shrimp are found. Turtles may be attracted there either by food resources naturally available to them, or, some think by the shrimpers discarded by-catch (Shoup and Ruckdeschil, 1982).

Since much shrimping is done in waters adjacent to heavily populated areas, people are rightly concerned with the numbers of either dead or injured sea turtles washing up on their beaches. The U. S. Department of Commerce's National Marine Fisheries Service is the lead organization for developing the technology needed to reduce the incidental catch of sea turtles in shrimp trawls (Ogren *et al.*, 1977).

In recent years it has become apparent that oil in the marine environment causes harm to small sea turtles (Witham, 1978; Witham, 1983). The extent of this problem is not yet fully understood but, since the so called ' lost year ' (Carr, 1956) class of turtles is the one being found after having become involved with either tar or oil, the impact could be considerable. Impacts of petroleum on sea turtles cross species lines. To date, *Caretta caretta, Chelonia mydas, Eretmochelys imbricata,* and *Lepidochelys kempi* have been found either dead or comotose after apparently having tried to ingest floating tar.

Florida has more than 500,000 motorboats using coastal and lagoonal waters (Anon., 1983). Some of these are capable of very high speeds and, from time to time, one of these boats strikes a sea turtle. These encounters are usually fatal for the turtle. If not killed outright, most do not survive rehabilitation attempts.

Florida sea turtles are protected by both state and federal laws. One state law, Florida Statutes 370.12 provides equal protection for all species, while another, Florida Statutes 372.072, says that the federal classifications may be used for Florida's endangered and threatened species. The Federal Endangered Species Act of 1973 has provisions for categorizing the species as either threatened or endangered (Public Law 93-205). Simply stated the difference between threatened and endangered is that a threatened species may become endangered and possibly extinct in the forseeable future. In the U. S., threatened loggerheads may be taken incidentally during fishing, but they must be returned to the sea, unharmed if possible. Technically, it is illegal to capture, and therefore harass or handle an endangered species, including sea turtles, by any means, whether incidentally or not.

Population estimates for sea turtles are difficult to make. They are usually based upon nesting surveys (*e.g.*, Carr *et al.*, 1982; Ehrhart, 1980), because no satisfactory method for estimating oceanic populations exists. Annual fluctuations in nesting populations can confuse even long term nesting surveys (Carr *et al.*, 1982), resulting in misleading assumptions regarding a populations status. While present methods of determining the need for federal listing of the various species rely upon population estimates it is suggested that it would be better to develop a human caused STRESS INDEX. Such an index could well be based on the species Step Down Plans from the U.S. Fish and Wildlife/National Marine Fisheries Service Marine Turtle Recovery Plan (Hopkins and Richards, eds., in press). The Step Down

Plans list mitigative measures need to increase sea turtle populations.

Management and Mitigation Techniques

The control of coastal artificial lighting, while seeming to be only a matter of turning off offending lights, involves considerable diplomacy in negotiating with property owners. It is often claimed that such lights are needed for security reasons so that intruders may be readily seen. This claim is made even when the lights are turned off about 0100 Hrs. It is more likely that the lights allow residents to have an attractive view of the ocean at night and that most of them retire for the night before the lights are turned off.

Since most of Florida's sea turtle hatchlings emerge at night, hatchling disorientation is a significant problem. While studies have not been made, it is believed that most hatchling emergence occurs after midnight due to the time required for temperatures to drop to appropriate levels (Hendrickson, 1958).

Ideally, offending lights should be turned off during the nesting and hatching season, which in Florida extends from about the first of May to the end of October. Alternatively, such lights should not be on after 2200 Hrs. Most property owners, after learning of the difficulties caused to turtles by their lights, gladly cooperate by extinguishing their lights. Some people are reluctant to comply with requests that they protect the turtles. There are differing opinions regarding the applicability of current federal and state regulations to the protection of sea turtle hatchlings from light disorientation. A legal test case would be required to make such determination.

While Americans dispose of large amounts of litter, most are offended by its presence in recreational areas. Efforts are being made to develop techniques for removing beach litter without harming turtle nests. One preliminary study, nearing completion, is designed to test the effects of light weight mechnical equipment. This study also assumes that biodegradable material is a desirable, normal component of beach ecology, and such material is not being removed from the beach area. It is placed in the vegetation area and time will tell if it benefits or harms the vegetation. Since, prior to man's intervention, such material was not removed from beaches, it might be assumed that any adverse effects would result from the particular method of placement of the material up into vegetation area beyond the wrack line.

Efforts of upland property owners to protect their properties are governed by Florida Statutes, Chapter 161. This law evolved from earlier attempts to prevent beach front construction that would endanger coastal dunes.

Beach renourishment, while very expensive, is probably the most desirable method, as regards to sea turtles, for protecting upland property. In some cases, material used for renourishment may be initially unsuitable for sea turtle nesting. However, the U. S. Army Corps of Engineers and the Florida Department of Natural Resources are making efforts to determine the desired characteristics of nesting sand and sources of suitable renourishment material.

Presently, the most frequently used method of beach renourishment is hydraulic placement of sand from nearshore borrow areas. Some renourishment has been done by trucking sand from relatively near-by sources, and considerable thought is being given to importing sand from the Bahamas. The Bahamian sand is being evaluated for its suitability for sea turtle nesting.

Artificial seaweeds, which attempt to control beach erosion by attenuating wave force (Ahrens, 1976), need to be evaluated for possible adverse impact on sea turtles either by ingestion or entanglement.

Some Florida beaches have such concentrations of human that relocating eggs to protected incubation areas or protecting the nests *in situ* is necessary (Pritchard *et al.*, 1983). The City of Boca Raton protects most nests *in situ* by placing wire cages over them. This requires the services of an employee who makes early morning checks of the beach to record and protect new nests. In unlighted parts of the beach, nest cages have openings on their seaward sides to permit hatchlings to move naturally to the sea. Cages in areas having artificial lighting have no openings and the turtle protection employee removes all hatchlings found each morning. On other beaches, nests may be relocated to protected sites on the beach or they may be removed for container incubation in shelters or buildings. In some cases, protection can be provided by indicating the nest location with an appropriate device—usually a stick. Areas having heavy foot traffic, usually are cleaned by mechanical equipment ; providing a double incentive for nest protection. Properly handled, nest relocation does not reduce hatch success (Anon., 1983) but there is an unsettled debate regarding the possible effects of the various incubation temperatures on hatchling sex ratios (Mrosovosky, 1983 ; Wood and Wood, 1982 ; Witham, *in press*).

Off road motor vehicles, particularly the heavy ones, are capable of digging deeply enough into the sand to destroy nests. Even if nests are not harmed, deep ruts may act as traps for seaward bound hatchlings. Nesting surveyors, who have to travel over many miles of beach, rely upon light weight, usually three wheeled vehicles, while such vehicles have been used in many areas for a number of years, there is no evidence of nest damage. The possibility of nest damage from these vehicles exists if they are used in a reckless manner. The apparent lack of nest damage resulting from the use of light weight vehicles has led to a study to determine if their use for beach cleaning would, or would not harm nests.

Of the coastal electrical generating facilities, the Florida Power & Light Company's St. Lucie Plant is the only one located on a major nesting beach. Cooling water for the two generating plants is drawn into a large canal through several large diameter pipes that extend more than 1,000 feet offshore. Water flow into the pipes is controlled by horizontal 'velocity caps' over the vertical openings of the pipes. Since the first plant became operational in 1976, more than 900 sea turtles of five species have been entrained in the system. Most of the turtles have been *Caretta caretta* (Wilcox, 1984).

Entrained turtles are caught in turtle nets and, if healthy, they are tagged and released. Some turtles are apparently in poor condition when they become entrained and die before they can be released. It is possible that a small percentage of turtles die from trauma resulting from entrainment and capture.

The Florida Power & Light Company, in co-operation with the Florida Department of Natural Resources and the National Marine Fisheries Service, has been studying techniques for preventing turtles from entering the intake system. While two methods have shown promise under laboratory conditions, no method appears to be feasible for installation at the offshore intakes (Wilcox, 1984). The company has requested permission to continue, for the operational life of the plant, the present method of capture and release. It has been suggested that the company establish an on site facility for rehabilitating sick or injured sea turtles.

Maintenance dredging of shipping channels by hopper dredges results in the deaths of some turtles. The U. S. Army Corps of Engineers established, in 1981, a Sea Turtle/Dredging Task Force to study the problem and propose methods of reducing or eliminating the incidental capture of turtles by such dredges. The Task Force is composed of representatives from the Corps of Engineers, the National Marine Fisheries Service, the U. S. Fish and Wildlife Service, the U. S. Navy, and the Florida Department of Natural Resources. During its most recent meeting, the Task Force recommended that the Corps of Engineers evaluate two of Florida Power & Light's turtle exclusion techniques. one method involves electrical current to repulse turtles and the other method uses sound to frighten the turtles away from an area (Wilcox, 1984).

There is a significant correlation between shrimp trawling and turtle stranding (Hillestad *et al.*, 1978). To reduce the harm caused by incidental capture of turtles in shrimp trawls, the National Marine Fisheries Service has developed a device known by the acronym TED. This Trawling Efficiency Device, is more than 90% effective in reducing the incidental take of sea turtles in shrimp trawls (Anon., 1983). Some resistance to its use results from the perception that it is hazardous because of its weight and size. The NMFS is continuing developmental work and is trying to design a lighter and smaller TED.

Hook and line fishing results in a limited number of turtles being injured. Some of these turtles need only an external hook removed, while others have been hooked in the throat or have had fishing line wrapped around a flipper. A turtle struggling to rid itself of monofilament line wrapped around a flipper can nearly sever the flipper. Sport fishermen are trying to enhance their catches by putting fish attracting devices (FADS) in the sea (Foat, 1984). These devices, sometimes made of plastic, need to be evaluated to determine if they pose a threat to sea turtles. Turtles may attempt to eat the plastic or they become entangled in parts of the devices.

Witham (1978) reported the first evidence of harm to small sea turtles from petroleum residue at sea. Since that time, published (Witham, 1978 ; Witham, 1983) and unpublished data have reported that *Caretta caretta, Chelonia mydas, Eretmochelys imbricata* and *Lepidochelys kempi* have been adversely impacted by such pollutants. Preliminary observations suggest that the mouths of small turtles trying to ingest floating tar are sealed by the tar. Fortunately, these turtles do not die rapidly, and a number have been rescued and rehabilitated. In an effort to determine the physiological and behaviorial responses of small sea turtles to petroleum residues, the Minerals Management Service of the U. S. Department of the Interior has contracted with the Florida Institute of Oceanography to study the problem.

Since sea turtles are so widely dispersed at sea and in lagoonal waters, it is not feasible to warn boaters of their presence as is the case for aggregating manatees *Trichechus manatus*. A few turtles with propeller injuries to their carapaces have been rehabilitated by veterinarians. These have been ones whose wounds did not sever the spinal cord or inflict deep internal cuts. The usual procedure has been to treat them with antibiotics and repair the carapace with epoxy resin.

The author believes that current laws are adequate to protect the State's sea turtle populations, but public awareness and interest in saving the animals plays a major role in their continuing survival. Public awareness has resulted in the inclusion of a sea turtle management section in a State growth management plan for Hutchinson Island (Cassens, 1983). This section developed from an agreement made with one ocean front builder.

It is not the intention of the author to propose a fixed set of guidelines for establishing a human caused stress index, but to suggest that the idea be given consideration by both governmental and non-governmental conservation organizations. The index could be based upon such things as the number of hatchlings successfully entering the sea, probable losses of turtles, both young and older, to pollutants, garbage at sea, losses resulting from incidental capture during activities directed at other species, and poaching. Since there is no legal take of turtles in Florida and the United States, this item is not suggested for a Florida stress index.

For species whose populations are considered to be greatly endangered, the 'head start' approach appears to be a viable concept (Witham and Futch, 1977; Witham, 1980; Dodd, 1982; Klima and McVey, 1981). The major argument against head starting is that some consider the technology to be experimental (Mrosovosky, 1984). However, Carr and Sweat (1969) reported that head starting green sea turtles was '. . . . of importance . . . . to the campaign to preserve the waining species . . . .'

While, in its strictest sense, the method may by considered to be experimental, prudence suggests that it is better to have a head start program; rather than to let a population continue to decline without using this technology.

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RESEARCH AND CONSERVATION OF MARINE TURTLES ALONG THE KARACHI COAST

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ABSTRACT

Green turtle (*Chelonia mydas*) and olive ridley (*Lepidochelys olivacea*) have been investigated nesting on the beaches of Hawkesbay and Sandspit, Karachi. These beaches are included among the major eleven nesting beaches of turtles in the world. Turtle eggs and their hatchlings have been protected from poachers and predators. From October 1979 to December 1984, 570044 eggs have been transplanted in the protected enclosure to save them from feral dogs and poachers on the open beaches. 175722 turtle hatchlings (146933 hatchlings from the enclosures and 28789 from the open beach) have been released into the sea. Surveys were conducted along the coast to estimate population density and to study the nesting and hatching season, incubation period, size, colour, feeding and tagging. Besides conservation and research, education of the masses is also given a considerable importance.

INTRODUCTION

IN 1966, on the invitation of the Government of Pakistan, the World Wildlife Fund sent a team of experts led by Guy Mountfort, to survey the Wildlife Habitats of Pakistan, with a view to drafting a Conservation strategy.

Among the recommendations submitted was one to set up a Wildlife Enquiry Committee to consider the various questions relating to conservation with particular reference to endangered species, their conservation and administrative arrangements. The Wildlife Enquiry Committee in their Report of 1970 listed Sea Turtles (of the Genera *Chelonia, Dermochelys, Caretta* and *Eretmochelys*) as endangered species and in need of protection.

Province of Sind was the pioneer for implementing these recommendations and promulgated Sind Wildlife Protection Ordinance in 1972. According to this ordinance all marine turtles are protected animals and it is illegal to exploit their eggs and hatchlings or to harass them (commercially or otherwise). Immediate protective measures have been taken by Sind Wildlife Management Board at Hawkesbay and Sandspit. In the past, no research work on sea turtles was carried out on these beaches and the relevant information was only available in few papers (Minton 1966, Salm, R. 1976) where brief references to their presence in offshore waters and along the beaches was recorded. In 1980, a three year conservation-cum-research project was started by Sind Wildlife Management Board, in collaboration of WWF (World Wildlife Fund), IUCN (International Union for the Conservation of Nature and Natural Resources and WWFP (World Wildlife Fund Pakistan) at Howkesbay and Sandspit, which has now been extended for further five years *i.e.* upto 1988 by the Government of Sind.

MATERIAL AND METHOD

For transplantation of eggs from the natural nest on the open beach, five enclosures have been constructed along the beach. Each enclosure is fenced by electrically weldmesh galvanised iron (1000 × 50 mm × 8 swg) covering an area of 80′ × 80′. The capacity of each enclosure is 300 nests, which are also made of weldmesh galvanised material. Each nest is 2½ ft. long with 2 ft. circumference. Plastic number plates are used to number the nests.

The carapace length and breadth of green turtle and Olive Ridely adults and hatchlings were measured. Both straight line measurements using a caliper and over the curve measurements using a flexible tape were taken. Weight was taken by suspending the specimen below a spring balance.

Tagging is being carried out for both the species by Monel metal tags (National Band and tag Company size 19). Tags are applied on the trailing edge of one or both the front flippers usually when the female just finishes laying and occasionally when returning to the sea without nesting.

Temperature within the clutch of incubating eggs has also been taken by thermistor thermometer. Temperatures are recorded by the probes buried within the nests.

The enhatched eggs examined by digging the old nests and opening each egg and counting the broken shells. All the rotten eggs and debris are removed from nest during excavation and the nest is left open to the sun and wind to use for nest time.

Nesting and Hatching Season

Green turtle and olive ridley visit the beaches of Hawkesbay and Sandspit, Karachi (Lat. 24° 48N, Long. 66° 58E) for nesting. The most suitable stretches of beach on Hawkesbay and Sandspit, as indicated by the greatest number of tracks and body pits are the areas where the protected enclosures have been constructed (see map). But turtles nest along the entire 20 km of beach as Sandspit runs in Hawkesbay. These sandy beaches are free of rocks and stones. Beyond Hawkesbay, there are rocky inlets and sandy coves.

The results of transplanted nests hatched and average incubation period over the five year period are summarised for each species in the figures (1-6) for both the species separately.

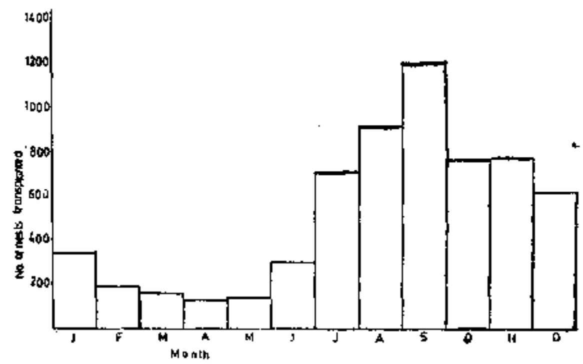

Fig. 1. *Chelonia mydas*. Nesting Frequency throughout the year with peak in September.

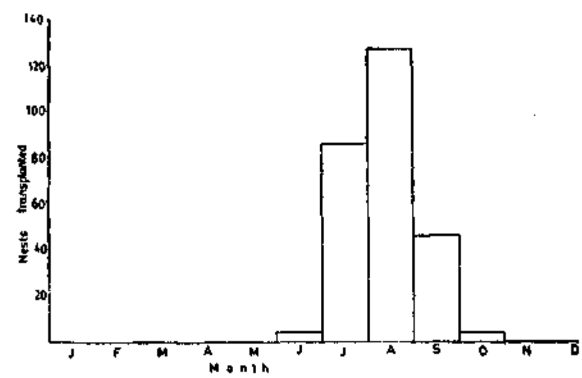

Fig. 2. *Lepidochelys olivacea*. Frequency of nesting during different months of the year, with peak during August.

Green turtle's nesting and hatching take place throughout the year. The peak nesting is reached in the month of September (Fig. 1) while peak hatching is reached in the month of October (Fig. 3). The data is obtained from the nests transplanted and hatched in the protected enclosures. Average incubation period in peak nesting season is 52 days while it ranged from 50-101 days throughout the five year period (Fig. 5).

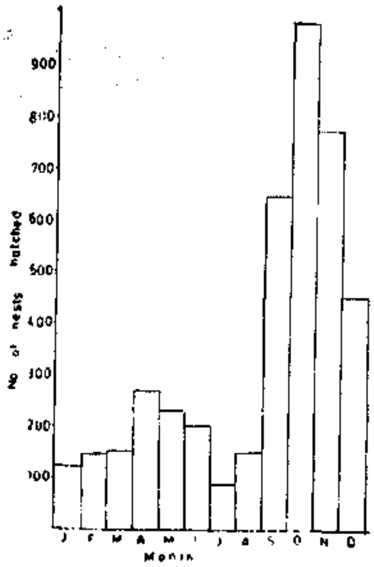

Fig. 3. *Chelonia mydas*, showing peak hatching during October.

Olive ridley shows a limited nesting season every year from June to October. But the peak nesting is observed in the month of August (Fig. 2) while peak hatching is in September (Fig. 4). Nesting coincides with the monsoon period. Although the total number of olive ridleys observed is lower than the green turtles, no arribada of olive ridleys have been observed. Average incubation period in the peak nesting season is 50 days while it ranged from 48-61 days throughout the five year period (Fig. 6).

Size and Weight

The sizes and weight of adults, subadults juveniles and hatchlings of green and olive ridley turtles are summarised in the Table 1. All sizes and weights of adults refer to females because no live adult male has so far been found on the beach. However, one or two dead males have been found on the beach,

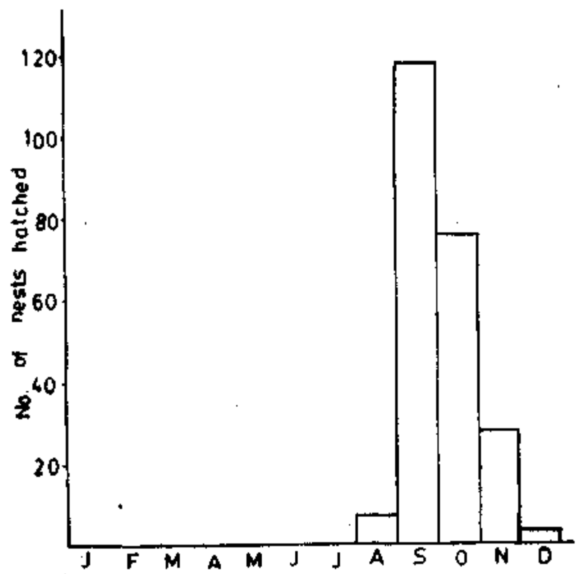

Fig. 4. *Lepidochelys olivacea*—Hatching during different months with peak in September.

but in such a decomposed condition that it is impossible to make accurate measurements.

Green turtles with over the carapace length of less than 80 cm have been found laying. The mean carapace length for egg laying green turtle is found to be 100 cm over the curve (O.C.) while for olive ridley, it is 70 cm over the curve (O.C.) Table 2.

The olive ridley has a dark almost black carapace with a chalky white plastron. The hatchlings are grey on carapace and plastron.

Food and Feeding

Wave washed dead turtles on the shore have been dissected to examine the stomach content for observing the food items. Seaweeds along

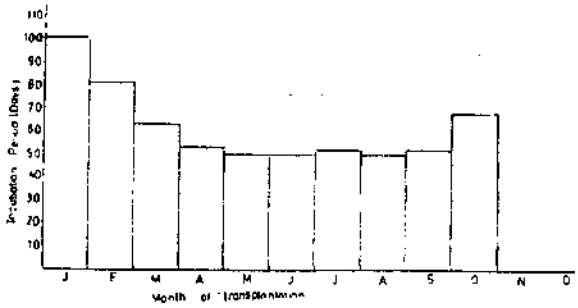

Fig. 5. *Chelonia mydas*—Incubation period ranging from 50-101 days. Average for five years.

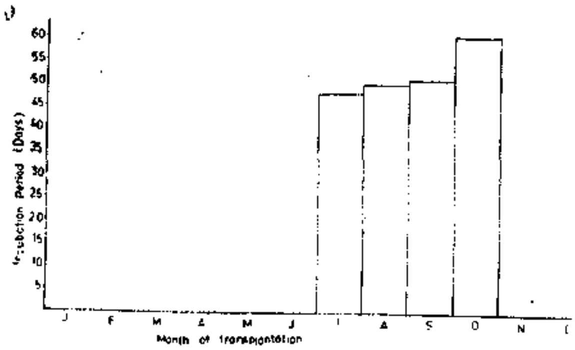

Fig. 6. *Lepidochelys olivacea.* Incubation period ranging from 48-61 days. Average for five years.

Colour

The carapace of adult green turtle has been found to be dark green with occasional blotches of olive dark brown. The Plastron is usually creamy yellowish white. Juvenile, subadult and hatchlings have light green shade on the carapace and white plastron. Once, an (albino) white green turtle hatchling was also found.

rocky coasts wave washed up on sandy beach have also been collected and identified. List of food content from gut of a dissected dead green turtle is as follows :

1. Phytoplankton, (Dinophysis, Centroceros).
2. Helminthes (only developmental stages of some species).

TABLE 1

GREEN TURTLE (*Chelonia mydas*)

SIZE :

	Length (cm) Average	Length (cm) Range	Breadth (cm) Average	Breadth (cm) Range
Adult (O.C.) ..	99.95	85.00-122.50	87.22	80.00-106.00
Adult (S.L.) ..	92.99	63.00-107.50	71.80	54.00-97.50
Juvenile (O.C.) & Sub-Adults ..	38.12	32.00-56.25	34.00	29.00-48.00
Hatching (O.C.) ..	5.75	4.50-6.50	4.94	4.00-5.70
Egg (Circumference) ..	15.22	13.00-16.50		
(Diameter) ..	4.84	4.14-5.25		

WEIGHT : (kg)

	Average	Range
Adult ..	117.90	83.25-135.00
Juvenile ..	3.00	—
Hatchling ..	0.027	0.018-0.031
Egg ..	0.053	0.034-0.070

O.C. = 'Over the Curve' i.e. All measurements taken over the curved carapace using a tape measure.

S.L. = 'Straight Line' i.e. All measurements taken over the curved carapace using a caliper.

TABLE 2

OLIVE RIDLEY (*Lepidochelys olivacea*)

SIZE :

	Length (cm) Average	Length (cm) Range	Breadth (cm) Average	Breadth (cm) Range
Adult (O.C.) ..	69.70	52.50-80.00	70.20	55.00-82.50
Audlt (S.L.) ..	65.00	60.00-70.00	63.50	60.00-67.00
Hatchlings (O.C.) ..	4,20	4.00-4.40	4.00	3.90-4.20
Egg (Circumference) ..	12.90	12.50-13.00		
(Diameter) ..	4.10	3.98-4.14		

WEIGHT : (kg)

	Average	Range
Hatchling ..	0.016	0.015-0.017
Egg ..	0.036	0.030-0.040

O.C. = 'Over the Curve' i.e. All measurements taken over the curved carapace using a tape measure.

S.L. = 'Straight Line' i.e. All measurements taken over the curved carapace using a caliper.

3. Molluscan shells (broken pieces).
4. Crabs (broken pieces).
5. Seaweed.
6. Turtle food found on rocky caves and beaches of Hawkesbay and Sandspit.
   (1) Caulerpa (Green algae).
   (2) Sargassum (Brown algae).
   (3) Gracillaria (Red algae).
   (4) Gelidium (Red algae).
   (5) Crustacea.
   (6) Jelly Fish.
   (7) Molluscsa.

The grazing of green turtle on the seaweed has been seen off the rock at Boleji and Paradise Point. It indicates that suitable feeding grounds exist along our shore line and that the green turtle population is certainly a resident one.

Nesting Behaviour

Female turtle emerges at night to lay eggs. Green turtle make a body pit of about 30-60 cm and an egg pit of 45 cm, while in contrast, an olive ridley makes a 15 cm deep body pit and 40 cm deep egg pit. The depth of egg pit is equal to the length of rear flipper. During laying the turtle breathes heavily, sheds tears and raises her head with a great sigh. Many nesting attempts are not successful due to various factors such as disturbance on the beach, presence of dogs and cement blocks along the sandy shore. Sometimes, the nesting site is unsuitable due to wrong particle size. The extremes of temperature also affect the nesting.

Green turtle is also observed making complete nest and filling it with the sand without laying a single egg, it may be a false nesting or the eggs are not ready to be laid. The time taken for complete nesting and laying by green turtle is about 2-3 hrs. and for olive ridley, it is 1½-2 hrs.

Olive ridley returns to sea more quickly than greens after laying, indicating its less tedious laying process which gives it greater energy to move.

Eggs

Eggs of green turtle are white, rounded, leathery, dropped into the nest hole singly or in group of two or three. The actual process of laying takes around 15 minutes.

Eggs weigh an average of 53 gms (range 34 gms-70 gms) each and have an average diameter of 48 mm (range 41.4-52.5 mm) Table I. Most of the eggs are soft and flexible without breaking. However, sometimes dumbell shaped or oval eggs without yolk have also been observed in a clutch of eggs. Average number of eggs per clutch observed for green turtle over the five year period is 88 (range 9-173).

Olive ridley eggs are similar in appearance to those of the green turtle, but smaller and lighter. Eggs weigh an average of about 36 gms (range 30-40 gms), and have an average diameter of 41 mm (range 39.8-41.4 mm) Table 2. Laying takes place rapidly as compared to the green turtle. The average number of eggs per clutch was found to be 116 (range 60-186).

Incubation Temperature

Temperature is the most important factor affecting the development of embryo within the egg. Higher ambient temperature decreases the incubation period and vice versa.

Ambient temperature also effects the nest temperature. A few temperature recordings have been taken by thermistor thermometer but there is not enough data to conclude the effect of intranest or sand temperature on hatchlings at Hawkesbay and Sandspit. An incubation temperature profile showing selected readings from a clutch of green turtle eggs in the enclosure is presented in Table 3. The intranest incubation temperature follows the same pattern reported by other workers (Limpus *et al.* 1983) where the optimum temperature range for good hatching is 25°C-32°C. At lower temperature (25°C) male hatchlings result, at high temperature (30-32°C) female hatchlings. Intermediate temperature (27.5°C) produce a mixed sex ratio.

TABLE 3. *Incubation Temperature Profile of a Clutch of Green Turtle Eggs within the Enclosure* (October, 1981)

Day	*Ambient Temperature (°C)*	*Intra-clutch Temperature (°C)*
0	29.00	28.00
1	29.00	32.00
7	29.00	33.00
12 (noon)	35.00	29.50
12 (midnight)	29.00	30.00
13	30.00	30.00
21	31.00	29.00
25	30.00	28.00
32	30.50	29.00
54	29.00	27.00
61	30.00	24.50 (Hatching and Emergence)

HATCHLINGS

After 40-60 days of incubation the mobile activity of hatchlings inside the nest forms a crater like depression on the surface which indicates the emergence of hatchlings is about to occur. Hatching occurs at night and hatchlings naturally escape from the bird predators (Gulls & Crows).

Hatchlings which emerge from the transplanted nests in the protected enclosures, are collected, identified, counted, measured, weighed and checked for deformities. They are then carried to the waves on firm sand and released. All the hatchlings head towards the light in normally undisturbed circumstances, but when there is light thrown by the visiting picnickers to the beach they are oriented towards the light and lose their way towards the sea, instead they crawl away from the sea. Therefore, when the hatchlings are released, light is thrown on the hatchlings by standing with torch in the sea. In this way, all the hatchlings are released safely without any loss. Green turtle hatchlings have been found to have an average carapace length of 57.5 mm (range 45-65 mm) and an average width of 49.4 mm (range 40-57 mm), with an average weight of 27 gms (range 18-31 gms) Table 1. Olive ridley hatchlings have an average carapace length of 42 mm (range 40-44 mm) and width of 40 mm (range 39-42 mm) with an average weight of 16 gms (range 15-17 gms) Table 2. The hatchlings if unaffected by cold, rains or high tides are active, and quite healthy and normal. Those hatchlings from the nests affected by any of the above mentioned factors are usually weak, sluggish, deformed and abnormal. The abnormal and weak hatchlings have also been observed during the digging of old nests from which no more hatching is expected. Sometimes, one or two quite active and normal hatchlings are also collected during the digging of old nests. They did not emerge themselves because it would be too difficult for a single hatchling to burrow through the sand above. It is also evident from the collection of dead hatchlings only few inches below the surface, with completely diminished yolk sac on the plastron. Sometimes, abnormally curved live hatchlings with inwardly indented plastron have also been observed when unhatched rotten eggs are examined.

Total eggs transplanted and total hatchlings released over the period from October 1979 to December 1984, is shown in Fig. 4A & 5A & 4B, 5B for green and ridley respectively.

From October 1979 to December 1984, 137974 hatchlings of green turtle from 539096 transplanted eggs and 8959 hatchlings of Olive Ridley from 30948 transplanted eggs have been released from the protected enclosure to the sea, in addition 28789 hatchlings were collected from the open beach and also released to sea.

For the green turtle the overall hatch rate for the five year is 30%. It is highest during September, 46% *i.e.* post monsoon when nests are not swamped and drowned by high tides and hatch before winter rains and cold temperature destroy them. The lowest hatch rate is observed in transplants of December when hatching takes place in January, February and March, the coldest months of the year.

A great variation has been observed in the individual nests where the highest hatch rate 99% and lowest 0.7% have been observed. The natural nests on the open beach when not transplanted into the enclosures and if they are undisturbed by the predators, show the similar percentage hatch rate as the protected nests.

For olive ridley the overall hatch rate for the five year period is 29%. Eggs transferred in September show the highest hatch rate *i.e.* 39%, while eggs transferred in July show the lowest hatch rate *i.e.* 13%. Individual nests showing hatch rate a maximum of 96% and minimum of 1%. These figures can be compared with those obtained by Cornelius *et al* (1983) in which a hatch rate between 0.2%-1.2% were obtained in natural conditions for olive ridley.

TAGGING

Between August 1981 to December 1984, 247 marine turtles have been tagged, while nesting on the beaches of Hawkesbay and Sandspit. These include 239 green turtle (*Chelonia mydas*) and 8 olive ridley (*Lepidochelys olivacea*). Tags being used are monel tags, (corrosion resistant alloy of nickel, copper, iron and manganese) attached to the trailing edge of front flipper (sometimes on both) near its base. It is stamped with tag number on one side and return address to Sind Wildlife Management Board, Karachi, on the other side. A tag weighs 5.5 gms and is about 4 cm long when attached. 47 turtles have been recovered from the local waters. Of these 36 Female green turtles are recovered from Hawkesbay and Sandspit for nesting a second time with an interval of about 2 hrs. to 78 days. Out of these, 19 turtles lay for the first time, when initially tagged, 21 for the second time and 12 for both the times.

Number of turtles alongwith their recoveries II, III, IV & V times with interval and the number of terms the eggs are laid is shown in Table 4. The most common intervals between nestings were 15-90 days. The greatest interval between first and last sightings of turtle at Hawkesbay and Sandspit is 130 days.

During 3 years of tagging no tagged turtle have been recoverd or reported away from the waters off Pakistan. 106 green turtles have made an unsuccessful nest attempt.

Olive ridley population in the same region is smaller than the green turtle and tagging work is still continuing on it. Fishermen may not report tags because it is illegal to capture turtles in Pakistan.

Short distance recoveries indicate that green turtle has a resident breeding population as no recovery was reported away from the local nesting ground.

Tags may be lost within the sea either by the misapplication or by the corrosion in varying degrees, therefore the recovery data even from the local waters is not enough to conclude the results.

TABLE 4. *Tagging Results from August* 1981—*December* 1984. *Total Number of Turtles Tagged*—247 (Green=239, Ridley=8) *Number of Turtles Recovered at the Beaches of Hawkesbay & Sandspit*

IInd Time Recovery

No. of Turtles came	Interval	No. of times Eggs Laid		
		I	II	Both times
36	2 hrs.-78	19	21	12

IIIrd Time Recovery

No. of Turtles came	Interval	No. of times Eggs Laid			
		I	II	III	All three times
5	5-83	3	4	4	1

IVth Time Recovery

No. of Turtles came	Interval	No. of times Eggs Laid				
		I	II	III	IV	All four times
4	15-75	2	1	1	1	—

Vth Time Recovery

No. of Turtles came	Interval	No. of times Eggs Laid					
		I	II	III	IV	V	All five times
2	89-130	—	1	1	1	—	—

POPULATION ESTIMATE

Number of turtles whose egg clutches have been transferred to the hatcheries per year is counted for 5 km beach of project area at Hawkesbay and Sandspit (a high density nesting zone) where protected enclosures have been constructed. Turtles do not confine to this 5 km stretch but the entire 20 km beach along Hawkesbay and Sandspit is turtle nesting ground. The eggs of 1500 green turtles have been transplanted from the 5 km beach to the enclosures in one year, so we can estimate the number of female green turtle on 20 km in a year is 6000. If the male-female ratio is 1 : 1 as found by certain researchers, then we get a figure of 12000. Approximately the same number of turtles found nesting each year from 1980-1984. In a five year period *6213* green turtles have been observed nesting on 5 km beach. The olive ridley has a definite nesting season. Population estimate of olive ridley has been worked out in the same manner as the green turtle, it is approximately 200 in a year on 20 km stretch. Considering the male and female ratio of 1 : 1 we get a figure of 400.

It must be strongly stressed, that these figures are very approximate and cannot be treated as accurate until verified by more reliable scientific methods. It is possible that the females were counted twice or thrice, each time they lay eggs in the same year. Since juveniles and subadults of green turtles have also been found, it is assumed that the population may be a resident one, feeding and nesting along the coast. More data and tag returns in next few years may indicate the migratory or resident pattern of the green turtle. At present the population of both the species, needs to remain under strict protection.

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OBSERVATIONS ON THE GREEN TURTLE *CHELONIA MYDAS* ALONG THE GUJARAT COAST

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ABSTRACT

The incidental catch of the green turtle *Chelonia mydas* by the bottom pair trawls operated by the Taiwanese Chartered Fishing Vessel *MFV HWA KUO No.* 2 during the period December 26, 1983—March 27, 1984 along the continental shelf and the continental slope off Gujarat Coast is reported. Data on the area and time of capture, depth, weather and sea conditions, size composition, sex ratio length-weight relationship and food of *Chelonia mydas* are presented in this account.

INTRODUCTION

AT PRESENT Great interest has been evinced on the occurrence, migration, nesting, behaviour and conservation of sea turtles in India. As sea turtles are protected animals in Indian waters and placed in Schedule I of the Indian Wildlife Protection Act, 1972 their capture is prohibited and active efforts are underway to study their behaviour and biology. These studies are very essential for the conservation and management of sea turtle resources (Silas *et al.*, 1983 and Silas, 1984).

I express my sincere gratitude to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute for valuable advice and suggestions. I am very thankful to Dr. K Satyanarayana Rao for help in the preparation of the paper and Shri M. Srinath for help in the statistical analysis.

MATERIAL AND METHODS

While participating in the Fishingt Programme of the Chartered Taiwanese Fishing Vessel *HWA KUO No.* 2, the green turtle *Chelonia mydas* was caught off Gujarat coast in trawl nets operated for demersal fishes on several occasions. A total of 70 green turtles *Chelonia mydas* were caught in 68 m long and 24 m wide trawl net operated at the bottom by *HWA KUO No.* 2 by pair trawling off Okha and south of Diu between 20°-23°N and 68°-71°E.

RESULTS

Area of occurrence

A majority of the turtles (54% of the total catch) were captured off Okha at Lat. 23°N and Long. 68°E (Fig. 1). The turtles were netted in moderate numbers southwest of Porbundar (Lat. 21°, Long. 69° and Lat. 23°, Long. 67° off Sir Mouth) and in lesser numbers at 22°N, 68°E ; 21°N, 70°E and 71°E West of Dwaraka, West of Veravel and south of Diu respectively (Table 1). One turtle with carapace length of 33 cm was found dead. It was cut open and its stomach contents were studied and given in a separate section here. The other turtles were released in the sea after noting particulars of size, sex and weight.

Depth and bottom conditions

The turtles where caught in areas ranging in depth from 42 to 280 m and they were most common in waters within the depth of 60 m. The sea bottom was muddy mixed with sand.

Time of capture

The turtles were captured at different times during the day and night but they were entangled in the net in larger numbers between 0900 hours and 2100 hours (Table 2). The sea conditions were rough.

Size

The males ranged from 33 cm to 81.5 cm in carapace length and the most dominant size group was 65-75 cm carapace lengtn. The females ranged between 41 cm and 80.5 cm in carapace length with the majority of the turtles being under the size range 65 cm—75 cm. The males showed 2 major modes, one in 65 cm and the other one in 75 cm; whereas in the females there was only one mode at 65 cm (Fig. 2). The width of carapace of males showed a range of 29.5 cm—78.2 cm and that of females the width ranged between 40 cm and 77.2 cm.

Weight of the turtles

The weight of the males ranged from 3.5 kg to 55 kg and the females ranged between 6.5 kg and 51.5 kg. The dominant weight mode of both sexes was 40 kg. (Males 33% and females 31%). As in the case of size range, only one mode was observed in the weight range of females, where as in males there were 2 dominant modes, one at 40 kg and the other at 50 kg (Fig. 3).

Sex ratio

In January-March, 1984, the female turtles were the dominant in the catches and formed 59-85% (Table 3). Only in December, 1983 males out numbered females, but the tota

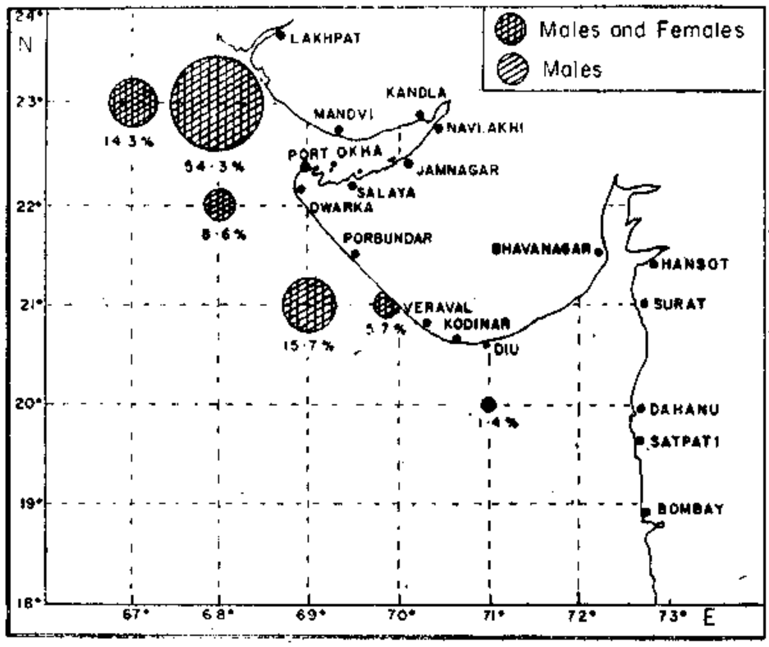

Fig. 1. Map showing the areas where the green turtle *Chelonia mydas* were caught off Gujarat Coast.

TABLE 1. *Number of* Chelonia mydas *caught in different fishing areas off Gujarat Coast*

Positions	Males and females	Males		Females	
	No.	No.	(%)	No.	(%)
20°N—71°E ..	1	1	(4.8)	—	—
21°N—69°E ..	11	6	(28.6)	5	(10.2)
21°N—70°E ..	4	3	(14.3)	1	(2.0)
22°N—68°E ..	6	2	(9.5)	4	(8.2)
23°N—67°E ..	10	1	(4.8)	9	(18.4)
23°N—68°E ..	38	8	(38.0)	30	(61.2)
Total Nos. ..	70	21		49	

TABLE 2. *Number of* Chelonia mydas *caught every three hours*

Hours	Males and females		Males		Females	
	No.	(%)	No.	(%)	No.	(%)
0300 +	6	8.6	1	(4.8)	5	(10.2)
0600 +	3	2.8	1	(4.8)	1	(2.1)
0900 +	20	28.6	5	(23.8)	15	(30.6)
1200 +	9	12.9	1	(4.8)	8	(16.3)
1500 +	10	14.3	4	(19.0)	6	(12.2)
1800 +	17	24.3	8	(38.0)	9	(18.4)
2100 +	2	2.8	—	—	2	(4.1)
2400 +	4	5.7	1	(4.8)	3	(6.1)
Total Nos.	70		21		49	

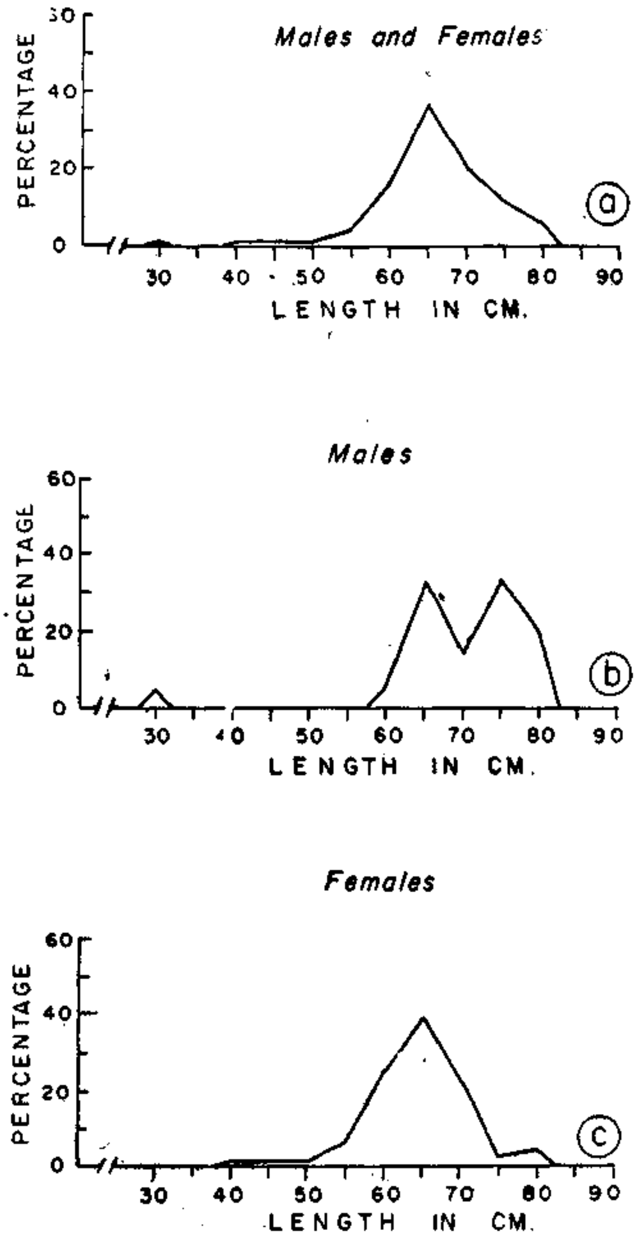

Fig. 2. Length frequency of *Chelonia mydas*—a. males and female, b. males and c. females.

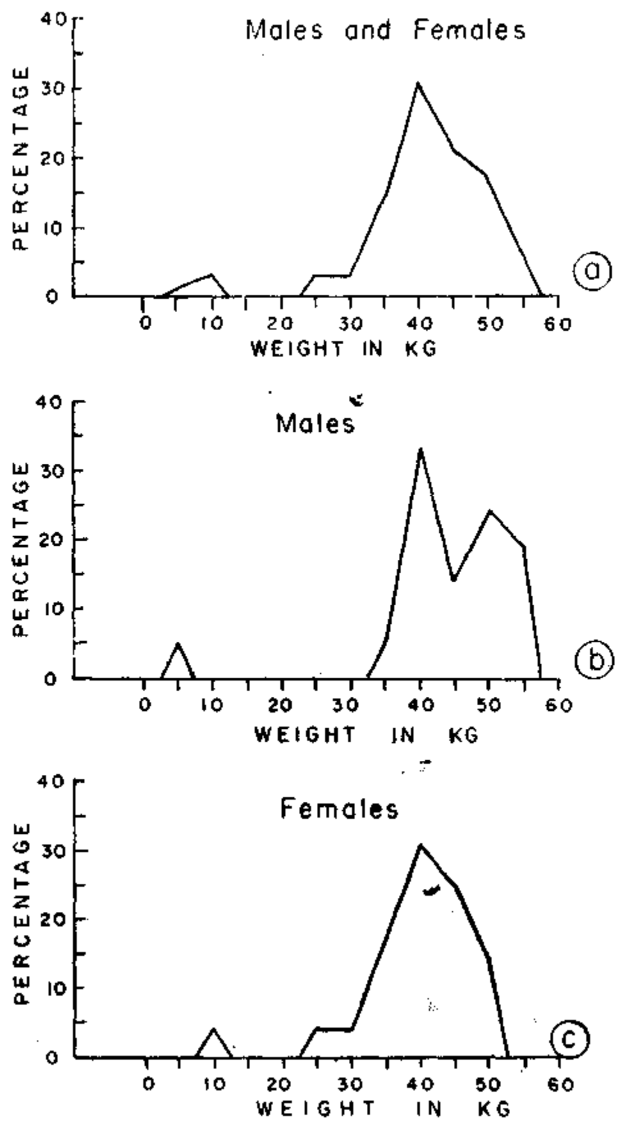

Fig. 3. Weight frequency of *Chelonia mydas*—a. males and females, b. males and c. females.

number of turtles caught in the month was very few.

Food

Seaweeds in advanced stage of digestion was the dominant item of food found in the stomach of a male turtle 33 cm in carapace length and 3.5 kg in weight. The seaweeds formed 79.3% of 66.3 ml of food in the stomach. The rest consisted of a variety of organisms: zooplankters 11.3% fragments of molluscs 6.6%; leaves of sea grass 1.2% feathers of sea gull 0.6% and an unusal item found in the stomach was a small green coloured plastic tube with a nylon twine tied to it 8.9%. Among zooplankters, Amphipods 97 Nos.,

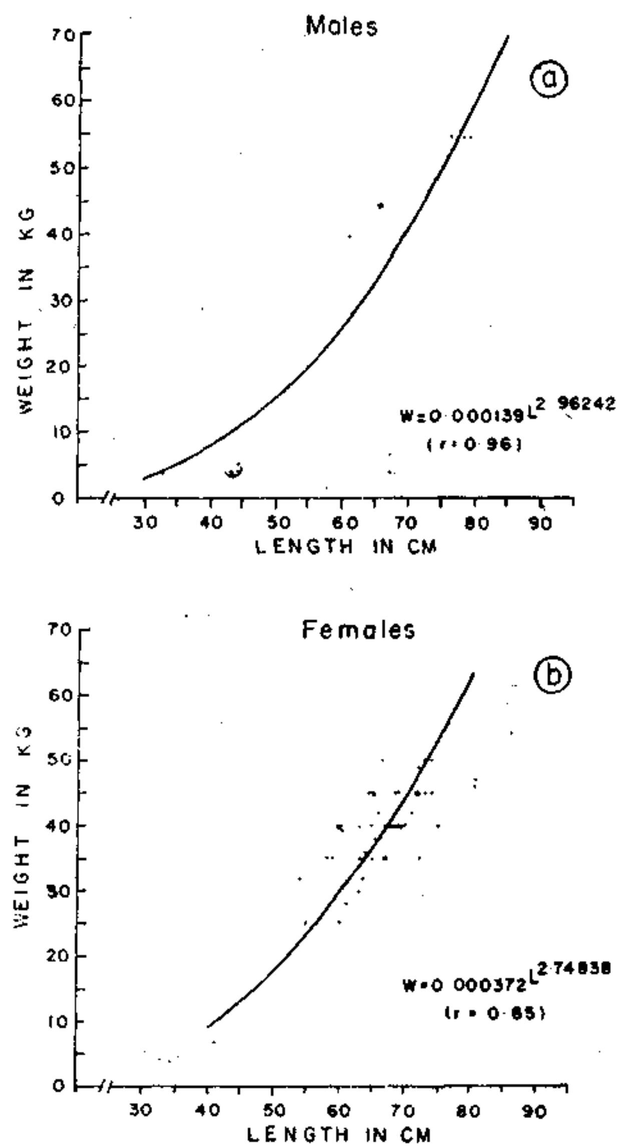

Fig. 4. Length-weight relationship of *Chelonia mydas*—a. males and b. females.

TABLE 3. *Sex ratio of* Chelonia mydas *caught off Gujarat coast during December* 1983—*March* 1984

Months	Males		Females	
	No.	%	No.	%
December, 1983	3	75.0	1	25.0
January, 1984	11	40.7	16	59.3
February, 1984	4	15.4	22	84.6
March, 1984	3	23.1	10	76.9
Total	21	30.0	49	70.0

Gastropod 8 Nos., Decapods 2 Nos., Phyllosoma 1 No. and 4 Nos. of unidentified zooplankters were found. The occurrence of these planktèrs might be accidental and these would have been

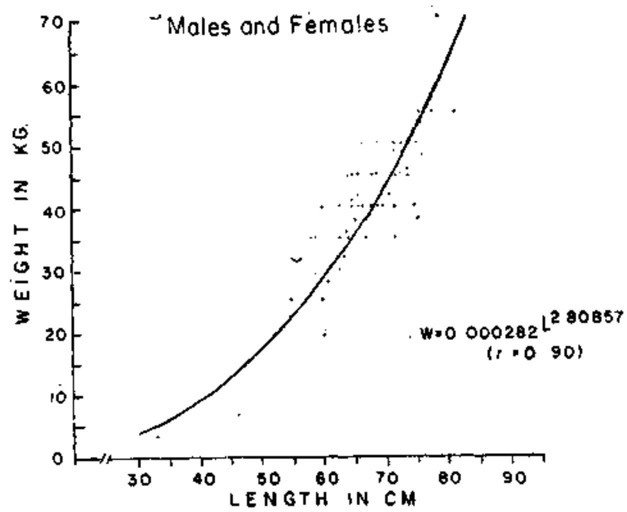

Fig. 5. Length-weight relationship of *Chelonia mydas*—both sexes combined.

consumed along with the plants to which these animals were attached.

Length-weight relationship

The carapace length-weight relationship of this species off Gujarat coast has been studied. The males, females and both the sexes are plotted and the line is fitted separately for males and females (Fig. 4) and also the combined sexes (Fig. 5). The rate of increase in weight relation to carapace length has been found not to differ in the two sexes. The growth formula for males and females and also the combined sexes are as follows:

In males, $W = 0.000139 L^{2.96242}$ $(r = 0.96)$

In females, $W = 0.000372 L^{2.74838}$ $(r = 0.85)$

Combined sexes, $W = 0.000282 L^{2.80857}$ $(r = 0.90)$

It is found that there is no significant difference among sexes with reference to length-weight relationship.

DISCUSSION

There is little information on the migration of turtles in Indian Seas. Records of turtle in the open sea are rather rare, although it is known that turtles occur in the coastal water in the feeding grounds or on their way for the purpose of nesting. In the present observation, *Chelonia mydas* has been recorded from the continental shelf waters and just outside the shelf edge along the Gujarat Coast. The migration routes of these turtles are not known. Silas (1984) has reported the occurrence of *Chelonia mydas* at the edge of the continental shelf off the southwest coast of India and outside it at 11° 15′N, 74° 54′E and 11° 61′N 74° 50′E during day time around Elikalpeni Island in the months of October and November.

Chelonia mydas enjoys a wide distribution in the Indian and Pacific Oceans. In the present observations the maximum carapace length recorded is 81.5 cm. A still larger specimen 127.5 cm has been recorded by Pritchard (1979) and the largest individual with 139.7 cm was reported by the same author around Ascension Island. He has stated that in Indian Ocean the important green turtle nesting grounds are on the mainland coastal area of the Arabian Peninsula especially on the coast of South Yemen and east coast of Saudi Arabia. It is very likely that there are good nesting grounds of *Chelonia mydas* along the Gujarat coast. In the present observation *Chelonia mydas* has been observed to swim on the surface off Okha and West of Veraval. Enquiries made at Okha showed that the green turtles are caught in trawl nets in good numbers off Okha Coast and they are secretly sent by lorries to Dwaraka. Meat of turtles obtained thus is consumed at Dwaraka and some turtles are transported to Bombay. As stated by Silas (1984), for the conservation and management of the turtle resources, intensive studies have to be carried out on the biology of the sea turtles, their breeding and nesting cycles, nesting grounds and seasons, migration to feeding and breeding areas and also the ecological factors influencing them. Steps should also be taken to prevent capture of the turtles for their meat and shells. The present observations made during commercial trawl fisheries in the 'winter' months December 1983-March 1984 along the Gujarat Coast points to the need for regular monitoring of commercial operations along the Gujarat-Maharashtra shelf waters for the occurrence of the green turtles.

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NATIONAL USE OF ESTUARINE AND MARINE REPTILES

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ABSTRACT

This paper briefly discusses the mairne and estuarine reptiles of India, their status, exploitation and some of the prospects and limitations of reptile conservation in India.

INTRODUCTION

IN the Indian region, four groups of reptiles (including four species of sea turtles, two 'freshwater' turtles, twenty sea snakes, one crocodile and one lizard) live mostly or entirely in the sea or estuarine areas (see Table 1).

With the exception of live bearing sea snakes, all of these reptiles must lay their eggs on land, a most vulnerable period of their adult life. Except in the case of the crocodile, maternal care is limited to choosing and excavating the nest site, depositing, covering and leaving the eggs to their fate.

TABLE 1. *Marine and estuarine reptile resources in India*

Scientific name	English name	Status	Distribution	Use
Crocodylus porosus	Saltwater crocodile	Endangered	Orissa, West Bengal, Andaman & Nicobar Islands	Skin, meat
Lepidochelys olivacea	Ridley sea turtle	Common	Main populations in Bay of Bengal	Meat, skin, calipee
Chelonia mydas	Green sea turtle	Uncommon	Kutch, Gulf of Mannar, Andaman & Nicobar Islands, Lakshadweep	Meat, skin, calipee, shell
Eretmochelys imbricata	Hawksbill sea turtle	Uncommon	Gulf of Mannar, Andaman Nicobar, Lakshadweep	Meat, shell
Dermochelys coriacea	Leatherback sea turtle	Endangered	Andaman & Nicobar	Meat, oil
Batagur baska	Batagur turtle	Endangered	West Bengal	Meat
Pelochelys bibroni	Bibron's softshell turtle	Rare	West Bengal, Orissa	Meat
Laticauda, Enhydrina, Hydrophis etc.	Sea snakes (20 species)	Common	Seas	Skin, meat
Varanus salvator	Water monitor lizard	Uncommon	West Bengal, Orissa, Andaman & Nicobar	Skin, meat

While complete studies on the biology of these reptiles have yet to be done, enough is known to make a beginning toward their sensible, sustained yield use for food and leather for, human consumption. All these groups of reptiles (except the sea snakes) have been exploited to some degree, notably the crocodile and sea turtles. Historically the use of reptiles for food by indigenous people in India probably had little detrimental impact on their populations. However, increasing human pressure on habitats and the commercialization of trade in these reptiles in the last thirty years has brought some, like the crocodile to the edge of extinction.

There are several conservation success stories in which highly endangered species have been rehabilitated for their own sake and are making a comeback. However, these are the exceptions and we are witnessing the irretrievable loss of several taxa every year worldwide. For India, which indeed spends more money and effort on conservation than any other developing country, the effective conservation of endangered species should be linked with their careful management and use. The promise of eventual economic returns from the investment of public or private money in studying and managing reptiles will, in the long run, be the strongest motivation for their protection. For example, there is little sympathy for the crocodile from fishermen; the ecological arguments of food chains and value of a master predator are rarely appreciated. However, if these same fishermen can be involved with the conservation and use of the crocodile as a lucrative resource, their co-operation is assured.

Strict laws help of course. But in India we see that, inspite of the sea turtles being protected under the highest category of the Wildlife Act, thousands are killed annually in Calcutta markets alone; and their eggs are illegally collected throughout the coastline and on the islands. Similarly the saltwater crocodile is still being heavily exploited in the Andamans.

There are several farming and ranching schemes used for reptile exploitation in other parts of the world. India has made excellent headway in the technology of crocodile husbandry and sea turtle research, and head starting has been proceeding for nearly a decade India has the resources, personnel and agencies to convert unmanaged and endangered reptile populations into important, rationally used resources. This paper briefly discusses some of the prospects and limitations of this approach to reptile conservation.

Thanks are due to my colleagues Shekar Dattatri and Harry Andrews for compiling the final draft of this paper and to D. V. Shyamala for typing it.

I. Saltwater Crocodile

The saltwater crocodile has the most valuable skin of any reptile and if properly managed, can be a very valuable resource. While it is a hardy survivor of the age of the dinosaurs, the saltwater crocodile is vulnerable to habitat loss and over hunting. As a result, the largest reptile one earth is being steadily wiped out throughout its range from India to Australia. It typically inhabits estuarine areas with mangrove and grass swamps. The three areas where it still survives in India are: the Sundarbans (Gangetic delta) in West Bengal, Bhitar Kanika (Mahanadi delta) in Orissa and parts of the Andaman and Nicobar islands. The total number of adult saltwater crocodiles in these areas probably does not exceed 1000, a sadly depleted resource but still viable enough to reverse the downward trend.

The government programmes started in 1975 to rehabilitate the saltwater crocodile have concentrated mainly on egg collection, several years of captive rearing and subsequent release back to the wild. The West Bengal Forest Department and the Madras Crocodile Bank have successfully bred this specise in captivity. The major constrains to the survival of expansion of the wild population are increasing human pressure on the little available habitat and the unpopularity of this large predator.

TABLE 2. *Optimum Growth rate of Marsh Crocodile* (Crocodylus palustris) *in captivity at Madras Crocodile Bank Trust*

Age (Years)	Average Length (cm)	Weight (gms)
0	28	64.39
1	90	—
2	125	—
3	180	—

While it is essential to protect and expand saltwater crocodile populations to the maximum within the habitat available, it seems likely that commercial usage could best be achieved in a combined scheme of ranching (captive rearing of young from wild collected eggs) and farming (closed cycle captive breeding).

A brief breakdown of the productive value of one adult female saltwater crocodile, conservatively calculated, will serve to indicate the value of this reptile as a resource and the tremendous waste resulting in killing one of these females (average figures):

1. Age of female at maturity—10 years
2. Number of years of productivity—30 years
3. Number of eggs per year—50 eggs
4. Number of hatchlings (60%)—30 hatchlings
5. Mortality in four years (20%)—24 survivors
6. Value of 24 four year olds (skin and byproducts)—Rs. 57,600
7. Rearing costs for four years (25%)—Rs. 14,400
8. Net value of 24 four year olds—Rs. 43,200
9. Life productivity value of one female—Rs. 1,296,000

It is thus apparent that the protection of wild crocodiles for ranching and their captive farming can be lucrative. The technology is still young but success has been achieved both in wild population management as well as commercial captive rearing in several countries including Thailand, Australia and Papua New Guinea.

The value of the saltwater crocodile in controlling fish predators and in its role as the ultimate predator/scavenger of estuarine areas cannot be underestimated. Studies on this species have unfortunately lagged far behind its over exploitation, and we stand to lose this economically and ecologically valuable reptile before we even partly appreciate its value. The single most important conservation measure required in India is the protection of the habitat of the saltwater crocodile—the remaining mangrove habitat (that we now know) must be retained as a cyclone buffer and breeding zone for many of the other commercially exploited species, especially fish, crabs and prawns.

II. Sea Turtles

Perhaps, the most heavily exploited reptiles are the sea turtles. The Ridley is the only common sea turtle in Indian waters, and its main nesting concentrations are limited to parts of the Orissa coast. The other three species regularly reported in the Indian region are much less common. Of these, the leatherback sea turtle is considered to be endangered, with significant numbers nesting only on some beaches in the Andamans and Nicobars.

Sea turtles are valuable for meat, calipee (the cartilage in the plastron which is used in soup making), shell (in the case of the hawksbill and green) and leather (which, though little is obtained from a turtle, came into fashion following the scarcity and high price of crocodile leather). Hawksbill shell (scutes) is now worth about Rs. 500 per kg).

But how can sea turtle be sensibly used as a sustained yield resource? Cayman Turtle Farm in the Carribbean is so far the only place that has succeeded in breeding them in captivity, after a great input of research and development of adequate pens complete with nesting beaches. Considering the high productivity of eggs (250-500 eggs per year per female) and high hatchling mortality (probably over 90%) the logical answer is collection of egg and rearing (ranching). This is in fact the present government programme in the States of Tamil Nadu (originally begun by the Madras Snake Park Trust) and West Bengal where thousands of transferred eggs are hatched and the hatchlings released each year.

The fairly rapid growth rates of sea turtles makes them seem to be logical candidates for commercial ranching of surplus hatchlings that would otherwise not survive in the wild. In 1984, for example, it was observed at Gahirmatha in Orissa (where the mass nesting of several lakhs of female ridleys takes place annually in January, February and April) that literally millions of eggs are destroyed by predators, erosion by the sea and digging up by successive waves of nesting females. It can be argued that a portion of the eggs could be collected and the hatchlings reared for commercial sale in West Bengal (few people will eat turtles in Orissa). But what will they be reared on? The fish, crab and prawn harvest in the nearby mangroves are the food of the local human inhabitants. Their protein resources obviously cannot be used to rear another protein resource which is to be then exported.

TABLE 3. *Growth rate of the Hawksbill Sea Turtle* (Eretmochelys imbricata) *at Madras Crocodile Bank Trust*

Age	Carapace Length	Carapace width	Head width	Weight
6 months	10	10	—	125 gms
1 year	23	22.5	4.5	1500 gms

The sea turtle resource deserves an urgent injection of research and study, already started in a small way by Orissa, Tamil Nadu and the CMFRI. Status surveys on the Indian beaches (mostly by one person, Satish Bhaskar) have identified important nesting beaches of the valuable hawksbill and green sea turtles, mainly in the Andamans and Nicobars and Lakshadweep. Without knowing more about the mysteries of their biology, we are still far away from using sea turtles as the valuable resources they are.

Similarly the two chelonians which live in association with the mangroves of Orissa and West Bengal, (the batagur and Bibron's softshell) deserve immediate attention because of their scarcity and consideration of their potential resource value for the future. In the old herpetological literature, batagur at least was reported to be a valuable protein source when millions of eggs were collected yearly in the 1800's from the banks of the Hoogly River where it is today extinct.

III. Sea Snakes

Several of the 20 species of sea snakes in Indian waters are very common, notably the hook-nosed sea snake (*Enhydrina sohistosa*) which has been in aggregations of lakhs off the West Coast. Several islands in the Andamans such as whitecliff in North Andaman are nesting sites of the amphibious sea snakes (*Laticauda*) which come ashore in large numbers to lay their eggs.

There is a significant demand for sea snake meat and skin in Hongkong and Korea where several island populations have been heavily exploited for decades. Recently commercial fishing firms in Queensland, Australia have been permitted to exploit incidental catches of sea snakes in trawl nets for their skins but no details of price or numbers are known.

Sea snake venoms, for research and the production of antivenom serum, are among the world's most valuable venoms with recently quoted prices as high as Rs. 20,000 per gram. However, the market is limited; and extraction is very difficult because of the small size of fangs and small venom output per snake.

Almost nothing is known about the status or biology of sea snakes in Indian waters, some of which grow to nearly 3 m in length. Basic studies could be easily taken up by collection of specimens brought in by commercial shrimp trawlers and, in some seasons, inshore seines.

IV. Water Monitor Lizard

The water monitor is one of the three largest lizards in the world, growing to 2.5 m in length. Its optimum habitat are the estuarine mangrove and grass swamps, and it survives in India in the same areas the saltwater crocodile still hangs on. It is an important predator of crocodile and sea turtle eggs and, in habitats where it is not harassed by humans, occurs in high densities. In India, it is endangered because of killing for skin, meat and fat and due to habitat loss. The water monitor is still locally common in some parts of the Andamans and Nicobars but, being very easy to catch with the help of dogs, is extremely vulnerable.

Little is known about the biology of this large lizard. As with most monitors, the incubation period of its eggs is quite long, nine to ten months. This means a longer period during which the eggs could be destroyed, seemingly a disadvantage for survival. Monitors very often use termite nests as incubation chambers for their eggs, apparently optimum sites.

The water monitor has bred in captivity at Ahmedabad zoo and the Madras Snake Park but not consistently and with little survival success. It would appear at first sight that commercial farming of monitors is not feasible because the rearing costs for the three or four year period needed to bring them to croppable size would not be offset by the value of the skin (now about Rs. 120 for a raw, salted skin on the world market).

A study on the breeding biology and captive rearing of the monitor would be an important contribution to its conservation and management and its utility as an economic resource.

CONCLUSION

The past decade has seen the development of what appears to be a viable industry based on the captive breeding and rearing of various crocodilians including the American alligator, Siamese crocodile, Nile crocodile and New Guinea crocodile. However, in spite of the obvious committment of several Governments to the careful usage of crocodiles as a sustained yield resource, it remains to be seen whether farmed products will replace those taken from the wild.

The fears of a certain lobby of conservationists that farming wildlife merely increases the market and demand, exerting even further pressure on endangered species (particularly in countries where enforcement of protective laws, if any, is inadequate) may be justified to some extent. These fears, however, can damage the chances for a wildlife farming operation to succeed. The best example is Cayman Turtle

Farms which, because of a strong preservationist lobby in the U.S.A., was stopped from selling its farmed products in that country, resulting in considerable losses that could jeopardize its existence. While one can appreciate the ideal of no commercial trade in wildlife products, farmed or otherwise, the economic situation of hundreds of millions of people in developing countries prevent them from sharing that ideal. They will use their countries' wildlife to extinction unless they are provided with and convinced of practical alternatives. It would be far more sensible if the same people who spend time and money lobbying for total protection of wildlife would invest in the research and technology of captive breeding, sustained yield ranching and scientific management of those taxa which have potential for rational use as economic resources.

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MARINE TURTLES IN THE MALDIVE ARCHIPELAGO

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ABSTRACT

All five pantropical species of marine turtles have been recorded in the Maldives ; two species, *Chelonia mydas* (L.) and *Eretmochelys imbricata* (L.) breed regularly and occur throughout the Archipelago. The other three species, *Lepidochelys olivacea* (Eschscholtz), *Dermochelys coriacea* (L.) and *Caretta caretta* (L.) in order of frequency, are uncommon to rare. The populations are dispersed and small—evidently much depleted from half a century ago. Changing traditions and increased exploitation on both turtles and their habitats coupled with bourgeoning human populations and habitat perturbations pose difficult questions for the future of these resources.

INTRODUCTION

THERE is no detailed report on marine turtles in the Maldive Archipelago, although the islands have a long history of trade in turtles, and provide vast areas of nesting and feeding habitats that appear to be ideal for tropical island species. In order to compile what little is known of marine turtles, their requisite habitats, and interrelated human situations, past and present, this report draws from a variety of sources.

The Ministry of Fisheries, Maldives, provided initiative and support for this survey, and we are indebted to many people of the Ministry for their help and kindness, in particular Minister Abdul Sattar, and Mr. Hassan Maniku, Senior Fisheries Development Officer. Many island leasses, boat owners, fishermen and other citizens gave generous assitance and hopitality.

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Geography

The Maldive Archipelago lies at the southern edge of the Arabian Sea, 520 km west-southwest of the Indian mainland. It sits atop the Laccadive-Maldive Ridge, a major oceanic feature which extends in nearly a straight line along the 73rd Parallel from 14°N to below the Equator, evidently as far as 8°S, including the Chagos Archipelago. Each of the three archipelagos on the Ridge is administred separately : Laccadives ('Lakshadwep') by India, Maldives as an independent republic, and Chagos as the British Indian Ocean Territory (BIOT), a Crown Colony.

All of the Maldives, except for the three southern-most atolls, rise from the steep-sided plateau which is 270 to 380 m deep, 650 km long and 130 km at the widest. There may be no shelf between Suvadiva and Addu, the southernmost atoll in the Republic, and the situation with Fua Mulaku is unknown. These shelves, or marine plateaus, drop rapidly to the sea floor 2,380 to 3,660 m to the West and 1,830 to 2,560 m to the East. In contrast to other mid-oceanic ridges, the Laccadive-Maldive Ridge is aseismic (Stoddart, 1966a). Whether the plateau and its islands were ever closer to the continent is not known.

The Maldive Archipelago is composed of more than 20 discrete 'atolls', or ring-shaped clusters of islands, that fall generally into two parallel lines . This is one of the largest concentrations of these formations anywhere, and the word 'atoll' or 'atolu' derives from Divehi, the Maldivian language. Each atoll usually represents the top of a steep-sided seamount which rises from the plateau. More than 1,200 islands are distributed over an area greater than 87,000 km^2, but the total land area is estimated to be only 298 km^2 (Maniku *et al.*, 1977).

Geology

The Islands are coralline cays, rarely more than 2 m above the sea level. Sand shifts continuously through action of wind and sea, and banks, beaches and cays come and go as sand is deposited and eroded. Four types of lithified strata have been described: reef rock, relict reef rock, cay sandstone and beach rock (Stoddart *et al.*, 1966). Only the last named is common, and both seaward and lagoonward coasts are dominated by sandy beaches. The northern islands are reported to be generally more fertile, but Fua Mulaku, in the south, is famous for its agriculture and relatively lush vegetation. There is little soil other than a shallow surface layer of coralline sand mixed with some organic matter. Spicer and Newbery (1979) and Newbery and Spicer (1979) studied soils on Wilingili Island, Addu Atoll.

Meteorology

The climate of the region is dominated by two monsoons. The Southwest Monsoon, from June to August or September, is typified by high winds and heavy rains. The weather is normally more clement from November through March, during the Northeast Monsoon. Variable weather occurs in the transition between monsoons. The highest air temperature recorded is 32.8°C in April. A record 20.6°C in January is the lowest (Hackett, 1977).

As with other environmental data, there are few records on rainfall. From north to south, annual totals are similar, but the northern atolls have a distinct peak in rainfall at the beginning of the Southwest Monsoon. The southern atolls have generally unsettled weather with rainfall more evenly distributed throughout the year (Hackett, 1977). At Addu Atoll, in the South, mean annual rainfall was reported to be 2,382.5 mm; at Male' Atoll it was 2,055.9 mm. The greatest monthly rainfall was in October, and the January value was second (Stoddart, 1971).

Oceanography

Sea surface temperatures show little fluctuation, rarely varying below 27° or above 31°C. Surface currents reverse with the monsoons, running eastward during the Southwest Monsoon, and westward from December to April. Tides are semidiurnal, with a maximum amplitude of 2 m (Hackett, 1977). Salinity data are in Stoddart (1966b).

Marine Flora

Marine algae include 21 Cyanophyceae, 163 Rhodophyceae, 83 Chlorophyceae, and 18 Phaeophyceae, many of which are recorded in stomach contents of sea turtles. Several marine angiosperms are recorded, but there are no large pastures. Mangrove forests are small (Hackett, 1977).

Marine Fauna

The coral reefs in Maldives are some of the richest in the world and there is no greater diversity of coral in the western Indian Ocean. The J. Stanley Gardiner Expedition, the John Murray Expedition and the Cambridge Expedition each made extensive marine collections (see Stoddart, 1966c for references). Fishes are abundant and diverse ; for millennia the islanders have exported fish, and fishing is the primary occupation.

Terrestrial Flora

These small, remote islands have a scanty flora. More than 50 species of Dicotyledons, 17 species of Monocotyledons, and 3 species of fern are reported from Wilingili Island, Addu Atoll (Fosberg *et al.*, 1966, Sigee, 1966). Forests of *Pisonia grandis* R. Br. probably covered much area before being cleared for settlements and agriculture (Spicer and Newbery 1979). Coconut groves, apparently self-seeded, occupy large areas of most islands, and there is also intensive agriculture of annual crops on some islands.

Terrestrial Fauna

The terrestrial fauna is likewise depauperate. There are no large indigenous predators, although introduced cats and rats are on some islands with permanent inhabitants, and rats are a serious problem for coconut plantations on uninhabited islands (being a Moslem country, no dogs are allowed in the Maldives). Large Predatory birds include frigate birds (*Fregata* spp.), boobies (*Sula* spp.), herons and egrets (*Ardea* sp., *Butroides* sp., and possibly other genera) and crows (*Corvus splendens* Viellot), as well as non-resident raptors (Watson *et al.*, 1963). There are no large lizards or resident populations of crocodiles and only one snake is known. Populations of land crabs can be sizeable and include ; coconut crabs, *Birgus latro* L., hermit crabs, *Caenobita* spp., and especially hosg crtabs, *Ocypode* spp.

Marine Turtles

In reviewing the status of marine turtles in the western Indian Ocean (Frazier, 1975, in press) it is striking how little is recorded from the Maldive Islands, although they have for centuries been important suppliers of tortoise-shell. Early historic accounts of the Maldives, dating from the 12th century writings of Al-Idrisee, show that the islands were important source of tortoise-shell for foreign traders. In recent years there have been strong trade ties between the Maldives and Sri Lanka, the Archipelago providing raw tortoise-shell for Sinhalese artisans, and the much appreciated Maldive-fish. Maldivians are traditionally excellent sailors and fishermen, plying among the islands of the archipelago and trading across to Sri Lanka and India as well. Readible accounts of the Maldives are given by Maniku *et al.* (1977) and Bevan and Greig (1982). The thousands of remote islands should provide prime nesting habitat for turtles, and the vast coral reefs probably provide ample food and shelter for large numbers of turtles.

Arab writers, *e.g.*, Al-Idrisee in the 12th century and Ibn Battuta in the 14th century, documented the fishery for tortoise-shell, but they found little else about sea turtles significant enough to record.

The first biologists' records of marine turtles in Maldives were made at the end of the last century, and these are also very scanty Chun (1903). Laidlaw (1902) found *Eretmochelys imbricata* (L.) common off the Maldives and the Laccadives and plentiful around Male' Atoll. Gardiner (1906 : 1050) reported a gravid *Dermochelys coriacea* (L.) from Addu Atoll.

Deraniyagala (1956) visited the Archipelago in 1932, and has written more about the sea turtles there than anyone else : *Chelonia mydas* (L.) was very common ; it was not eaten at Male', but was eaten on some other islands. In a single night in December 6 females were netted for Deraniyagala. Nine newly hatched turtles were observed on Hulule Island, Male Atoll, on 22 December 1932. He suggested (1939 : 241) that *C. mydas* bask during the daylight on beaches of the Maldives, a habit that it is known from remote islands in the Galapagos (Snell and Fritts, MS) and French Fregate shoals, Hawaii (Whitton and Balazs, 1979)—and occasionally claimed (incorrectly) to be unique to the Wrench Fregate shoals.

Deraniyagala (1956 : 13) considered *Eretmochelys* to be more common in the southern atolls, and he thought *Dermochelys* was very rare. A nest, reputedly of the latter species was reported on Hulule island, but this refers to the same event reported earlier by Gardiner (1906).

On the basis of a nest with eggs 42 and 44 mm in diameter, and tracks the size of *Chelonia*, Deraniyagala (1956) deduced that *Caretta caretta* (L.) also nested. However, no specimen of this turtle has been confirmed from the Maldives until the present report, and the egg sizes reported are not unusual for *Chelonia* (see below).

Phillips (1958 : 219) visited the islands, and recorded two young *Eretmochelys* at Male' in December 1956. Colton (1977 : 170) spent over a year in the Maldives and claimed that : 'The coral reefs of Maldives are also home to the loggerhead, green, olive ridley, and leatherback sea turtles—all, like the hawksbill, endangered species'. She saw shells of *Eretmochelys*, *Chelonia*, and *Lepidochelys* offered for sale to tourists, and presented photographs of the first two. It is unlikely that she had any evidence of either *Caretta* or *Dermochyles*.

Didi (1983) summarized an account of Mulhado (or Mulhadhoo) Island, famous for large numbers of nesting turtles half a century ago. He also described past developments and the decline of turtle populations in the Maldives.

A claim (Anon., n.d. : 5.18) that four species (*Chelonia mydas*, *Eretmochleys imbricata*, *Dermochelys coriacea*, and (*Caretta caretta*) are caught and breed in Maldives was evidently based on a review of published accounts. However, no sources for this information were given.

Methods

A preliminary survey of the Maldives involved four phases : meetings in, and day trips from, Male'—intermitently from 21 December 1983 until 26 January 1984 ; an excursion to Baa Atoll, including the islands of Kunfunadhoo, Eydafushi, Maadhoo, and Thuladhoo—from 28 December 1983 to 7 January 1984 ; an excursion to Laam Atoll, including the islands of Hithadhoo, Gaadhoo, Dhabidhoo, Isdhoo, Maabaidhoo and Maamendhoo—from 10 to 17 January 1984 ; and an excursion to South Male' Atoll (Raannaalhi Island) and Ari Atoll, including Dhagathi, Hurasdhoo, and Hukuruelhi Island from 21 to 24 January 1984. Mr. N. T. Hasen Didi, Senior Under Secretary of Fisheries, participated in the last two trips, Mr. Jadula Jaleel, Junior Under Secretary of Fisheries, in the trip to Baa, and Mr. Hassan Maniku, Senior Fisheries Development Officer, in some trips from Male'.

Wherever possible Island Chiefs and experienced fishermen were interviewed about turtles. In addition, Mr. N. T. Hasen Didi (NTHD) has spent nearly 60 years observing and enquiring about turtles in the Maldives.

Island names, which are in Divehi (an ancient form of Sinhala), are now written in Thaana, which is similar to Arabic script. There are various ways to transliterate these to roman script, so as standards we use 'Map of Maldives' Anon., 1979) and 'The Islands of Maldives' (Maniku, 1983). Atoll names are given (usually in parentheses) after each island name that is mentioned.

THE FINDINGS

Species Accounts

Chelonia mydas (L.)

Common names: The name 'Vela' (or 'Wela') is heard throughout the Archipelago from north to south and is used exclusively for the green turtle, *Chelonia mydas*. Curiously, the name has not been previously recorded except by Deraniyagala (1956 : 13), and neither its meaning nor its origin are clear. It has no obvious similarity with any other turtle name in the Indian Ocean (Frazier & Salas, in prep).

Occurrence: Vela are found throughout the Archipelago. Nesting was confirmed at Kunfunadhoo and Maadhoo Islands (Baa), and spoor or remains of *C. mydas* were found on Huku ruelhi (now changed to Hukurudhoo) Island (Ari) and Gaadhoo, Hitadhoo and Isdhoo islands (Laam) (Table 1).

TABLE 1. *Specimens of* Chelonia mydas *from Maldives*

JGF No.	Island (Atoll)	Date	Specimen	Remarks
		1983 *December*		
4204	Kunfunadhoo (Baa)	28	skull	adult, found on SW beach, collected.
4205	Kunfunadhoo (Baa)	29	femur & scute	on SW beach (probably same animal as JGF 4204), collected.
4208	Kunfunadhoo (Baa)	31	egg shells & embryo	exhumed from nest that emerged night of 30 Dec., collected.
4211	Maadhoo (Baa)	31	egg shells & embryo	exhumed from nest that emerged 30 or 31 December, collected.
		1984 *January*		
4209	Thulhadhoo (Baa)	2	shell, head & flippers	remains of adult female, collected (with H. Didi to send on).
4210	Thulhadhoo (Baa)	2	carapace	adult, scuteless, in the sea, measured.
4213	Baros (North Male')	8	Juvenile	hatched—13 months ago, measured.
4218	Gaadhoo (Laam)	10	fresh eggs	sample of 10 measured.
4222	Maavah (Laam)	14	hatchling	20 days old, kept in Chief's well. at Dhabidhoo.
4223	Maavah (Laam)	14	hatchling	,,
4224	Isdhoo (Laam)	14	female	adult, caught last night, measured.
4225	Hithadhoo (Laam)	13	pleural scute	adult (?), collected.
4226	Isdhoo (Laam)	15	assorted bones	immatures and adults, discarded by islanders, collected.
4226	Hukuruelhi (Ari)	23	bones	adult, collected (with H. Didi to send on).

Population structure: Adults and immatures are found throughout the Archipelago (Table 2). Carapaces of less than 75 cm long (far below adult size) were commonly offered for sale in the late 1970's, as shown in photos in Colton (1977). and this size class is still commonly displayed for sale in Male'. In November 1983, NTHD photographed an animal with a carapace that was little more than 10 cm long. It was being offered for sale, but it is not clear if it was wild-caught or captive-reared.

Feeding Biology: A large marine pasture, with *Syringodium isoetifolium* (Ashers.) Dandy and *Thalassia hemprichii* (Ehrenb. Aschers, in Petermann, was examined east of Thuladhoo (Baa). However, it does not seem to be an important feeding area. There are large pastures of *Thalassia hemprichii*, with smaller patches of *Thalassodendron cilliatum* (Forsk.) den Hartog, along the eastern and southern sides of Laam Atoll, and the waters between Fonadhoo and Baraasilhoo, in the southeast of the Atoll are reputed to be a favorite haunt of feeding turtles. Large marine pastures are evidently rare in the Maldives.

Breeding biology: Data on nesting season are available only from Gaadhoo (Laam), were there is a peak between June and December and a lull from March to May Nesting is evidently restricted to night-time, although long ago it may have occurred in late afternoon and early morning (Didi, 1983). Nests are made in a narrow coastal strip, from the beach crest to 17 m inland; 95% of all nests are within 10 m of the beach crest. Most nests are shaded, and many are under heavy shade.

Nest JGF 4208 was 82 cm deep, with the top of the hatched egg shells at 73 cm. The same nest had approximately 110 shells of hatched eggs and 3 unhatched eggs. JGF 4218 had approximately 110 fresh laid eggs. Eggs from three clutches were measured; diameters ranged from 40.8 to 46.1 mm, averaging 42.2. Weights from one clutch varied from 39.5 to 41.0 g, with an average of 40.6 (Table 3).

Bodysize and characteristics: The few measurements we have, that evidently come from adults (Table 2), are of normal size for the species in the Indian Ocean. Scalation and coloration are also normal. Two females seen at Thuladhoo (Baa), and Isdhoo (Laam), however, were all spotted, without concentrations of dark pigment in the postero-medial corners of the carapace scutes and without chestnut-red bull's -eyes, unlike the coloration that is normal for females in the western Indian Ocean (Frazier, 1971),

Local accounts: A number of islands are known for their nesting turtles, presumably Vela. 'Mulhadhoo' (Thiladunmathi), in the extreme north, has some fame: hundreds of turtles are reported to have nested each night (Didi, 1983). At Baa Atoll, Kunfunadhoo and Maadhoo, and formerly Dhunikolu, Fares, Maarikilu and Miriyandhoo are known for the large numbers that nest, or once nested. Nesting is also reported from other islands, *e.g.* Olhugiri and Kanufushi. These islands are scattered about the Atoll, and all are uninhabited except the first named, which has recently had a tourist resort built on it.

The best turtle island in Ari Atoll is said to be Hukureulhi. In Meemu Atoll, there is evidently an island in the southwest with a reputation as a turtle rookery. At Thaa Atoll, Kanimedhoo Island in the south, was once known for turtles. The only island in Laam Atoll that is known today for its turtles is Gaadhoo.

Every atoll is likely to have its turtle island(s), but the above examples, despite the scanty nature of the data, are all that is documented at present. It seems that there is more

TABLE 2. *Measurements and observations of* Chelonia mydas *in Maldives (see Table* 1 *for more data)*

JGF No.	Sex	Measurements (mm): Carapace Length, Medial St	Carapace Length, Medial Cv	Carapace Length, Lateral Cv	Carapace Width St	Carapace Width Cv	Nt	Plastron Ln	Scalation: Cp	Head Po	Plastron Im	Plastron Ax	Plastron In	Plastron Pa	Plastron Ig	1st. White Marg	Epizoa	Comments
4209	F	950	1020	1035	720	930		770	N		4/4	3/3		sm		—	Ch	black spotted
4210	?		1030															
4213	?		163	164		150	2	132	N	4/4	4/4	2/3*	1/1*	3	lg			*pores ; 13 months old
4222	?	54							(1)	5/5	5/5	4/3	1/1	sm	lg	5th		20 days old
4223	?	56							N	5/5	4/4	3/3	1/1	sm	lg	4th		20 days old
4224	F		1015	1020		935	0		N	4/4							B	black spotted

Abbreviations :

Measurements ; Medial (from midline of cervical to posterior-most projection of supracaudal) ; Lateral (from anterior-most projection of carapace to posterior most projection of supracaudal) ; 'St '= straight line ; 'Cv' = over the curve ; 'Nt '= depth of supracaudal notch.

Scalation : 'Cp' = carapace ('N' = normal, '(1)' = carapace normal except 12 pairs of marginals, excluding supracaudals) ; 'Po' = postoculars ; 'Im' = inframarginals ; 'Ax' = axillaries ; 'In' = inguinals ; 'Pa' = postanal ('sm' = small, '3' = 3 mm long) ; 'Ig' = intergular ('lg' = large).

Ist. White Marg. = First marginal on which white line begins.

Epizoa : 'Ch' = *Chelonibia* ; 'B' = barnacles.

TABLE 3. *Measurements of sea turtle eggs in Maldives*

JGF No.	N	Diameter * (mm) min	max	x	(sd)	Weight x	(sd)
Chelonia mydas							
4208	2	44.4	46.1	45.5	(0.62)	/	
4211	10	40.5	43.1	41.7	(0.63)	/	
4218**	10	48.8	43.5	42.1	(0.61)	40.6	(0.52)
Total		40.5	46.1	42.2		40.6	
Eretmochelys imbricata							
4207	2	34.4	37.8	35.6	(1.26)	/	

* Three perpendicular diameters were measured for each egg

** One extraordinary egg had a minimum diameter of 38.9 mm and weight of 33.0 g.

nesting in the north and more on the eastern side of the archipelago.

Vela are said to be most accessable during the change between monsoons and December-January, when they can be caught using hook and line at the surface, outside the atoll. Smaller animals are reported to be inside the atoll, and they are said to be lighter (whiter) in color. At Mundhoo (Lamm) turtles as small as 20 cm long are found on sea grass beds. Copulating pairs are found during these months also, when males appear 4 or 5 times more common. Females caught at sea can have shelled eggs as well as enlarged follicles. There are said to be two kinds of nesting Vela, one with a round back and one with a slightly longer back.

At Thiladunmathi there was year round nesting with a peak at the beginning of the Northeast monsoon, starting in about November. Nesting at Baa Atoll was claimed to be most active during December-January, when the current runs West to East. In mid-August 1983, eggs were exploited from Kurendhoo (Lhaviyani). At Gaadhoo (Laam), the only place for which there are quantitative data, nesting goes on most of the year with a peak from June to December.

P o p u l a t i o n s i z e : There are very scanty data relevant to the numbers inhabiting or even nesting in Maldives. Nesting spoor observed on 18 islands (Table 4) indicates that several hundred turtles nest yearly. Taken together with what is estimated by experienced people from other islands (Table 5), there may be about 1000 nesting. Considering the entire archipelago, it is likely that several thousand Vela nest each year.

It is unanimous, in every atoll from which there is information, that the numbers nesting have declined catastrophically. evidently tens of thousands of turtles once nested in Maldives.

Eretmochelys imbricata

C o m m o n n a m e s : The name 'Kahambu' is used through the Archipelago and is used exclusively for the hawksbill

TABLE 4. *Nest spoor and estimates of population size of sea turtles in Maldives*

Atoll	Island	Nest pits					Annual Estimates	
		+	?	+ and ?	—	all	Nests	FF
Baa	Kunfunadhoo	81	24	105	23	128	420	210
	Eydhafushi	0	0	0	0	0	1	1
	Maadhoo*	64	10	74	5	79	296	148
	Thuladhoo	0	0	0	0	0	0	0
	Subtotal	145	34	179	28	207	717	359
N. Male'	Baros	1	0	1	0	1	1	1
	Kuda-ban'dos	0	0	0	0	0	1	1
	Kani	0	0	0	0	0	1	1
	Vilinggili*	0	0	0	0	0	2	2
	Male'	0	0	0	0	0	0	0
	Subtotal	1	0	1	0	1	5	5
S. Male'	Raannaalhi	0	0	0	0	0	3	3
Ari	Dhagathi*	0	0	0	0	0	3	3
	Hurasdhoo	0	1	1	0	1	4	2
	Ækuruelhi	1	5	6	1	7	24	12
	Subtotal	1	6	7	1	8	28	14
Laam	Hithadhoo	0	0	0	0	0	2	1
	Mamendhoo	0	0	0	0	0	0	0
	Gaadhoo +	10	50	60	10	70	240	120
	Dhabidhoo*	0	0	0	0	0	1	1
	Isdhoo	1	4	5	1	6	20	10
	Subtotal	11	54	65	11	76	263	132
	Total	158	94	252	40	292	1016	513

*= Nest survey not thorough.

+ = numbers approximate, spoor too dense to interpret reliably.

Nest Pits : + = thought to have eggs, ? = uncertain, — = thought not to have eggs

Annual estimate derived by : nests = 4 x number of + and ? nests (assuming spoor seen is representative of an average 3-month period) ; FF (number of females) = half of annual nests, assuming each female nests twice in a season.

Where no spoor were seen, the annual estimates are based on interviews with local people.

TABLE 5. *Estimates made by island Chiefs, and other experienced people, of Vela* (Chelonia mydas) *nesting activity in Maldives*

Atoll	Island	Years ago	Numbers Estimated Nesting[1]		Calculated Number Nesting Annually	
			Formerly	presently	Formerly	Presently
Thiladunmathi	Mulhadhoo	(50)	150-200/night	1-2/night ?	20,000 ?	400 ?
Baa	Dhunikolu	(40)	10-15/night	1/2-3/mo	400	6
	Fares	(40)	10-15/night	1/2-3/mo	400	6
	Kunfunadhoo	(10)	10-15/mo	3-4/mo	150	40
	Maadhoo	(40)	10-15/night ?	2/mo	400 ?	24
	Maarikilu	(40)	10-15/night	1/2-3/mo	400	6
	Miriyandhoo	(40)	10-15/night	1/2-3/mo	400	6
Ari	Dhalgathi			2-3/yr		3
	Hurukuelhi			2/mo		24
South Male'	Raannaalhi			3/yr		3
	Vaagali			2-3/mo		36
Laam	Dhabidhoo			1/yr		1
	Fonadhoo			1/6 mo		2
	Gaadhoo	(60)	10/night	1/night		200
	Gamu			1/yr		1
	Isdhoo	(10)	8/mo	3/mo	96	36
	Kalhaidhoo			1/yr		1
	Maabaidhoo			2/mo		24
	Mundhoo	(10)	1/mo	0		0
	Uvadevfushi			8/yr		8

[1] Where there is some uncertainity about an estimate it is indicated by '?'.

turtle, *Eretmochelys imbricata*. It was recorded by Deraniyagala (1956 : 13) and a variant, 'Carhambu', was reported by Laidlaw (1902). There is no obvious relationship between this name and any other used in the Indian Ocean (cf. Frazier & Salas, in prep.)

Occurrence: *E. imbricata* occurs throughout the Archipelago. Nests were found on Kunfunadhoo (Baa) and Baros (North Male'). Specimens were seen in Baa, North Male', South Male', and Laam Atolls, and Photographed at Vavu (Table 6). There is probably nesting, at least in small numbers, on most uninhabited islands in all of the atolls.

Population structure: Turtles with carapaces less than 60 cm long were commonly displayed for sale in the late 1970's (see photos in Colton, 1977), and such imature animals are still the most common to be seen for sale. The few animals we handled (Table 7) were all immatures. Scales, coloration, and other morphometric features are all normal for the species in the Indian Ocean.

Feeding biology: Stomach contents of JGF 4212 show entirerly sessile soft bodied invertebrates—sponges especially. This sample is being further analized. The predominance of sponges in the diet is expected for this

TABLE 6. *Specimens of* Eretmochelys imbricata *from Maldives*

JGF No.	Island (Atoll)	Date	Specimen	Remarks
		1983 November		
No no.	Felidhoo (Vavu)		Photographs	immature, photographed by H. Didi.
		December		
4206	Kunfunadhoo (Baa)	29	mandible	adult (?), found on beach, collected.
4207	Kunfunadhoo (Baa)	30	egg shells & embryo	exhumed from nest that emerged 30 Dec., collected.
		January 1984		
4212	Dhigalhi (?) (Baa)	4	carapace limbs, stomach contents	immature, collected (With H. Didi to send on).
4214	Baros (North Male')	8	alive	hatched on Baros, 18 months old, measured.
4215	,,	,,	,,	,,
4216	,,	,,	,,	,,
4217	,,	,,	,,	,,
4219	Hithdhoo (Laam)	12	alive	immature from nearby, measured.
4220	Hithadhoo (Laam)	13	alive	immature from nearby, measured, tagged, & released.
4221	Dhabidhoo (Laam)	13	carapace bones	immature, collected.
4232	Vaagali (South Male')	ca 1	scutless carapace	immature, collected by Sigee, measured.

species, and the rich coral reefs in Maldives must provide a vast and well stocked feeding area for *Eretmochelys*.

B r e e d i n g b i o l o g y : Nests of *E. imbricata* are made in the same areas as those of *C. mydas*, concentrated in a narrow zone from the beach crest to 10 m inalnd. The majority of nests are shaded, often heavily.

Only one confirmed nest was examined; JGF 4207, which emerged on 30 December, had about 125 hatched egg shells that were between 40 to 50 cm deep. Diameters of 2 unhatched eggs varied from 34.5 to 37.8 mm (Table 3).

L o c a l a c c o u n t s : Kahambu are reportedly caught most often at the end of the Northeast Monsoon, from December to March. This turtle is rarely seen outside the atolls. It is commonly seen near coral reefs of uninhabited islands. The northern reefs of Goi Fehen Fulhadhoo Atoll, *i. e.* Fulhadhoo,

TABLE 7. *Measurements and observations of* Eretmochelys imbricata *in Maldives (see Table 6 for more data).*

JGF No.	Measurements (mm): Carapace Length, Medial St	Medial Cv	Lateral St	Lateral Cv	Carapace Width St	Width Cv	Nt	Plastron Ln	Scalation: Cp	Head Po	Plastron: Im	Ax	In	Pa	Ig	1st Dent. Marg.	Comments
4212	545	570	550	580	430	490	3.5		N							6th	
4214		227		227		191	6.0	170	N	3/3	4/4	3/4	1/2	abs	lg	6th	
4215		249		249		204	10.0	187	N	3/3	4/4	3/3	1/1	abs	lg	6th	
4216		223		228		194	6.0	168	N	3/3	4/4	2/2	3	lg	5th	5th	
4217		242		247		209	7.0	188	N	3/3	4/4	3/3	1/1	5	lg	6th	
4219		325		327		312		246	N	3/3	4/4	3/3		8	lg*		* black spots
4220		378		385		333	20.0	281	N		4/4	2/2*	*	5	lg*	5th	* black spots

Abbreviations :

Measurements ; Medial (from midline of cervical to posterior-most projection of supracaudal) ; Lateral (from anterior-most projection of carapace to posterior-most projection of supracaudal) ; 'St' = straight line ; 'Cv' = over the curve ; 'Nt' = depth of supracaudal notch.

Scalation ; 'C' = carapace ('N' = normal) ; 'Po' = postoculars ; 'Im' = inframarginals ; 'Ax' = axillaries ; 'In' = inguinals ; 'Pa' = postanal ('abs' = absent, or length in mm) ; 'Ig' = intergular ('lg' = large) ; '1st Dent. Marg.' = First dentate marginal.

Fehendhoo and Goidhoo islands, are said to have large numbers, as are the reefs near Raannaalhi (South Male') and Mahibadhoo (Ari).

Mating has been seen in Baa Atoll in December-January. Very few Kahambu are known to nest, but when they do nest they seem to use the same beaches as do the Vela. The main period of nesting in Baa Atoll is said to be December, but they reportedly nest throughout the year. On Baros (N. Male') a nest was made on 17 November 1983; two nests in 1980 had a total of 365 eggs. Hatchlings, evidently of this species, emerged from a nest on Raannaalhi (S. Male') in February.

The attitude toward eating flesh of Kahambu varies : it may be relished just like that of Vela (*e.g.* Maavah Island, Laam), rejected while Vela is eaten, or neither Vela nor Kahambu may be eaten. Representatives of nine different islands (7 in Laam Atoll) reported eating: both (6), Vela only (1), neither (2).

Records of poisoning from turtle meat in Maldives appear to be few. In 1978 there was a case in one of the southern atolls. The only turtle regularly implicated in cases of poisoning in the Indian Ocean is *Eretmochelys imbricata.*

Population size: Data on *E. imbricata* are inadequate to do more than guess about population size. With nesting evidently occurring in all atolls, but never in concentrations, there are likely to be hundreds of animals nesting each year.

Lepidochelys olivacea (Eschscholtz)

Common names: 'Va washi' is a name heard infrequently north of Male'. It means 'round frame', as in a drum, and evidently is used for the olive ridley, *Lepidochelys olivacea,* a turtle that is distinctively round in shape. It is also called 'Va' (or 'Wa') 'Washi Vela'.

First record: No specimens of *L. olivacea* from Maldives are known to exist, but at least two individuals have been photographed by NTHD. The carapace of one was about 25 inches (61 cm) in straight length and a life-size sketch of the other on 6 March 1977, has a straight length of nearly 44 cm. Both are below adult size.

Local accounts: The color of 'Va Washi' is said to be similar to that of Vela, *C. mydas,* although, lighter or more yellow, and it is samller in size. Neither nestings nor gravid females have been seen. There is no particular season when these turtles are reported to be more common, but they are said to be mainly in the lagoons, particularly in the deeper areas where there are plants. Stomach contents include sea weeds. This turtle is occasionally caught for oil, but the flesh is considered to be poisonous. Not one of a dozen Island Chiefs from Laam Atoll had any knowledge of this turtle, and it seems to be unknown in the south of the Archipelago.

Caretta caretta (L.)

Common names: The only common name that has been reported for this turtle in Maldives is 'Varvohori' (Deraniyagala, 1956: 13). It is unlikely that this name is relevant, for there is only one confirmed record of this species in Maldives.

First record: On 13 December, 1981, NTHD photographed a female turtle about 2 1/2 feet (76 cm) long. The shape of the head, with a slightly protuberent beak, the posterior of the carapace, with a prepygal swelling, and the 5 pairs of pleural scutes all confirmed that this is *C. caretta.*

Dermochelys coriacea (L.)

Common names and local accounts: From the descriptions that were provided for a turtle called 'Musimbi', or 'Mussimbi' (Deraniyagala, 1956 : 13), there is a little doubt that it is the leatherback, *D. coriacea.* It was described regularly with several distinctive features: grows to large size (>1 m), has ridges down the back, with a pointed end to the shell, and produces large amounts of oil. Not infrequently the eggs or turtle itself are said to be poisonous. Two other themes are commonly recounted about Musimbi: the eggs are distinctive, for they are joined together or have hair—(or root-) like structures; they were even said to be blue coloured by one ex-Atoll Chief of Baa. A second point is that the turtle jumps when it is on land; impossible as it is, this claim seems to be based either on an inference from the condition of tracks or on the repetition of some remarkable account that now is legend.

A fisherman from Thuladhoo (Baa) had not heard of 'Musimbi' but a turtle 3 to 4 feet long (approx. 1 m) that was black and could be seen outside atolls was 'Dhevi'. This is the Divehi word for 'demon'. Clearly, sightings of this turtle are rare; a man of more than 60 years of age who lives on Gaadho (Laam) one of the best turtle islands, had never seen a Musimbi. Each of the few people that have seen this turtle have seen no more than one.

Curiously, 'Musimbi' is the Divehi term for Mozambique, being evidently a corruption or earlier form of it. African slaves did arrive in Maldives *via* returning pilgrims who acquired them on their *Hadj* to Mecca. There also seems to have been trade between eastern Africa and Maldives, and this could also explain the presence of cultural elements in Maldives that have an African origin. *D. coriacea* does nest in Mozambisque, but the turtle also nests in Sri Lanka, which is considerably closer to Maldives, so the origin of the name is not clear.

Local Legends and Lore

Aside from local accounts, summarized in the species accounts above, there are several local stories about turtles. These give an indication of how much interaction there has been between man and turtle.

An epic song tells of a shark fisherman who captures turtles for bait, including finally the 'King of Turtles'. Another homorous verse compares the chicken, which lays an egg and then makes a lot of noise cackling, and a turtle which lays more than a 100 eggs and says nothing.

There is a belief, at least at Laam Atoll, that a turtle will nest when an unmarried girl becomes pregnate. The turtles may even come up the beach in front of her house. At Maavah Island (Laam) the penis of a turtle is thought to be an aphrodisiac.

A practice of the past was to slaughter a turtle (Vela) and bless the ground with its blood before crops were planted. This predates the arrival of Isalm in Maldives and is understandably discouraged by the authorities nowadays.

When the airport was under construction on Hulule Island (North Male), a limestone turtle was unearthed. It is about 20 cm long and carved with realistic representation of body parts. The ventral surface has a small rectangular niche. In older times a holy verse from the Koran would have been placed in the niche and the effigy buried under the house in a mixture of Islamic and preIslamic beliefs to bring good fortune.

Exploitation

Human exploitation on marine turtles in the Maldives shows a pattern of progressively greater utilization and predation. When the islands were first colonized turtles may have been taken for local consumption only, and international trade was probably insignificant. Infact, depending on the strength of the religious beliefs at the time—*i.e.*, Hindu and then Buddhist—there may have been no significant killing of turtles for any motive. However, there is a simply insufficient information from this early period to know what form of exploitation was prevalent.

Expk itation for local trade and consumption must date back hundreds of years. Turtle eggs have been brought to kith and kin in the capital and also collected for sale between islands. This may once have been an important occupation at islands such as Mulhadhoo (Thiladunmathi) (Didi, 1983). Fifteen years ago 2,000 to 3,000 eggs were collected annually at Kunfunadhoo (Baa) and sold 6-8 eggs/Rf.

At some point, international trade in hawksbill shell developed, and the Maldives had international fame as a source. This was the case at least by the time of the Islamic era (i.e., 1153 A.D.). Local consumption of eggs evidently occurred, but the killing of the turtles was minimal. The interpretation of the Koran left turtle meat as 'haram', or unclean. Some turtles, mainly *Chelonia mydas*, were killed each year to provide bait for shark fishing and oil for preserving wooden boats.

In the beginning of the 1950's a local religious leader argued that turtle meat is not banned by the Koran. Although this may be the case, most oriental Moslems consume only eggs of sea turtles. The effect of resinding a previous ban was widespread killing of sea turtles for meat and a small amount for local trade.

In 1972 the tourist industry began in earnest, and nearly twice as many tourists visited in a year as there were citizens in the capital. A fisherman could suddenly earn the equivalent of a month's income (300 Rf in 1984) with the sale of a single carapace to a tourist. Immature turtles, that had previously been ignored, were caught and prepared in large numbers to sell to tourists—mainly Italian and German. The art of processing or stuffiing turtles was evidently learned from Japanese fishermen who were working in the areas. There are no figures for this trade, but the numbers of shells and turtles displayed, and the numbers of departing tourists that openly carried objects, was great, as Colton (1977) has described. In a single day in 1977 some 400 turtles were for sale in just shops near the waterfront on Male', (Colton, *in litt.*), so the total numbers for sale in just Male' was about 1,000 on that day.

Before 1968 raw tortoise shell was selling for 30-40 Rf/kg, but the competition for thick shell drove the price for better quality products up to 60/70 Rf/kg. By 1970 the central government had begun keeping records of tortoise shell exports ; the decade of figures available (Table 8), shows a rapid rise from 1970 to 1974 and then a gradual slowing down and decline. Although this is symptomatic of overexploitation, it is impossible to interpret these figures without knowing the volume of the direct exportation by tourists.

TABLE 8. *Tortoise-shell exported from Maldives (Data from the Ministry of Fisheries)*

Year	Metric tonnes	Value (Rf)
1970	0.680	22,260
1971	0.270	7,998
1972	0.270	7,350
1973	1.560	41,210
1974	5.580	324,962
1975	4.110	156,863
1976	6.440	542,299
1977	6.030	812,810
1978	1.895	181,237
1979	4.520	347,373
1980	0.040*	
1981	4 **	1,195

* worked tortoise-shell together with black coral.
** number of 'pieces' (*i.e.*, shells or stuffed turtles).

In late 1980 the export of whole turtle shells was banned, and a second regulation banned the catching, sale or display for sale of small shells (less than 60 cm for *Eretmochelys*, and 75 cm for other species—*i.e.*, *Chelonia mydas*; Didi, 1983). These seem to have reduced direct exportation by tourists, but even in 1984 the vast majority of shells displayed for sale in Male' or in tourist resorts are well below minimum legal size. The average tourist is not about to carry home a turtle shell nearly a meter long—no matter how exotic it seems.

waters they can be chased with a boat to tire and catch them.

There are no figures available to evaluate the total annual capture of turtles in the Maldives. Export statistics for tortoise-shell give no indication of exploitation on *Chelonia mydas* for local consumption or on turtles or turtle parts sold locally in the tourist trade. Estimates by islands chiefs, and other experienced people (Table 9), on turtle capture indicate tremendous variation from one island to another and it is uncertain how realistic

TABLE 9. *Estimates made by island Chiefs, and other experienced people, of turtle capture in Maldives*

Atoll	Island	Original Estimates		Calculated Annual Total	
		Vela (*C. mydas*)	Kahambo (*E. imbricata*)	Vela	Kahambo
Baa	Eydnafushi	< 6-40/boat/mo	6-40/boat/mo	180-1200	180-1200
			8/boat/mo		240
	Thulhadhoo	2-4/boat/day			
	(10-12/boat/mo)			100-120	
Ari	Dhalgathi	2-3/yr ?	2-3/yr	3	3
	Hurukuelhi	2/mo		24	
Laam	Dhabidhoo	1/yr ?	1/yr ?	1	1
	Fonadhoo	1/mo	1/mo	12	12
	Daadoo	0	0	0	0
	Gamu	0	0	0	0
	Isdhoo	3/mo*	30/yr	36	30
	Kalhaidhoo	2/yr	5/yr	2	5
	Maavah	6/mo?	6/mo?	72	72
	Maabaidhoo	0	0	0	0
	Mundhoo	0	0	0	0

* Two were caught in the first two weeks of January, one sell in Male' for Rf 200 (1US$ = 7 Rf).

In Maldives, marine turtles are caught most easily while nesting, and on many uninhabited islands every turtle that has the misfortune to nest there is likely to be caught. They are also caught in nets ; today this involves mainly accidental capture in shark nets. Turtles in waters less than 10 m deep can be hooked with grapnels or caught by free divers. In shallow there figures are. In several cases, however,

the estimated captures equal the estimated nestings.

LEGISLATION

Three legislative acts in Maldives have dealt specifically with marine turtles. On 6 February 1978 the Majlis (Parliament) passed Bill No. 24/78 which prohibits the catching of

Eretmochelys imbricata under two feet (61 cm) in carapace length, and all other turtle, less than 2 1/2 feet 76 cm) in carapace length. This is the only law which regulates the catching of turtles.

Bill No. 31/79 prohibits the export of any item of *Eretmochelys imbricata* that is in the raw form. Articles manufactured from *E. imbricata* are premitted.

A regulation of the Ministry of Fisheries, bans the same and display for sale of turtles below the size specified in Bill 24/78. This regulation has been in effect since 1980, but is not usually enforced.

In addition, the use of spear guns, spears and explosives have been banned recently by legislation. This limits the legal ways that turtles can be captured.

RESERVES

There are as yet no specific reserves in the Maldives. However, there are several situations which create areas which function as reserves.

On inhabited islands the Island Chief can set a policy to regulate resource utilization. The only example relevant to marine turtles is Gaadhoo (Laam). Here, the population of several hundred people decided that no nesting turtle will be killed, and only eggs will be collected. The eggs are auctioned and the proceeds put towards village needs, *e.g.*, the school or mosque. This arrangement is so well agreed upon that when, on a rare occassion, a male turtle followed a female to the beach and laid quietly at the foot of the beach while she ascended it to nest, the beach patroller at the time was uncertain as to whether stranded males were fair game (the situation being so unusual) and ran to ask the Island Chief what to do. The resolution was probably not in favor of the male, but he had gone back to sea before the patroller returned.

It is known that turtles nest in fair numbers at Gaadhoo and when boats of other islands visit, the residents are careful to inspect them to ensure that no turtles are being poached.

Only the Government can own land, but uninhabited islands are rented to citizens of Maldives (and only Maldivians) for 1 Rf each coconut tree on the island. The leasee, or his manager, sets the general policy of how the island and its reefs are to be used. Years ago it was usual that leasees would prohibit the killing of Vela on their island(s). This restriction is now unusual, if indeed it exists at all.

Some islands that were formerly uninhabited are now developed as tourist resorts. A few (the minority) cater to serious SCUBA divers and the resorts have built up reputations for the quality of their marine environments. At Raannaalhi, for example, the management has established a steep set of fines (e.g., $ 100) to discourage the collection of corals and mollusks by tourists. Other established resorts have similar, although less stringent rules.

Twenty-three small uninhabited islands have been leased by the Direction of Tourism (at 2 Rf/year for each) to keep them form being developed and maintain some uninhabited islands (Appendix). Mr. Ahmed Zahir, Director General of Tourism, is well informed about the necessity of maintaining reserves, and hopes to develop a more extensive system.

DISCUSSION

The relative commonness of *Chelonia mydas* and *Eretmochelys imbricata* and relative rareness of *Dermochelys coriacea* in the Maldives is consistent with the situations at other Indian Ocean islands. *Lepidochelys olivacea* is generally rare away from mainland areas, and that it apparently occurs regularly in Maldives may be a manisfestation of the proximity of major breeding areas on the Indian subcontinent. By the same token, *Caretta caretta*, with the largest population in the world at the north end of the Arabian Sea, should occur in Maldives more regularly than is the norm for other Indian Ocean Islands ; but this species is rare in the Archipelago.

The individuals of *C. mydas* which occur are comparable to those from other Indian Ocean localities. However, the coloration of adult females is more like that of adult males on Aldabra ; they are more melanistic than females in the western Indian Ocean. One could speculate that the Maldive turtles may show characteristics intermediate between those in the western Indian Ocean and those in the east Pacific (which are extremely melanistic) : *viz* there may be a cline in coloration across the Indo-Pacific.

Marine pastures are evidently few and of relatively small area in Maldives. Possibly they can substain the numbers of adult *C. mydas* that occur now-a-days, but it is unlikely that the Maldivian pastures could feed the much larger populations that are said to have occurred earlier in the Century. Like so many other island-breeding oppulations of this species (Meylan, 1982), it is likely that turtles migrate to Maldives from feeding grounds on larger continental platforms : the Gulf of Mannar is relatively close and a likely feeding area for turtles nesting in Maldivies. The contention that nesting is more common in the north and east of the Archipelago is consistent with this hypothesis. No tagged animals have been recovered, but given the relatively small numbers of *C. mydas* that have been tagged in the region this is not surprising, and well organized tagging studies are needed to investigate the dispersal and migratory habits. Some people believe that each island in the Maldives has its own population ; this would be consistent with what is known of other island populations, and several distinct feeding populations could be breeding in Maldives.

Several migratory habits, involving movements over large distances, have been explained evolutionarily by linking them to continental drift (Hirth, 1980 ?). However, it is unknown whether or not the Maldives were formerly closer to India.

The timing of the breeding season on Gaadhoo is apparently completely out of synchrony with that in Sri Lanka, and slightly later than that in Aldabra and elsewhere in the western Indian Ocean. However, much too little is documented precisely about breeding seasons in the Region—particularly the Maldives. Indeed, several accounts would have it that there are several different breeding seasons in different parts of the Atoll (this strengthens the idea of more than one population bieedingin the Archipelago).

Immature *C. mydas* are frequently displayed for sale, and there does seem to be a regular presence of this size class. The claim that immatures occur predictably in certain areas indicates that the Maldives is not just a breeding ground, but provides other habitats for *C. mydas* in the region.

Although the data are inadequate, there is little doubt that the Maldivian population of *C. mydas* has undergone a drastic decline in numbers. This pattern has been repeated throughout the Indian Ocean (Frazier, 1980) and is complicated by overexploitation and perturbations on breeding grounds but also on feeding grounds and other requisite habitats which may be distant and politically separate from the breeding area (Frazier, 1983).

Examples of *Eretmochelys imbricata* that are found in the Maldives are comparable to those from other Indian Ocean localities. However, despite its abundance, the species is poorly studied. There is evidently a resident population, with individuals in most age classes, feeding and living on the vast coral reef systems. Inter-atoll movements are posible: a turtle, apparently of this species, with a metal ring was caught in Baa Atoll in 1975, and in the 1970's *E. imbricata* were being raised, ringed, and released at Viligili, 100 km to the south in North Male' Atoll.

The timing of the breeding season is apparently comparable to that in the western Indian Ocean. Data on nesting will be difficult to obtain as this turtle is a dispersed nester that uses the same areas as *C. mydas*, which has concentrated nesting.

With centuries of exploitation for export and now intensified demands from a large tourist community, it is unlikely that the *E. imbricata* population has not been dramatically reduced from former levels. The absence of data makes it impossible to study historic trends or even to estimate present day population size.

If, indeed, *L. olivacea* occur regularly in Maldives this raises the question from where these turtles emanate, for breeding is not known in these islands. Flotillas of turtles, evidently of this species, have been seen at sea moving northward up the coast of eastern India (Silas *et al.*, 1984); the east Pacific populations of *L. olivacea* seem to occur in large numbers thousands of km from the continent. If the Maldives are within the range of normal oceanic distribution of *L. olivacea*, this warrants further study. If immatures of these turtles occur predictably in certain areas within lagoons and feed on plant materials, there are several more aspects of their basic biology that could be illuminated for the first time in this Archipelago.

Recommendations

Because less than 20 islands, from five atolls, were surveyed, it is not possible to determine which are the best turtle islands in the Maldives, but with the little information available there is no doubt that sea turtles were much more common 30 years ago than they are today. Both the Government and private citizens are interested in managing the turtle populations as natural renewable resources, and there are certain steps that must be taken immediately, before the possibilities of success are very much reduced.

Actions

1. Solicit information about turtles from island and atoll chiefs as well as turtle fishermen—a questionnaire was prepared in March 84 by JGF for this purpose.
2. Survey the islands known as 'best turtle islands' to establish the actual status of the populations.
3. Create sanctuaries or protected areas where turtles are (or were) found most abundant—notably nesting and feeding areas. Along with protecting nesting and feeding habitats for turtles it would be possible to protect the few small islands that remain with vestiges of the original vegetation. These islands have 'Loss' (*Pisonia grandis*) forests and often populations of nesting sea birds. Hurasdhoo (Ari) is an excellent example, and there are said to be other Loss islands: in a northern atoll, at Olhugiri (Baa), and in Suvadiva atoll in the south. The small, uninhabited atolls of Vattaru and Kaashidhoo should also be included in a sanctuary system.
4. Completely stop the killing of all nesting females for the next 15 years.
5. Establish closed and open seasons for collecting turtle eggs and fix the quantity of eggs that can be collected from each island.

6. Keep accurate records of all turtle products exploited, *i.e.*, numbers of turtles and turtle eggs taken with at least date and locality.

7. Prohibit, or at least carefully monitor, the sale of turtles and turtle eggs in Male'.

8. Establish high fines for: (*a*) tourist resorts and curio shops that keep shells for display or sale *e.g.*, by cancelling licences or stiff fines; (*b*) anyone catching or killing protected turtles or eggs; and (*c*) make island leases dependent on co-operation with the management scheme. Establish a system with rewards and punishments to encourage the support of a sea turtle recovery program. The rewards can be assistance to buy new boats, or special credits for the acquisition of engines or other desired goods. Also the public approval of the local leaders will be of significant importance.

9. Prepare and distribute a pamphlet for all arriving tourists explaining the necessity of protecting sea turtle—the largest wild vertebrate to be found in the islands, and informing them about the punishment applicable to transgressors of the laws and regulations in Maldives as well as in Europe.

10. Translate into Divehi the Sea turtle coloring book and other children's books, adapting it to local necessities and distributing them to Maldivian school children.

11. Organize a network system with the island and atoll chiefs to implement the program.

12. Utilize the money collected from fines to pay rewards and turtle management programs.

13. Begin pilot projects to investigate the potential of ranching hawksbills to supply tortoise shell for a cottage craft industry.

Justifications

1. Because the country is composed of more than 1,200 islands distributed in 21 atolls, soliciting information from local people will facilitate the location of important turtle areas.

2. To establish rational management for this natural renewable resource it is necessary to know what has to be managed.

3. The creation of protected areas, if properly established and managed, will speed the recovery of the populations and decrese the time until turtles can again be utilized, under a rational plan.

4. This measure, a complete ban on killing females, will be very unpopular, but if exploitation pressure continues at the present rate the future can only be devastation of turtle stocks. It is relevant to point out that several responsible, knowledgeable people have, in conversations, requested that the ban be instated.

5. Turtle eggs are an important protein source in the islands away from Male'; however, egg collection is so intense that hatchling recruitment is virtually eliminated on the few islands where concentrated nesting still occurs. The prohibition of selling eggs will stop the widespread collection of them, keeping the collection only for personal consumption. After studies it will be possible to establish which seasons have the highest hatching success, and it will be possible to allow the trade in periods

when the success is relatively low and there is no major recruitment for the turtle populations.

6. The only way to manage a resource over the long run is by having accurate detailed records of exploitation.

7. Because of the biggest human population and most economical power is in the capital, it essentially functions as a colonial power over the outlying islands, exploiting their natural resources. This measure, the control or monitoring of turtle products, will be easily implemented by controlling their arrival in the harbour and the fish market at Male'.

8. Written laws have little value if they are not followed and not enforced. If there is no intention to enforce a law it best not to expend the effort getting it passed and set a precedent of unenforced laws.

9. It is very important that tourists know that the Maldives is trying to manage its sea turtle populations, by rehabilitating decimated stocks, and the tourists can help—or at least not interfer—with the program. West Germans, an important percentage of the Maldivian visitors, will generally be very respectful if they are informed about the conservation program.

10. To create a real concern about the status of natural resources for the future, it is important to educate the future citizens of the country.

11. The political organization of the country outside Male' concentrates in the atoll and island chiefs; serious crime is not common in the Maldives, and the cooperation of chiefs will make it possible to control the situation in every island and atoll.

12. If a resource has been destroyed money will not replace it, but money will help development programs for rehabilitation and recovery.

13. The issue of turtle ranching and farming is very emotional and there are few precidents for success. There is potential for a ranching project in Maldives, and a *small* pilot project is needed to test the situation.

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APPENDIX

Islands Leased by the Direction of Tourism :

Huragadu (Haiyhuraafalhu)
Hathikolhu Finolhu
Raiyfalhu Hura
Boahuraa
Kanuhuraa
Kaihuhura
Kohdhipparu
Iruvaa Kaduhura
Akirifushi
Oidhuni Finolhu
Maniyafushi
Maimagu Finolhu
Furahani
Fuhgiri Finolhu
Feydhoo
Foojaadi Finolhu
Dhoonihoali
Dhefinolhudheatherey Finolhu
Tholhimaraa Hura
Aanugadu Finolhu
Hikey Finolhu (Galufalhugaionna)
Kohdhipparu Finolhu
Vaagali

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THE STATUS, CONSERVATION AND FUTURE OF THE SALTWATER CROCODILE *CROCODYLUS POROSUS* SCHNEIDER IN ORISSA

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ABSTRACT

The Saltwater Crocodile in Orissa suffered a dramatic decline in numbers as a result of a combination of poaching and habitat loss. At present the Government of India/FAO/UNDP assisted State Project will give guarantee to the continuing existence of the remaining populations of *C. porosus* along with their habitat in Orissa.

INTRODUCTION

IN Orissa, Bhitarkanika Wildlife Sanctuary is the only mangrove (estuarine) forest which holds a good number of the Saltwater Crocodile. To save this greatly endangered species from extinction, a conservation programme has been intiated by the Government of India through the State Forest Department, Orissa. This Project was started with active assistance from the Food and Agriculture Organisations of the United Nations Development Programme. The major achievement of this Project in its first phase has been to 'rear and rehabilitate' the Saltwater crocodiles. The future programme will be commercial farming of the surplus crocodiles which will definitely guarantee the future of both the crocodile population and the mangrove habitat.

I acknowledge support from the Government of Orissa (State Forest Department) and Govt. of India.

STATUS

The Bhitarkanika Wildlife Sanctuary and to a lesser degree the Bay of Bengal coast of Balasore District, Orissa are the remaining estuarine forests where the Saltwater Crocodile is seen. In the postwar period, due to indiscriminate hunting for hides for luxury leather market as well as over exploitation of mangrove habitat, the numbers of crocodiles declined drastically. Prior to 1973, there was no precise data on the position of the Saltwater Crocodile in Orissa until the visit of Daniel and Hussain (1973). Later Daniel and Hussain (1975) reported the presence of a number of Saltwater Crocodiles both adults and juveniles in Bhitarkanika. Bustard (1974) noted the presence of a viable number of *C. porosus* in the main Bhitarkanika river systems and its associated creeks but still their status was considered most precarious. In the year 1976-'77 winter census of *C. porosus* revealed a low population of 29 breeding crocodiles, 6 sub-adults and 61 juveniles (Kar and Bustard, in press) in the entire Bhitarkanika Wildlife Sanctuary. But during the last census (Jan. '84), 13 sub-adults, 34 adults (males and females) and 165 young crocodiles were counted in the river systems of the Sanctuary. The recruitment of the young and the sub-adult crocodiles is due to the effective protection of the remaining breeding population and its nesting habitat/mangrove forest.

At Nandanakanan Biological Park of Orissa, there are only a pair of breeding size Saltwater Crocodiles and two sub-adult crocodiles which were collected from Bhitarkanika, and kept for exhibition as well as captive breeding purpose. It is hoped that the female *C. porosus* will lay viable eggs in the coming nesting/egg-laying season (May '85).

CONSERVATION

A programme for conservation of the Saltwater Crocodiles and its habitat was mooted in the year 1975. The entire mangrove habitat was declared as Bhitarkanika Wildlife Sanctuary on 22nd April 1975 to protect these Saltwater Crocodiles. A Saltwater Crocodile Research and Conservation Project has been established at Dangmal, close to main Bhitarkanika river inside the Sanctuary by the Satate Forest Department and this is being financially assisted by the Central Government. Strict laws has been enforced by the State Forest Department, not to allow any poachers to enter inside the Sanctuary and to do any illegal traping and killing of crocodiles. Wildlife (Protection) Act-1975, prohibits the killing of the Saltwater Crocodile which is also included in the Schedule-1 of the Act.

Now, the adult, sub-adult and juvenile crocodiles are well protected in the sanctuary and every year, since the start of the project 250-300 eggs are being collected from the forest blocks of the Sanctuary for Project Hatchery incubation. To build up the depleted wild populations of *C. porosus*, 350 juvenile crocodiles (1.5 m size approx.) were released into the creeks of the Sanctuary. Further, a few more crocodiles including both males and females, are planned to be released into the wild in future. At present, 625 crocodiles of hatchlings to tenth year age group, including two white crocodiles (one sub-adult female and the other one is a hatchling) are being reared in the rearing pools with sound husbandry conditions.

RESEARCH

This Research and Conservation Project is the first of its kind in the country. The author is in charge of this Research Centre since its inception and has taken up an intensive study on *C. porosus* both in captivity and its natural estuarine habitat. Collection of wild-laid eggs for project Hatchery incubation, incubation of these eggs, rearing the young in the rearing pools with best husbandry conditions and release of the captive reared crocodiles into the wild have already been achieved successfully by this Project. Studies on the nest/nesting, parental care, food and feeding of the captive reared crocodiles and behaviour of both captive and wild crocodiles have been taken up and the scientific research data was compiled into a Ph. D thesis 'Studies on the Saltwater Crocodiles, *Crocodylus porosus* Schneider' by the author and the author has been awarded the Ph.D. degree from the Utkal University, Orissa. Moreover, regular tracking and sightings of the rehabilitated crocodiles in the wild has been taken up at regular intervals.

In the last nesting egg-laying season of the Saltwater Crocodile, attempts were made to take up experiments on the effect of incubation temperature of the eggs on sex determinations. A clutch of 30-eggs, collected from Kalibhanjadian forest block of the Sanctuary were brought to Wildlife Conservation Division Office at Chandabali and were kept in three incubators in three temperature gradiations (32-33°C, 33-34°C and 34-35°C). Hatching commenced after 76 days of incubation and 16 hatchlings hatched out including one white hatchling which is perhaps the third white crocodile in the world and second one in our rearing pools at Dangmal. Attempt will be taken to sex these crocodiles after they reach six months of age or more (anal probing is the best method to sex the crocodiles as they have no sexual dimorphism) to ascertain the sex ratio and the effect of temperature for control of sex. The main objective of this study is to find out whether the temperature at the time of incubation of eggs plays a role in sex determination. At present it has not been possible to maintain a proportionate sex ratio among the released crocodiles as per the 'rear and release' programme. At the Corcodile project. Dangmal till 1983, only 5% male crocodiles are found among the total stock and it is becoming quite impossible to maintain the required sex ratio among the released crocodiles. This experiment will definitely provide some data on control of sex among the crocodiles.

State Requirement

Protection of mangrove forest

Protection of mangrove forest is most important for further success of the Saltwater Crocodile Project in Orissa. Unless, the habitat is fully protected, no crocodiles will survive and the conservation programme would be a failure. Perhaps, the best guarantee for the future of the area would be to iuclude the Bhitarkanika Wildlife Sanciuary, among India's Bishophere Reserves.

Extension programme

Since poaching of the saltwater crocodile usually happens with the assistance of the local people, it is extremely important for the Forest Department (Wildlife Wing) to start successfully a village extension programme on the saltwater crocodile in order to let the villagers participate in the Scheme, to start with at least a couple of crocodiles in village pools (pens) could be reared. Once, the villagers become a participant in the Scheme, it is in his own interest to assist in preserving the breeding stock (dewaard, 1975).

Social forestry

To keep the mangrove/estuarine forest intact, the State Forest Department would start as soon as possible the farm forestry scheme covering the periphery of the Sanctuary. This will no doubt be an alternate source of timber and fire wood to the local people, who primarily depend upon the mangrove forest for their day-to-day fire wood use. The 881 villages depending on the Sanctuary would require about 1,20,000 tones per annum of firewood to meet the firewood demand (Kanungo 1976). To provide 1,20,000 tonnes of firewood an area of 1,200 hectares has to be harvested by farm forestry scheme per annum. Government (Forest Department) should take up this scheme in this marginal and degraded land for safeguarding the future of the Saltwater crocodiles and its natural habitat.

Sanctuary management

Success of the Saltwater Crocodile Conservation depends primarily on the management of the Sanctuary. Protection of the mangrove forest based upon the management procedure of the personnel involved in it. This should be in a most planned fashion and the attitudes of the officers should be conservation oriented. The local people residing inside the Sanctuary may also be encouraged to get involved with the Conservation Programme.

Education

Importance should be given to educate and motivate the local people who are residing in and along the outskirts of the Sanctuary about the importance of the crocodiles as well as other wildlife and forest for their 'very' survival. Such publicity can be taken up by means of monographs, journals, slide shows and film shows T.V., media and also other feasible methods.

Tourism

The success story of the Saltwater Crocodile rearing and rehabilitation Project will no doubt draw the attention of the people in and outside Orissa as well as from overseas. Seeing them will help to educate and convince the people about the importance of wildlife conservation and may help remove their blind believes about crocodiles and other wildlife. Regulated tourism can be encouraged.

FUTURE

The future of the Saltwater Crocodile Project in Bhitarkanika Wildlife Sanctuary in Orissa is not only to ensure conservation of the species from past catastrophic decline of their population during the last 4-5 decades, but also to takeup farming of the crocodiles (as in Thailand, Papua New Guinea and African countries) to build up an export industry with a potential for foreign exchange earnings. This will help to educate the people, particularly the weaker sections of the society by their keen involvement in the Project and ultimately, they will certainly be benefited financially.

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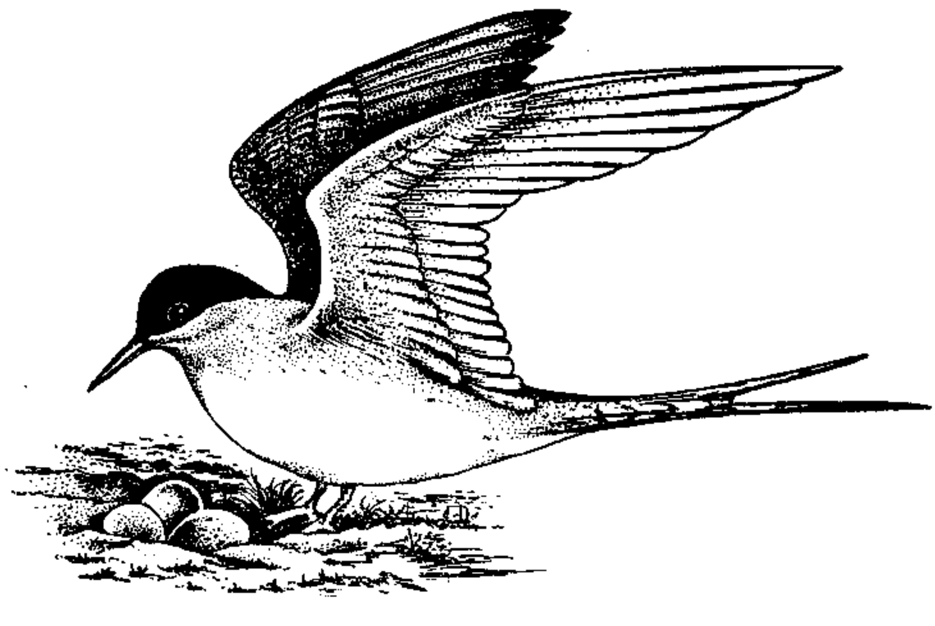
Other Marine Vertebrates and Invertebrates



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PROTECTED ENDANGERED SPECIES IN THAILAND WITH SPECIAL EMPHASIS ON MARINE SPECIES

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ABSTRACT

There is a wide spread concern among the people in Thailand on the deterioration of the natural marine habitats and the rapid diminishing of many marine species. The paper reviews the history on the conservation practice of aquatic animals and emphasises on certain marine species such as the sea turtle and the dugong or sea cow. The recommendations for conservation and protection of endangered marine species are on the following: First the government should urgently set up a national policy for conserving and protecting wildlife as well as the aquatic animals. The other recommendations are on the strengthening of the existing law enforcement, the updating of the conservation and protection laws, the establishment on more marine parks and their effective operation and increasing public awareness of the conservation of the aquatic organisms. The government should also actively participate with CITES.

INTRODUCTION

WITH the rapid population growth in the last three decades, Thailand faces a severe physical and biological deterioration of the environment. The destruction of the country's natural resources such as forests, water resources and others is increasing at an alarming rate. The need of the land for increasing food production, for sheltering, and for industrial sites has led to the destruction of forest lands. This in turn has destroyed the natural habitats of wildlife.

The cause of the extinction of wildlife in Thailand can be categorised under two headings. The first heading classifies the direct causes such as uncontrolled hunting, the collecting and destroying of eggs and offsprings, natural disasters, accidents and so on. The second category concerns the indirect causes, namely the destruction of the natural habitats, the increased use of hazardous chemicals and pesticides. It is estimated that the rate at which wildlife is decreasing in Thailand is not less than 5 per cent per annum. There are 27 species of mammals, 11 species of reptiles and 15 species of birds which are considered as endangered species. There is, however, no report on the endangered species of fish and other marine organisms (Inkapathanakul, 1981).

HISTORICAL BACKGROUND ON THE WILDLIFE CONSERVATION AND PROTECTION IN THAILAND

1. *Terrestrial wildlife protection*

The historical background on wild animal protection in Thailand can be traced back to before the year 1900, during the Absolute Monarchy Period. It was only the elephant that was well protected. Thai King as well as the common people used elephants in war, for transportation, and as a symbol of the King's greatness and sacredness, especially the white elephant (Khambanonda, 1972).

After the constitutional monarchy period, government awareness on the protection of wildlife in Thailand is reflected in the Wild Animal Reservation and Protection Act. B.E. 2503 (1960). This Act was proclaimed into law on January 1st, 1961. The law gives the power to the Minister of Agriculture to make a list of reserved and protected animals by ministerial proclamation.

In the 1960 Act, only 8 species were listed as reserved wild animals. However, the list in first Ministerial Regulation (1961), divided protected wild animals into two categories : the first category consists of 39 species and the second category of 18 species.

Nevertheless, for about 11 years after the first Ministerial Regulation was passed, the results still showed that the destruction of wildlife had not decreased. Many of the listed animals had been destroyed and some are extinct. Thus, the first Ministerial Regulation was replaced by the sixth Ministerial Regulation in B.E. 2515 (1972). This Regulation increased the numbers of protected wild animals of the first category to 118 species and of the second category to 30 species.

In order to extend the protection to the carcasses and dry specimens of the protected species, the eighth Ministerial Regulation was established in B.E. 2516 (1973). This Regulation covered 148 species of both groups.

However, with this regulation, the situation with regard to wildlife destruction in Thailand did not improve. Thus in the year 1975, 1978 and 1980, three Ministerial Regulations (numbers 10, 12 and 13) were proclaimed. In every one of them, additions were made to the list of protected species. In the thirteenth Ministerial Regulation (1980), the list of protected animals are arranged according to their taxa. This regulation also takes into account people who are willing to breed protected species for commercial purposes.

2. *Protection of aquatic animals*

The history on the conservation practice regarding aquatic animals in Thailand can be traced back to the Sukothai Period (1251-1350). It is a customary practice in Thailand that a monastery is a holy sanctuary for wildlife and aquatic animals (Alexander and Robbins, 1981). In the present day anyone who pays a visit to the temples in Bangkok can see many fishes and turtles or even crocodiles, in the ponds within the temple's compound. These ponds can retain water during the dry season and they serve as a refuge for aquatic animals throughout that period. There is also a custom in Thailand that the people should release birds and fishes when celebrating the Thai traditional New Year on April 13. Many of them are released into these ponds, and more of them into rivers throughout the country. When the rainy season comes, these fishes escape through the flood water into the rice fields and streams nearby. They then reproduce and increase in number. Thus, one can imagine that the cultural heritage in Thailand can help, protect and conserve the population of aquatic organisms.

In modern times, the conservation of aquatic animals was started from the time when the present King's father, Somdej Pramahitalathibes Adulyadejvikrom (Prince of Songkla), donated money to be used as fellowship for two Thai students to study abroad in the field of fisheries (Department of Fisheries, 1981).

In 1947, the fisheries Act B.E. 2490 (1947) was promulgated. The main objective of this law is to protect aquatic organisms for future utilization. This Act has divided fishing ground into 4 types, amongst which conservation areas are also specified. The law gives the power for granting permission to exploite the fishing grounds to the provincial authorities. Preservation areas, such as the temple boundaries, the areas close to the gates of a reservoir and so on, are prohibited for fisheries. It is also prohibited to use dynamites or poisonous materials as a means of catching fishes. Those who violate the law are subject to penalties.

In B.E. 2496 (1953) this law was amended as proclaimed in the Royal gazettee on September 17, 1953. It was then called The Fishery Act. (2nd Version) B.E. 2496 (1953). In the conservation section, this law forbids anyone to dry ponds or reservoirs in protected areas in order to catch fishes. It also increased the penalties for those who use dynamite or poisonous materials for fishing.

In B.E. 2515 (1972), there was widespread use of electricity, dynamite and poisonous materials for catching fishes. It was considered by the authorities as a serious destruction of the fisheries resources in Thailand. The Revolutionary Party of Thailand amended the second Fisheries Act B.E. 2496 (1953), and strictly prohibited the use of electricity and dynamite for fishing. It not only penalized the wrongdoer but also confiscated all his tools.

The Present Status of Protected Endangered Marine Species

Of all wild animals, marine organisms are the least protected species. Only two groups of marine animals are included in the protected species list of the Ministerial Regulation number 13 (1980), namely six species of sea turtles (protected animals of the first category) and one species of dugong or sea cow (protected animals of the second category). In the list of threatened wild animals in Thailand, Pitayakajornvudhi (Korbkate, 1980) includes one species of decapods, a sea grasshopper (*Emerita emeritus*) and two species of shell oysters (*Pinctada fimbriata* and *Pinctada lurida*).

The other threatened marine mammals such as porpoise and whales are omitted from the protected list of the 13th Ministerial regulation (Korbkate 1980). There are numerous marine organisms that are considered to be endangered species. Typical examples are the many beautiful coral reef fishes and shells which have now disappeared. These two groups are collected extensively and exported to foreign markets.

In this article two kinds of marine animals are selected as examples for our discussion. One of them is a marine reptile and the other is a marine mammal, the dugong or sea cow. These two species are believed to be threatened with extinction.

The Sea Turtle

In Thai waters there are at least 5 species of sea turtle. Among them only two species can be found in the Gulf of Thailand. They are the green turtles (*Chelonia mydas*), and the hawksbill (*Eretmochelys imbricata*). The others are on the Andaman sea coast line in the Indian Ocean which include the leather-backed turtle *Dermochelys coriacea* the largest species.

At present, there are no reliable statistics on the abundance of sea turtles in Thai waters. However, it is suspected that the number of these animals has decreased very rapidly. There are many factors that seem to support such a statement. The killing of sea turtles by trawlers is a common occurrence. The disruption of the egg-laying activities by coastal developments has recently been confirmed. However, the most severe cause of destruction is the selling of sea turtle eggs and shells by fishermen. All 5 species are seriously threatned with extinction from Thai waters (Conservation news, 1977).

Reliable evidence on the decline of sea turtles in the Gulf region is given by Polunin, (1977) who reported on his observations at Ko Khram. The statistics indicated that turtle eggs which were collected from this island in 1955-1957 was 1,71,402 eggs. In 1963-1965 the average was 1,85,000 eggs. However, in 1972-1973, the average was 50,850 eggs. This indicates a fourfold decrease since 1955.

Polunin (1977) explained that the cause of this decline is the increase in sea bottom trawlers in the Gulf region and the selling of the turtle eggs. He also speculated that the change in natural habitats on the sea shore might be one of the main factors, brought about by the building of a tapioca loading pier on the opposite site of the breeding ground and the loading activities which were going on for twenty four hours a day. He also suspected that the bright light from the pier and the noise from the motorboats passing by might be the cause for the turtles to frequently abandon their nesting sites.

In order to protect the turtles from extinction, the Fishery Act B.E. 2490 (1945), prohibits the collection or sale of marine turtle eggs without permission from the authorities. Unfortunately with a long coast line and with few marine inspectors, the power given by this law is never implemented. Thus, the government obliges the turtle egg collectors to release a certain number of young turtles into the sea each year. However, the situation has not improved satisfactorily. The Fisheries Department is now constructing hatchery ponds and preparing rearing grounds for sea turtles at Ko Man Nai ; Rayong Province. Private sector is also helping to increase the turtle population in the Gulf of Thailand. However, the most appropriate and effective way to conserve this species would be by implementing very strictly the Ministry Regulation No. 13, B.E. 2523 (1980), which lists most of the sea turtles as protected species of the first category.

The Dugong

Dugongs are usually found in the shallow warm waters in the seas of the Indo-west Pacific Region. The dugong was commonly found in the Gulf of Thailand about 30 years ago. The fisherman in the eastern coastline and the southern Provinces of Thailand caught dugong by fishing nets or by harpoons. Its flesh is considered delicious. It is also believed that dugong oil can effectively cure muscle pain and be used as a potent. Its hide can be used for various purposes (Thiemmedh, 1968).

During November 1981, the local newspapers in Thailand printed a short column reporting that the last dugong was captured east of Phuket Island by fishermen. An officer at the Phuket Marine Biological Center, Phuket Province, bought this animal and kept it in an aquarium for study. It is 1.80 meters long and its weight is 40 kilograms. This animal died a month later by disease infection. The Director General of the Fisheries Department in his interview to the local press, suspected that it might be the last one. Two years ago, a member of this species was also captured along the Andaman Sea Coastline. However, it died a month later in captivity.

Dugong was listed as a protected wild animal of the second category, in the 13th Ministerial Regulation (1980). It has never been reported as being found in the Gulf of Thailand within the last ten years.

Urgent need for protection of endangered Aquatic Animals

In reviewing both the Fishery Act B.E. 2490 (1947) and the Wild Animal Reservation and Protection Acts. B.E. 2503 (1960), one must realize that these two Acts do not cover a broad spectra of aquatic animals. Some of the endangered aquatic marine species, such as marine turtles and dugong, were not included prior to the Ministerial Regulation No. 13 (1980).

It is alarming to learn that the catch of bottom-living fishes in the upper part of the

Gulf of Thailand declined from 150 kg per hour fishing in 1965 to about 30 kg in 1981. The main factor was overfishing. However, one should also realize that the changing of marine habitats and the introduction of chemical toxicity into the marine environment are also important factors. There is strong evidence that many species of marine organisms in the Gulf of Thailand region are extinct, or nearly so.

SOME RECOMMENDATIONS FOR CONSERVATION AND PROTECTION OF WILD ANIMALS AND ENDANGERED MARINE SPECIES

1. *Set up a firm national policy for conserving the wildlife*

After reviewing two of the wildlife conservation and protection laws in Thailand, one can understand that Thailand urgently needs a firm national policy for conserving and protecting wildlife, both terrestrial and aquatic. Since the first Economic and Social Developing Plan in 1961, Thailand made it part of its National Policy to conserve and project the country's forests. The main goal of this plan was to conserve about 50% of the total land. This policy was, however, cancelled at a later date. The forest reserves were reduced and the government allowed illegal intruders to occupy forest land. At present (1981), at the end of the fourth plan, there are only about 25% of the forest lands left. At the present time there are about 24 wildlife sanctuary areas throughout the country and 10 established marine parks. However, illegal intrusions into the reserved areas have not decreased. Thailand urgently needs a firm national wildlife protection policy. This policy should lead to effective wildlife management.

It should also include the protection of forest and aquatic resources in the general plant.

2. *Increased conservation law enforcement*

Illegal hunting of protected wildlife species is all too common. Many protected wildlife species have been killed for food and for commerce. Some of them are exported into foreign markets. A statistics from the Forest Department indicates that during the first six months of 1981 (Jan-June, 1981), five species of protected animals, including 5 gibbons and 4 peacocks, were exported through the Bangkok Airport Check point alone (*Thairath* Newspaper Jan. 11, 1981). Thus it is necessary to increase law enforcement capabilities in order to protect both the natural habitats and the wildlife.

3. *Updating the conservation and protection laws*

As was already mentioned earlier, the Wildlife Reservation and Protection law and the Fishery Act were promulgated more than twenty years ago. Since there has been a rapid change in natural habitats and also more emphasis on the conservation concept, these two laws should be updated as soon as possible.

4. *Increase the establishment of the marine parks*

With the present overfishing of the marine organisms in Thai waters, the risks of the extinction of certain endangered species are increasing. Therefore, the establishing of the marine national parks in certain suitable locations are urgently necessary. The examples of the successful conservation of the spawning grounds of Chub—mackerels and sea turtles by the establishment of the marine parks are well understood. The main obstructions are the lack of funds and the well trained personnel to carry on the successful conservation-management jobs. Therefore, international organizations support are needed.

5. *Increasing public participation in wildlife conservation activities*

The success of wildlife conservation in Thailand needs more public participation. The monastery used as a sanctuary is one good example. The expansion of this concept to the general public through the assistance of the monks would be one effective way to protect wildlife in Thailand.

Public participation will also be improved by stressing conservation concepts in the existing curriculum at all education levels.

6. *Active participation with CITES*

Thailand had been a party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) since 1973, and is a signatory of this agreement. Under the general principles of this convention, no less than 200 species of wildlife and 50 species of plants are protected.

The Parliament had ratified this agreement in 1983 and the matter now rest on the implementation and active participation with that convention.

Conclusion

There is widespread concern among the people in Thailand on the deterioration of the natural habitats and the rapid decrease of many wildlife species. The main purpose of this paper is not only to urge the authorities to protect terrestrial animals from extinction but also to bring into focus some of the endangered marine species. It is necessary for Thailand to re-organize the structure and function of its conservation laws. It is also important to stop exporting protected species and endangered species. To do this effectively, Thailand should actively enforce the convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

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SOME OBSERVATIONS AND REMARKS ON THE ENDANGERED MARINE ANIMALS OF ANDAMAN AND NICOBAR ISLANDS

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ABSTRACT

The Andaman and Nicobar Islands being oceanic in nature, harbour a number of marine animals such as whales, dolphins, turtles, saltwater crocodiles, dugongs and robber-crabs. All these animals are now listed as endangered species. The author during his stay of three years in Andaman and Nicobar Islands recorded a number of instances of these animals. Also records and informations collected from others are included in the paper to make it more comprehensive. The paper also includes interesting observations on the anatomical details of false-killer whale which is recorded for the first time from the Andaman Sea, growth rate of saltwater crocodile in captivity, mode of capture and maintenance of live turtles by Bengalee settlers in earlier days and also on the habits of robber-crab.

INTRODUCTION

THE ANDAMAN and Nicobar Islands being oceanic in nature harbour such animals as whales, dolphins, turtles, saltwater crocodiles, dugongs and robber-crabs in the seas around them. All these animals are now protected under the Indian Wildlife Protection Act, 1972 since they are considered as endangered species. Earlier all these animals were indiscriminately killed for food, recreation, skin, oil and for other products. Due to the far flung nature of the Islands and also due to their remoteness and isolation from the mainland of India records regarding them are few and far between. Nevertheless, during the stay of the author in Andaman and Nicobar Islands for three years during 1975-78 some observations were made by him on them. Also information collected from other sources are presented in the paper.

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WHALES

Very little is known about the whales of Andaman and Nicobar Seas. Kloss (1902) has made a passing reference to the sighting of a killer whale. Two false killer whales *Pseudorca crassidens* (Owen) (Pl. I A) were entangled in a gill net at Port Blair on 27th July 1976. However, one of them escaped while being brought to the Jetty. A description of the animal is given below.

The specimen was 3.9 metres long and jet black in colour. The eye was small and teeth were small and blunt (Pl. I B). The teeth were 7-8 in number. The dorsal fin was small and sickel-shaped. The flippers were also small. The caudal fluke was well developed. The stomach was cylindrical in shape. When the stomach was cut open head of a *Barracuda* and tail portion of a Carangid fish were found in semi-digested condition (Pl. I C). The intestine was very long and the liver was triangular in shape (Pl. I D). Hundreds of live nematode parasites were seen in the stomach. The body wall was thick (50 mm) with blubber.

Some of the measurements in mm taken of the Carcass are given.

Total length	3962
Distance from the tip of the snout to the origin of the dorsal	1395
Distance from the tip of the snout to the eye	481
Distance from the tip of the snout to the angle of the mouth	329
Distance from the tip of the snout to the anterior insertion of the flipper	575
Length of flipper	428
Breadth of flipper	201
Width of whale	657
Breadth of the dorsal fin	428
Height of the dorsal fin	228
Distance between the posterior margin of the flipper and the anterior margin of dorsal fin	714
Distance from the posterior margin of the dorsal fin to the notch of the caudal fluke	1828
Width of the caudal fluke	228
Length of the largest tooth	98
Diameter of the blow hole	47

Remarks

False killer whale has a world wide distribution. It is a truely oceanic form and gregarious in nature moving in schools (Fraser, 1938). On the Indian side it has been reported from the neighbourhood of Trivandrum by Fergusen and Lydekar (1903) and also by Dawson (1911). Silas and Pillai (1960) have recorded the stranding of two specimens from Pozhikara north of Cape Comorin. The other records of *P. crassidens* from the Indian region are those of three schools stranded on Sri Lanka coast and reported by Pearson (1931) and Deraniyagala (1945). The present one is the first record from the Andaman Sea.

On 7th March 1983 two false killer whales were stranded near Shastri Nagar (32 km from Campbell Bay). Both the animals died sometime after stranding. The male measured 4.57 metres and the female 4.87 metres in length.

CROCODILES

Andaman and Nicobar Islands are famous for the salt water crocodile *Crocodylus porosus* which grows to a large size of over 8 metres in length. Due to its valuable leather it was much hunted and the numbers dwindled alarmingly.

Whitaker and Whitaker (1978) have furnished the following figures regarding Crocodile population of Andamans.

Area	No. of breeding females	Total No. of crocodiles
North Andamans	50	150-200
Middle Andamans	20	50-100
South Andamans	10	20-30

The above figures very much reveal the effect of human interference since the number of crocodiles is inversely proportional to human settlement. The chief causes for decline are indiscriminate hunting for hide, loss of habitat due to land reclamation programmes, drainage of swamps and finally clearing of the mangrove swamps. Unfortunately the ecological significance of mangroves as barrier to cyclone damage, beach erosion and as a natural spwaning and nursery grounds for many species of marine fish, prawns and crabs has not been properly appreciated.

During the authors stay at Andamans a small crocodile measuring 1.52 metres in

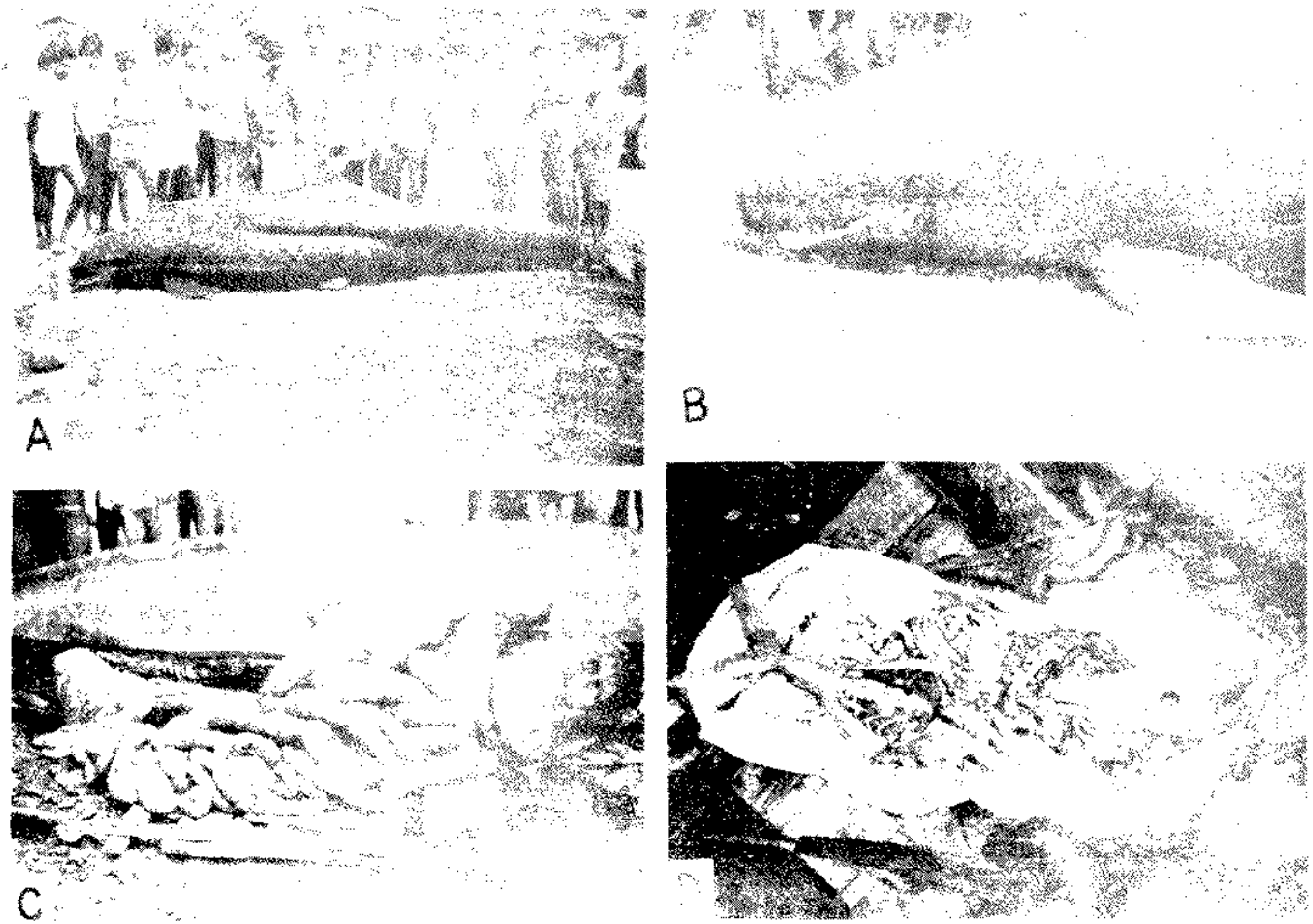

PLATE I. A. *[illegible]* [illegible]; B. Head portion showing small eyes and teeth ; C. Viscera of the animal showing the stomach, intestine and ovaries and D. Stomach cut open to show semidigested fish.

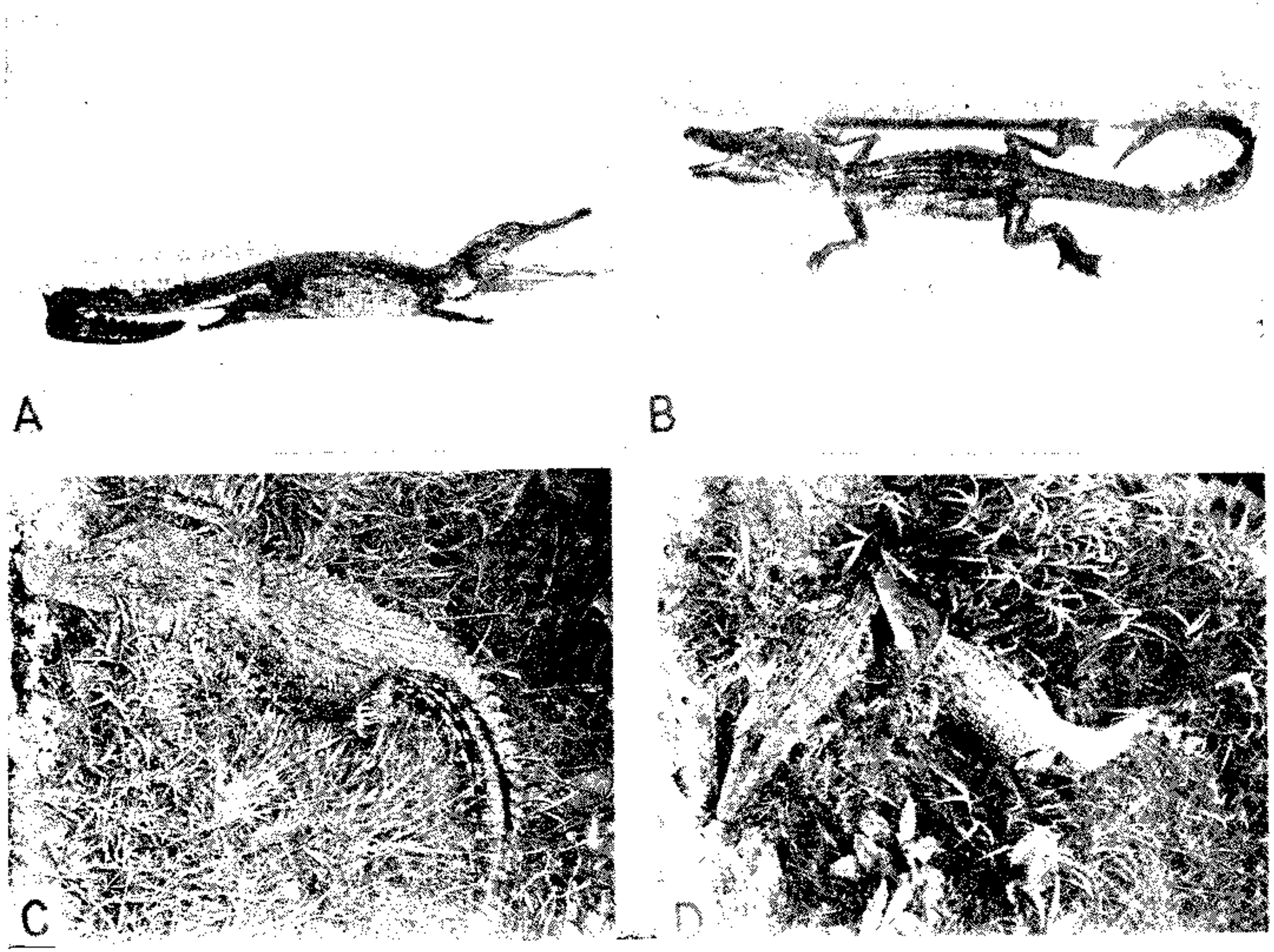

PLATE II. A, B. Baby crocodiles and C, D. Crocodiles from the Andaman Zoo.

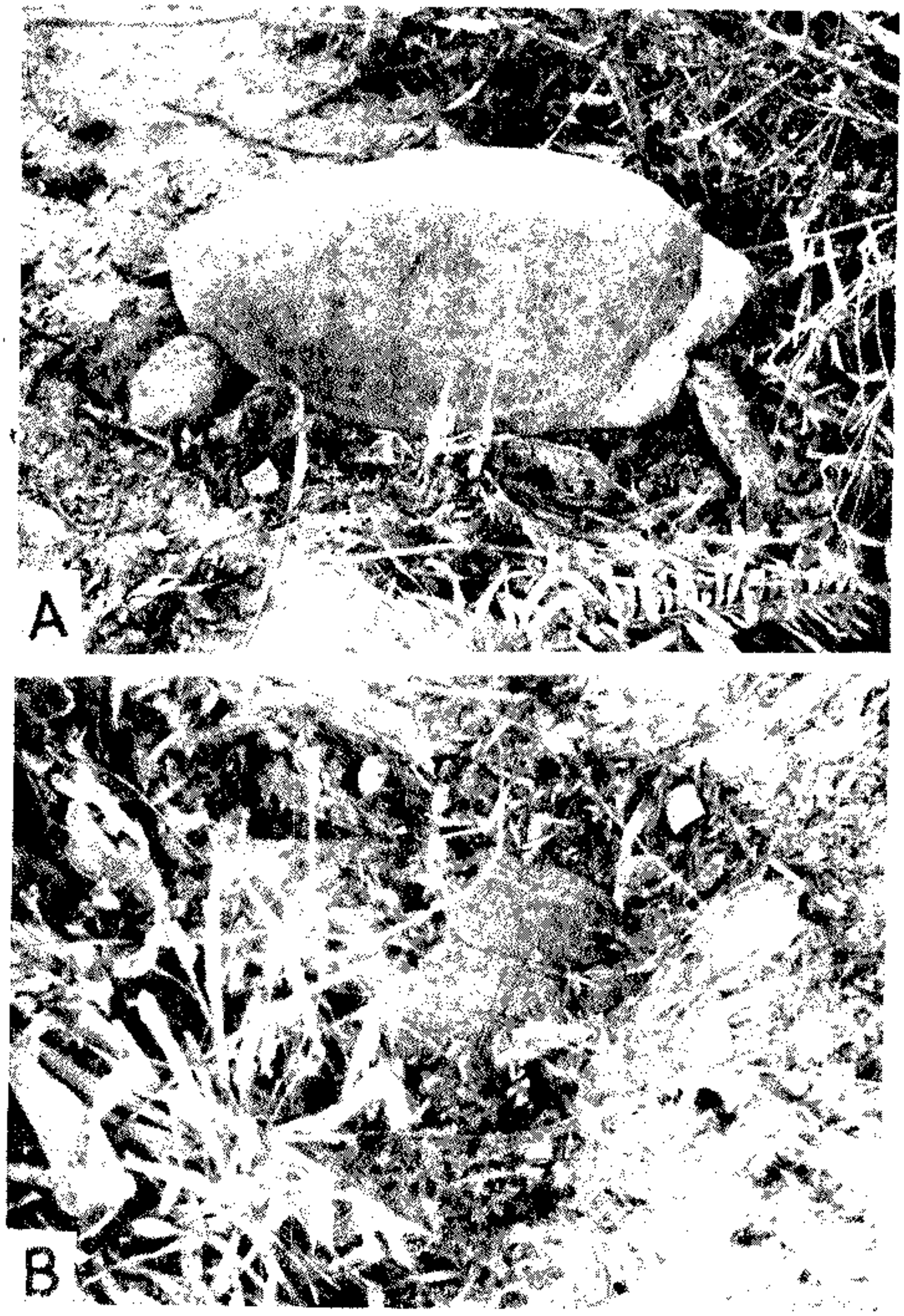

PLATE III. A. *Chelonia mydas* and B. *Chelonia mydas* tied to the ground and covered by twigs.

length and weighing 12 kg was caught in a fishing net at Corbyns Cove which is a prime tourist centre where people take bath in the sea. This was brought to the notice of the Fisheries Department and it was promptly released back into the sea. During the three year period four instances of crocodiles attacking man were reported, all from North Andamans. At the end of 1975 a small baby crocodile measuring 280 mm. in length was brought from North Andamans and presented to the Deputy Commissioner who handed it over to the Zoology Department of Government College. Due to feeding problems the baby crocodile died after a week (Pl. II B). The webbed feet are clearly seen in the Photograph.

The Andaman Zoo of the Forest Department at Port Blair was maintaining some crocodiles (Pl. II C, D). One crocodile brought on 28th July 1976 was 381 mm. in length and was estimated to be four months old. This was kept in a separate enclosure and daily fed on deer meat. The total length from the tip of the snout to the tip of the tail were recorded every month. From Table 1 it will be seen that there was an increase of 635 mm in a period of 13 months. The rate of growth in captivity works out to be 48.8 mm per month.

TABLE 1. *Length measurements of* Crocodylus porosus *in captivity*

Date	Length (mm)
28- 7-75	381
29- 8-75	457
27- 9-75	.. 527
27-10-75	.. 577
25-11-75	.. 609
28-12-75	.. 660
30- 1-76	.. 711
28- 2-76	.. 762
15- 6-76	.. 927
2- 7-76	.. 939
12- 8-76	.. 965
1- 9-76	.. 1016

On the night of 9th October 1983 a crocodile measuring 1.82 metres got entangled in a gill net near Magar Nullah which is three kilometers from Campbell Bay. Probably it was attracted by the fish which were entangled in the net. By morning it died. The same was collected by the Forest Department. On 13th October 1983 one more female crocodile measuring 4.57 metres was washed ashore near Magar Nullah. This was brought to Campbell Bay by the Forest Department staff. It was found that the crocodile was injured by a sharp weapon like a spear on its head. It was interesting to note that from the dead animal one toe was removed from each limb. The toes were probably collected for witchcraft by the settlers from Ranchi.

SEA TURTLES

Turtles of South Sentinel Island which is 100 km south of Port Blair have been commented by Davies and Altevogt (1976). According to them Green Turtle weighs upto 1.2 tonnes. Bhaskar and Whitekar (1983) have given information about sea turtle resources of Andamans. The author during his visits to Wandoor in South Andamans has observed big green turtles (Pl. III A) caught by the Bengalee settlers and kept alive. Thick ropes were fastened to the fore limbs and then securely tied to the pegs driven to the ground. Over the turtles some twigs and shrubs are cut and put to give them shade (Pl. III B). Wandoor area looked like a grave yard for turtles with all the bones scattered everywhere. The tribals used to spear them when they come ashore to lay eggs. The Bengalee settlers used to turn them quickly upside down when they come to lay eggs. Later they bring them to their settlement and keep them alive in the manner described above. While snorkeling on the reefs at Campbell Bay on 1st March 1977 the author has seen a medium sized turtle. Hatchlings of leather-back turtles and olive ridley were collected from Gandhi Nagar which is 30 kilometers from Campbell Bay. The people of Nicobar Island use green turtle shells for ornamental purposes.

Dugong

Kloss (1902) mentioned about the occurrences of *Dugong dugon* in Andaman Islands. In the Little Andamans there is a creek known as Dugong Creek due to the past presence of dugongs there. Ongee tribes living there used to catch them to eat and later keep the lower jaw in front of the huts to ward off evil spirits. During the stay of the author only one *Dugong* was caught near Aberdeen Jetty in 1976. It was later released into the sea. In 1967 one *Dugong* was caught at Terressa and again in 1976 one *Dugong* which was 2.75 metres was caught. Four dugongs were caught at Diglipur during the years 1960-66. In 1977 fishermen of Campbell Bay caught one *Dugong* and tried to sell the meat in the market. They were caught by the Forest Department staff and fined for it. In 1981 one more *Dugong* was caught in a fishing net at Vijay Nagar 18 Kilometers from Campbell Bay. In the Office of the Assistant Commissioner at Nancowry there is a good photograph of a *Dugong* caught there. From the above stray records it is seen that the *Dugong* is distributed from the North Andamans (Diglipur) to the southernmost group of Nicobar Islands (Campbell Bay).

Robber-Crab

The robber crab or coconut crab *Birgus latro* is found only in the South Sentinel Island in the Andaman and Nicobar group of Islands. According to Davis and Altevoget (1976) it is found during day and night in South Sentinel Island whereas in other Pacific Islands it is nocturnal. It is distributed in the Indo-west Pacific region and according to Motoh (1980) this species is in danger of extinction. It is also eaten in Philippines. Drs. Davis and Altevogt after their second expedition to the South Sentinel Island in 1974 left one live specimen of *Birgus latro* at the then Research Centre of the Central Marine Fisheries Research Institute, Port Blair. This was daily fed on coconut and lived for several days. When left on a coconut tree it used to climb the tree fast.

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Proc. Symp. Endangered Marine Animals and Marine Parks, 1985, 1 : 341-344

THE WELFARE AND CONSERVATION IMPLICATIONS OF CLEANING OILED BIRDS

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This whole question finally came to the attention of the general public when the first major oil tanker incident occurred in 1967; the Torrey Canyon grounded off the South-west coast of England, spilling 1,19,000 tons of Kuwait crude. At that time, there were estimated to have been at least 9,000 bird casualties, representing 17 species. The French League for the Protection of Birds were reported to have received 651 birds, of 11 species, from this number only 26, or 4%, survived; similarly, figures from the Royal Society for the Prevention of Cruelty to Animals show that of nearly 8,000 birds received in its establishments, 450, or 5.7%, were still alive 3 months later, however, many more must have died before they were eventually released. The Royal Society for the Protection of Birds estimate that 3% were finally released.

Again, in 1969, at Santa Barbara, California, an experience involving 1,500 birds returned an even worse success rate, that of 0.1% ! Of course, these figures do not take into account birds which would have succumbed before reaching land. These statistics indicate that the then current cleaning methods were totally inadequate, and, although a viable technique has been developed, it has proved to be a costly and labour-intensive task, which can be a very considerable drain on resources. At this juncture, I must emphasise that cleaning oiled birds does not contribute to the solution of the oil pollution problem, it should never be considered as anything more than a salvage operation to limit the effects of pollution—priority must be given to prevention.

However, contemporary society runs on oil, and it cannot do without it. Conceivably, there may come a time when all dumping at sea will be eliminated and collisions, explosions, etc., will be dramatically reduced; yet, accidents will be caused by machine and human error, therefore, having a successful method of salvage would be invaluable.

In conservation terms, saving individuals representing rare species is undoubtedly useful, yet the animal welfare, or humane, argument is a little less obvious; in general, the species normally affected have large, mainly stable populations, and the number of birds ultimately released may represent only a small proportion of those affected. So, why not humanely destroy them, avoid the cost of cleaning, and eliminate any further suffering the process may cause?

First, when considering animal welfare issues, we should avoid becoming too involved in the question of species survival, and, thus, implying that the individual is of secondary importance, particularly if the species is common; the principle of animal welfare requires care of and consideration for, the single animal, Second, and this is certainly a big problem in the West, there are well-meaning members of the public who pick up single oiled birds and attempt to clean them, using methods now known to be quite inadequate—sawdust, china clay and, even, lard, have been used! Let there be no mistake, birds that are not cleaned properly will die, probably slowly, while suffering acutely. An organisation like the RSPCA, which develops an efficient and successful method of cleaning, and publicises it, creates a climate in which the public are more likely to accept it as the 'expert', and contact it when oiled birds are encountered, thus, these birds are treated properly, and humanely, even if they have to be killed.

Finally, why not destroy the animals, and eliminate any stress and suffering incurred during the cleaning process? Of course there is a degree of suffering involved, but we believe it is acceptable, because its duration is short and the suffering is not as great as one might, at first, think. It seems that auks (*Alcidae*) quickly adapt to unusual circumstances, and have been known to fall asleep, or preen themselves, in the middle of the cleaning operation.

Clearly, when resources are available, cleaning oiled birds is a valuable and worthwhile tool in the armoury of animal protection.

The Advisory Committee on Oil Pollution of the Sea established a Research Unit on the Rehabilitation of Oiled Seabirds at the Department of Zoology, Newcastle University, in November of 1967, and the cleaning method developed by the Unit forms the basis of that used by the RSPCA, although usage has resulted in refinements and improvements. I will be drawing, extensively, on the information contained in the Research Unit's reports.

There is a difference between the plumage of water birds and land birds; feathers of water birds are significantly more curved, press down on neighbouring feathers and are much less subject to disarray. Further examination of the fine structure of the feathers reveals that aquatic birds have an arrangement of barbules and hooks that make the feathers more coherent than those of land birds. Other factors also contribute to the greater water repellancy of aquatic birds. However, let us consider what happens when a bird becomes contaminated with oil; the orderly arrangement of feather barbules and matting feathers become disrupted, thus, the plumage becomes waterlogged and the bird needs to expend more metabolic energy in keeping warm, finally it has difficulty in flying and finding food. In severe oiling, the bird losses buoyancy, and has to use its wings to stay on the surface—if it fails to reach land it soon drowns, if not killed by hypothermia first. A further hazard the bird must face is the effect of any ingested oil.

In order to assess the likely effect of disasters involving oil around the India coastline, I have been in touch with Mr. Hussain, of the Avifauna Project at the Bombay Natural History Society, to whom I am most grateful, and he tells me that oil pollution has not, as yet, been a serious problem, partly because major oil slicks have not occurred, and partly because there are few pelagic birds visiting, or breeding on, the Indian coast. In fact, I understand that the only birds likely to be involved during an 'oil disaster' in India are, basically; gulls, terns, waders, petrels, pelicans and cormorants. Because of their habit of picking up food in flight, gulls and terns rarely seem to get more than patches of oil on their feathers, and these do not significantly inconvenience them. Waders generally feed along the shoreline, and if this becomes contaminated with oil they are unable to do so, therefore, the birds are inclined to move on to unpolluted areas.

Cormorants, on the other hand, certainly do appear vulnerable, although to what extent is unclear. I have to admit to no experience with regard to petrels or pelicans, but both species may well be vulnerable.

The danger is that India is in the process of exploiting off-shore oil, and it is possible that accidental spills could occur, the consequences of which may be such that the skill we are discussing would certainly be useful.

In an emergent situation in U.K. the sequence followed would be as follows:

The RSPCA, through the public, first becomes aware of an incident when contaminated birds start to be washed ashore. A number of different species of birds may be involved, but, because of their life-style and numbers, the auks (*Alcidae*) are most often affected. This group of birds spends a majority of the year at sea, only coming to the breeding cliffs to lay their eggs and rear their young. The most numerous of these is the guillemot (*Uria aalge*). A cleaning success rate of nearly 100%, for small numbers of contaminated birds, is common.

The next most likely species to be affected is the razorbill (*Alca torda*), but cleaning tends to be less successful, possibly about 40% success rate. Other auks are also vulnerable, but RSPCA do not deal with large numbers; whether this reflects the fact that species are less numerous, or do not occur to such a great extent in vulnerable areas, or simply that, once affected, they quickly succumb, because of their smaller size, is a matter of speculation. These include: the puffin (*Fratercula critica*), and the little auk (*Plautus alle*). Other marine species include ducks, such as scoters (*Melanitta* species), long-tailed ducks (*Clangula hyemalis*), and eiders; like the common eider (*Somateria mollissima*), and also the Shag (*Phalacrocorax aristotelis*). Probably the largest marine species RSPCA deal with is the gannet (*Sula bassana*). Some care needs to be exercised with this species. RSPCA Inspectors bring birds to the cleaning centre. A mobile receiption unit donated by Shell (UK), is used purely to receive birds, keep them warm, fed and medicated, prior to transport to the permanent cleaning centre in the South-west of England. Once a bird arrives, it is placed in a small cage, and given a kaolin-based antibiotic (Kaobiotic), which reduces the caustic effect of the oil and combats any enteritis which the bird might be suffering from. Choosing a bird which is fit for cleaning requires some experience. It is also important to protect the operator, and a strategically-placed elastic band is essential; care should be taken not to block the nostrils. After the birds are cleaned, they are left in a clean room, with some heat, to rearrange their plumage overnight. The next day, they are released onto an outdoor pools, with an edge, allowing the birds to get out of the water to feed. They would enjoy returning to an aquatic environment. All birds are ringed before release. After a day, or so, on the pools, and having been tested, they are taken to a stretch of suitable, unpolluted coastline, and released. It should be reiterated that cleaning oiled birds is not the panacea, but is merely a salvage operation. (An extract of part of the illustrated talke given by Mr. P. H. Vodden).

It is essential that marine birds, in particular, are returned to sea as quickly as possible. Factors such as their inability to cope with hard surfaces for extended periods and their propensity for becoming imprinted on their keepers are the major reasons. However, the bird's physical adaptations must not be overlooked; many workers, for instance, have commented on the adverse effect of captivity on organs such as the lateral nasal gland.

It is difficult to give a categorical success rate because of the number of variables involved; however, an experienced team, using appropriate equipment, can return release figures approaching 100% for a relatively low number of birds. This number is significantly affected if the birds have taken a long time to come ashore and are in bad condition. Also, some oils leave a waxy residue in the plumage and, despite rigorous and repeated cleaning, the contaminated birds, unfortunately, have to be humanely destroyed.

I have, as you have already realised, spoken only about marine species which have been affected by oil, so I will briefly cover the effect on birds found mainly on freshwater.

Most pollutants that affect inland waters are light, domestic fuels and freshwater species, particularly swans and dabbling ducks, are better able to cope with oiling; which can be dealt with by confining them in an outdoor enclosure, with food and drinking water, but without access to a pond, until the pollutant has been removed by the action of the weather and the birds' activities.

Having discussed the external condition, we must not avoid the very real problems associated with ingestion of oil; I have already mentioned that a kaolin-based antibiotic is used to considerable effect. Most ingestion seems to occur when the bird is first affected, and it is the period between ingestion and medication which is particularly important. If this period is protracted, damage to the gut wall can be irreversible—the oil literally burns it—and humane destruction of birds passing blood in their faeces is probably the only alternative to a slow and painful death.

It is unfortunate that the media only becomes interested in an incident if large amounts of oil, or accidents to vessels, are involved; I say unfortunate because it is usually not the amount of oil, but when, and where, the incident occurs that is significant for bird populations. For instance, in the Firth of Forth, near. Edinburgh in Scotland, 802 birds were killed in an incident where only 1 ton of oil was spilt; whilst this was significant for those species involved, it attracted little publicity.

I have twice said that cleaning birds should be viewed as a salvage mechanism, and must not supercede prevention. Any nation concerned about the effects of oil pollution would be advised to undertake surveys of beaches to ascertain the extent of the effect on bird species and populations, in this regard I would recommend the Beached Bird Surveys, carried out by the Royal Society for the Protection of Birds, which have provided the basis of our knowledge in the United Kingdom on the effects of oil pollution and other, natural or unnatural, disasters. This information is collated with other data and used to pressure Governments and industry to introduce strictes preventative measures.

I should mention that birds are not the only element likely to be involved; there are many vertebrates and invertebrates at risk, and not only animal, but plant species, as well.

Finally, may I suggest that in those cases where there must be a choice between salvage or prevention, the latter must take precedence, and the only commitment to the former may simply be to ensure a humane death for the oiled birds.

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ECOLOGICAL OBSERVATION ON THE ENDANGERED WHITEBELLIED SEA EAGLE *HALIAEETUS LEUCOGASTER* (GMELIN) IN THE SUNDARBANS, BANGLADESH

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ABSTRACT

The present work was done between December, 1980 and March, 1983. 3291 km of the forest edges of 1 km breadth were surveyed along the bank of the rivers and canals of the Sundarbans from wooden boats and launches. 62 whitebellied sea eagles were observed in surveyed area during the study period. The population density of the eagles was calculated as one individual per 53.1 km. Whitebellied sea eagle was found more in number towards the Sea-coast provided with keora forests and in fishing and fish drying places. Eagles became more active in the morning and in the evening. Marine fishes and snakes were the stable food items of these eagles. Breeding success was very low. Maintaining large trees in the eagle habitat and educational awareness among the people are the most important factors for conservation of Whitebellied Sea Eagle in the Sundarbans.

INTRODUCTION

ABOUT 36 species of Birds of Prey are known to occur in the Sundarbans, Bangladesh. Whitebellied sea eagle (*Haliaèètus leucogaster*) is one of the endangered raptor in the Sundarbans. Whitetailed sea eagle *Haliaèètus albicilla* (Linnaeus) of Europe is now endangered (Helander 1982). Mountfort (1969) visited the Bangladesh part of the Sundarbans in 1967 for 11 days in connection with the management of tiger in the area. He wrote in his book that the nests of whitebellied sea eagle are commonly found on the branches of trees which usually hang over the water from the bank of the rivers. But no such feature is found anywhere in the Sundarbans, though the eagles are seen to perch in the trees on the bank of rivers. Mukherjee (1969, 1975), Hendrichs (1975), Husain *et al.* (1983) and Sarker and Sarker (1981, 1982) did not give any information about the population status, distribution, food and feeding habits, activities and breeding biology of these eagles. However, it was necessary to conduct methodical survey of whitebellied sea eagle including other birds of prey in the Sundarbans. Hence, the author started detailed studies on the status, distribution, habitat, food and feeding habits, activity, behaviour and breeding biology of these whitebellied sea eagle in the Sundarbans.

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METHODS AND MATERIALS

The field work was carried out between December, 1980 and March, 1983. The survey along the edge of the forests on the bank of rivers was conducted mainly from wooden boats locally called 'TAPURIA' and dinghy canoes of 1.5 m $\times$ 0.5 draft and 6-10 m length manupulated by one or more boatmen, and launches of 2.5 m bean, 1.5 m draft and 9-11 m length with 3-4 crew. The speed of boats and dinghy canoes was between 3-5 km per hour and for the launches it was between 12-15 km per hour.

Observation in the forests was done on foot accompanied by armed guards for protection against tigers. Gumboots were used to protect the feet and legs from injury caused by countless mangrove pneumatophores.

Approximately 3,291 km of the forest edges of 1 km breadth were surveyed along the bank of rivers and canals of the Sundarbans. Observation was made with 8 $\times$ 22 roof prism and 20 $\times$ 50 coated field binoculars between 4 a.m. and 6 p.m. Canon F.1 35 mm with 55 mm wide and 200 mm autozoom telephoto-lens and 15 mm black and white and colour slide ektachrome and kodachrome 64 films were used for photography in the field and laboratory. Canon Super 8, 318 autozoom 9.5-47 mm lens movie camera with 8 mm colour kodachrome films were exposed for filming of raptors and their habitats. Food items preyed upon white-bellied sea eagle were recorded during the observation. Remains of food items in the nests were collected from the nest sites and preserved in 10% formalin and then they were identified in the laboratory, Department of Zoology, University of Dhaka.

Study Area

Sundarbans are located just south of the tropic of cancer at Latitude 21° 30 N and Longitude 89°E, at the southern extremity of the Gangetic Delta along the sea coast of the Bay of Bengal and extended about 80 km north from the Bay of Bengal.

The Sundarbans as a whole both in Bangladesh and India comprise of an area of 10,000 km² of which about 6,600 km² is land. The total land area of the Sundarbans forests in Bangladesh consists of 5030 km². The gross areas including khals and rivers are about 7129 km² (Hendrichs 1975). The boundary of the forests is mostly natural ones formed by the creeks rivers, estuaries, sea and to a small extent of artificial boundary lines. There are several fishing and fish drying places in different parts of the forests. The tidal water flows over the areas of forests twice daily and it persists for approximately about 6 hours. The rise and fall of tidal water vary between 1.5 m and 2 m. The salinity of the water increases and fertility of top soil decreases from the east to western part of the forests. There is no natural fresh water sources in the forests. The surface soil of the Sundarbans consists of tenacious clay loam and subsoil consists of alternate layers of clay and sand and more deeper is a mixture of compact shale and sand stone but no rock is seen anywhere in the forests.

Vegetation

A high percentage of the tree species growing in the Sundarbans produce pneumatophores which protrude out from the ground like innumerable inverted tent pegs. The prominent tree species in the Sundarbans are *Heritiera minor, Excoecaria agallocha, Rhizophora conjugata, Amoora cucullata, Bruguiera gymnorhiza, Phoenix paludosa, Carapa meluccensis, C. obovata Ceriops roxburghiana, Nipa fruticans, Sonneratia apetala, Typha elephantina, Orando karka, Saccharum cylindricum* etc. The height of the trees is generally 15-30 m from the ground. During monsoon from June to September and during thunderstorms in spring and autumn rainfall is an average 170 cm per day with variation between 120 cm to 250 cm (Chaudhury 1968; Hendrichs 1975). Floating population in the Sundarbans is about 20,000.

RESULTS AND DISCUSSION

Population density and distribution

In all 62 whitebellied sea eagle *Haliaeetus leucogaster* (Gmelin) were observed in the surveyed areas of the Sundarbans during the study period. Of these eagles 19 individuals were in Sarankhola, 35 in Nalianala, 5 in Chandpai and 3 in Satkhira ranges (Table 1).

Population density of whitebellied sea eagle was calculated as one individual per 53.1 km throughout the surveyed area. The density of the eagles in relation to different ranges was also calculated as one individual per 55.3 km in Sarankhola range, 1/39.1 km in Nalianala, 1/91.7 km in Chandpai and 1/135.7 km in Satkhira range.

Maximum distribution of whitebellied sea eagle was noted towards the sea coast and minimum towards the mainland. These eagles were also observed more in number along the bank of large rivers and large water mass at the junction of rivers where two or more rivers opened together. However, the eagles frequented along the periphery of the forests throughout the Sundarbans. Besides, whitebellied sea eagles are reported to be distributed scatteredly along the sea coast of Teknuf and char kukri-mukri off, Potuakhali outside of the Sundarbans.

In relation to the habitat it was found that whitebellied sea eagles were more common in old tall keora predominant areas where large water mass was available than Sundri and gewa predominant areas of small water mass areas.

In relation to food, whitebellied sea eagles were observed in different fishing and fish drying places and Mongla Port where food supply *e.g.* estuarine fishes and snakes was more easily available for them than elsewhere.

Variation in the population size of whitebellied sea eagle was also marked during the study period. Maximum number was found in summer months particularly between March and May probably due to presence of breeding couples and fledged young in and around the nest sites. In other months number of eagles decreased perhaps due to dispersal of young and breeding adults. Month wise population was 15 in January, 3 in February, 14 in March, 26 in May, 11 in July and 3 in December.

Activities

The activities of whitebellied sea eagle was observed in relation of different period of the day. More eagles were observed between 8 hours and 10 hours and between 12 hours and 17 hours of the day. During the above mentioned period, low tide usually prevailed throughout the forests and the eagles were more active in hunting and feeding. They remained in roosting places during high tide around the mid-day. This activity was probably observed in whitebellied sea eagles as well as in blackeared kites and brahminy kites. Eagles were observed: 10 individuals between 6-8 hours, 15 between 8-10 hours, 13 between 10-12 hours, 9 between 12-14 hours, 14 between 14-16 hours and 15 from 16-18 hours.

Whitebellied sea eagles were found to spend more time in perching than in flight. On the basis of 43 observations it was noted that 27 times the eagles were in perching condition and 16 times were in flight.

Eagles usually were observed to perch at a height between 4 m and 19 m from the ground. They mainly preferred dead trees for perching which were nearer to the water edge on the bank of rivers and canals. They usually perched as pairs on the top of trees from where birds can see the prey species in the water.

Habitat

The habitat of the nest site of whitebellied sea eagle at Hiron Point composed of approxi-

TABLE 1. *Observation of whitebellied sea eagle in different places in the Sundarbans between* 1980 *and* 1983.

Ranges	Places of occurrence	Date of observation	Total number	
Sarankhola	Supoti	20-1-1980	1	
	Supoti	21-1-1981	2	
	Kachikhali	21-1-1981	3	
	Sarankhola	25-1-1981	1	
	Mongla Port	24-1-1981	1	
	Bogi	26-1-1981	2	
	Cucumari	26-1-1981	7	
	Dublar Char	26-1-1981	2	
				19
Nalianala (Khulna)	Sutarkhali	3-3-1981	3	
	Kalabogi	4-3-1981	1	
	Nalianala	5-3-1981	2	
	Hiron-Point	6-3-1981	3	
	Hiron-Point	21-5-1982	4	
	Nilkamal Sanctuary	27-5-1981	4	
	Bandarkhal	27-5-1982	1	
	Putney Island	24-5-1982	6	
	Kaga	23-5-1982	3	
	Alticoup	31-5-1982	2	
	Shipsha	31-5-1982	2	
	Baniakhali	9-3-1981 and February 1983	4	
				35
Chandpai	Dhangmari	14-1-1981	3	
	Charputia	24-25-7-1981	2	
				5
Satkhira (Burigoalni)	Kodabak	6-2-1983	2	
	Kadamtala	26-1-1983	1	
				3
		Total		62

mately 80% of keora, 10% of Sundri, 8% of gewa and 2% of bain, kakra, pasur, goran etc. The height of the trees around the nest sites was between 10 m and 20 m from the ground. The diameter of the trees was between 25 cm and 125 cm at a height of 1 m above the ground. Territory of the whitebellied sea eagle was calculated between 3 km and 5 km around the nest. The territories of the eagles composed of 15 to 75% of water and the rest was forest land. Eagles preyed on the prey species from the water and utilised the forests for perching, roosting and nesting.

Food and feeding habits

Whitebellied sea eagle fed mainly marine snakes and fishes (Table 2). When they came up to the surface of the water. Besides eagles fed on dead snakes and fishes floating in the water and from the bank of rivers rejected by fishermen. They also preyed around the stationary ships and large boats at the mouth or junction of the rivers and canals, where eagles seemed to get prey easily. Whitebellied sea eagles usually perched on the keora, gewa, sundri trees on the bank of rivers and preyed on fishes and snakes in the rivers about 50-200 m from the bank. They flew slowly and swiftly snatched out the prey from the water surface by their feet and claws in the air while plunging or touching the water with the wings. Sometimes, birds circled round over the prey repeatedly before swooping and catching it. Eagles hold the prey by the claws and carry it to the nest for the young from 1-1.5 km. Both the sexes were observed to engage themselves in the activity.

TABLE 2. *Prey species identified from the nests and nesting areas of whitebellied sea eagles*

	Snakes	
Colubridae	Cheekered Keelback Water Snake	(*Xenochrophis piscator* (Schineder)
	Dark Keelback Water Snake	*X. cerasogaster* (Cantor)
	Olive Keelback Water Snake	*Atretium schistosum* (Daudin)
	Common Smooth Water Snake	*Anhydris enhydris* (Schiniedeer)
	Dogfaced Water Snake	*Cereberus rhynchops* Gunther
Elapidae	Comomn Krait	*Bangurus candidus* (Linnaeus)
	Cobra	*Naja naja*
	King Cobra	*Ophiophagus hannah* (Cantor)
Hydrophidae	Hooknosed Sea Snake	*Enhydrina schistosa* (Daudin)
	Annulated Sea Snake	*Hydrophis cyanocinctus* (Daudin)
	Bandede Sea Snake	*H. fasciatus* (Schinieder)
	Estuarine Sea Snake	*H. obscurus* Daudin
	Narrowheaded Sea Snakes	*H. gracilks* Gunther *H. cantoris*
Viveridae	Russel Viper	*Vivera russellii*
	Fishes	
Carcharinidae	Grey Dog Shark	*Scoliodon palasorrah* Cuvier
Sprynidae	Arrowheaded Shark	*Sphryna blochii* Cuvier
Torpedinidae	Brown Electric Ray	*Narcine brunnea*
Rajidae	Prickly Skate	*Raja mamilldens* Alcock
Hemirhamphidae	Viviparous Half beak	*Hemirhamphus disper* (C & V)
Exocoetidae	Twowinged Flying Fish	*Exocoetus volitans* Linnaeus
Eleotridae	Flatheaded Gudgeon	*Butis butis* (H & B)
Lobotidae	Four band Triped Tail	*Datiodes* quadrifasciatus (Savas.)
Tetraodontidae	Estuarine Blow Fish	*Chelonodon fluviatilis* (H & B)

Breeding

11 pairs of whitebellied sea eagles were studied in 10 different places. Among them 3 breeding pairs occupied the same territory in three successive years. All breeding pairs built their nests in keora trees except one which built the nest in a Sundri tree. The height of the nest trees was between 20 m and 30 m from the ground. Nests were constructed between 2 and 3 main branches which projected from the trunk. Dimension of the nests was on an average 50 cm × 30 cm × 28 cm. Nest materials were the branches of mainly keora, gewa and Sundri trees. Breeding pairs occupied the nesting areas throughout the year and they became more territorial during breeding period. It seemed that they occupy the same nest after a little repearing the next year. On the other hand some of the pairs constructed new nests when the nesting trees became dead or were cut by wood cutters. One or two eggs were laid between October and November and the young hatched between December and January. Young fledged between March and April.

Breeding success of whitebellied sea eagle was very low. One young each was observed to fledge from 4 active nests in the Sundarbans. Low breeding success of these eagles was due to human disturbances, cutting of wood within the territory, cutting of nesting trees, destruction of their hunting habitats. Helander (1982) also reported of low breeding success of endangered whitetailed sea eagels *Haliaeetus albicilla* (Linnaeus) in Sweden.

Conservation

Population of the birds of prey as a whole is rapidly decreasing due to wanton destruction of their habitats in the Sundarbans e.g. cutting of old tall trees particularly keora during the breeding period. As an result, birds do not find suitable trees for nesting and perching.

It was observed in the Sundarbans that trees were selected and marked by forest personnel and wood cutters and even fishermen cut these trees containing nests with eggs and young during the breeding period. For conservation of Whitebellied Sea Eagle in the Sundarbans following steps may be considered.

1. Large tall old trees of keora, kakra, Gewa, Sundri, etc. to be left uncut for perching, roosting, hunting and nesting of the eagles. Wood cutting should be stopped and less disturbances to be maintained around the nest sites at least during breeding season.

2. Every year a large number of sea snakes are caught in different fishing grounds by fishermen. These snakes die when they are kept along with fishes and ultimately they are thrown out by fishermen without any use. Marine snakes are stable food of Whitebellied Sea Eagle in the Sundarbans. This unnecessary killing of marine snakes should be stopped for the maintainance of regular food supply for the eagles throughout the year by throwing them back into the waters soon after the catch is landed on the deck-that is at the sorting stage.

3. Unlimited fishing in non-seasonal period in the Sundarbans cause food shortage for the raptors, so it should be minimised. Because most of the raptors in the Sundarbans depend on various kinds of fishes and snakes.

4. People around the Sundarbans should be educated about the usefulness of raptors and their role in the ecosystem, so that the people of this areas become more interested and sympathetic to the protection of whitebellied sea eagle as well as other raptors. It can be done through news media e.g. newspapers, radio, television, film shows, seminar, conference, symposium, public meeting etc. Educational awareness among the people would play an important role in and conservation activity.

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CAPTURE OF COASTAL BIRDS IN THE PILLAIMADAM LAGOON AT MANDAPAM, SOUTH-EAST COAST OF INDIA

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Abstract

Regular observations were made on the coastal birds caught in the Pillaimadam lagoon by a specially designed nylon net. Blinded birds are used to lure the birds. *Gelochelidon nilotica, Sterna bengalensis, S. bergi, S. sandvicensis sandvicensis* and *Hydroprongne caspia* are some of the common birds caught. Seasonal variation and the species composition were also observed.

Introduction

We have fairly good knowledge of the lagoon birds of India (Jerdon, 1864 ; Ali and Ripley, 1981). However, information on the details of various methods of catching coastal birds and the number of birds caught are still wanting (Ali, 1963). In the present investigation method of capture of coastal birds, their seasonal variation and the species composition are studied.

Material and Methods

Regular visits were made to the Pillaimadam lagoon (09° 17′N and 79° 6′ E) situated along the Mandapam Coast adjacent to the Palk Bay to study the bird catching during 1981 to 1983. The birds were caught by the 'Narikuravas' a nomadic tribe, experts in bird trapping. Platforms were made in the mud flats to erect the bird-nets. The nets were made of 0.5 mm nylon twine with 40 mm mesh. Bamboo poles of length 1 m were attached to the head rope and the foot rope at 1 m interval. One end of the net was fastend to a peg driven in the mud and the other end to a lever through an iron wire of length 30-40 m. The bird-catcher waits at the end of the wire which, is attached to the lever.

The length of the net is about 15 to 20 m. The bait-birds are blinded by tying their eyelids together with their own feather rachis. Further they are stunned by delivering a strong hit at the back of the head. The stunned birds stand stationary inside the net. On seeing the bait birds, the other overflying lagoon birds land near them. When sufficient number of birds land in the net, the lever is released and the net collapses on the birds trapping them. The operation is repeated for about 6 to 8 hours.

Observations

Seasonal variation

The coastal birds were caught during the months of May to November with a peak in September when the mud flats were exposed. During this period small pools were formed making the fishes vulnerable to the birds of prey. Further the rise in water temperature and the consequent increase in salinity result in high mortality of the fishes in the pools. The dying or the dead fishes form a forage to the coastal birds which visit the lagoon in large numbers.

The nets were operated from May when a few patches of land were exposed in the lagoon. Usually the operation of the nets was restricted to a few days in a month. The covering of the exposed land in the lagoon by the influx of sea water during 4 days before and after the new moon and full moon prevented the setting up of the nets. Nets were not set during the days of heavy wind also. However, by July-August more land area was exposed and the number of birds visiting the lagoon also increased. It may be observed that 26.5% of the birds were caught during September 1982 and 23.5% in September 1983. From August to September the distant migratory birds start frequenting the lagoon and are captured (Table 1).

Species composition

Gelochelidon nilotica was the most common species forming 46.6% of the catch during 1982 and 33.5% in 1983. It was followed by *Sterna bengalensis* contributing 22.8% and 21.2% during the years 1982 and 1983 respectively. *Sterna bergi* accounted for 14.7% in 1982 and

TABLE 1. *Occurrence of coastal birds in the nets at the Pillaimadam lagoon during* 1982 *and* 1983

	1982							
	June	July	Aug.	Sep.	Oct.	Nov.	Total	%
G. nilotica	70	85	200	250	170	80	855	46.6
S. bengalensis	20	48	120	125	90	25	428	22.8
S. bergi	30	20	70	80	65	10	275	14.6
H. capsia	10	17	20	17	20	25	109	5.17
S. s. sandvicensis	—	—	2	4	15	8	29	1.5
Other species	30	20	46	20	34	26	176	9.4
Total	160	190	458	496	394	174	1872	

	1983							
	June	July	Aug.	Sep.	Oct.	Nov.	Total	%
G.nilotica	85	120	140	214	164	40	763	33.5
S.bengalensis	30	80	97	108	100	70	485	21.2
S.bergi	50	78	108	90	84	65	475	20.8
H.capsia	20	14	20	47	60	15	176	7.7
S.s.sandvicensis	—	8	10	15	20	14	67	2.9
Other species	40	70	50	64	72	22	318	13.9
Total	225	370	425	538	500	226	2284	

20.8% in 1983. Other species of coastal birds such as *Hydroprogne caspia, Sterna sandvicensis sandvicensis, Calidris minuta C. alexandricus* also occurred in the nets.

Economic importance

The coastal birds form a delicacy with the meat eating population of the coast. During the season a pair of *G. nilotica* weighing 150-200 g was sold at a rate of Rs. 4.00 and the smaller birds for Rs. 2.00. A few families of ' Narikuravas ' consisting of about 15 members subsist on bird catching, leading a nomadic life.

Discussion

Information on the number of coastal birds caught and the impact of such capture on the coastal bird population is much desired (Ali, 1961). However our present knowledge on this aspect is far from satisfactory. The present study pertains to the number of coastal birds caught in the Pillaimadam lagoon. But apart from Pillaimadam lagoon there are many mud flats, tidal flats, low lying areas and lagoons in the Rameswaram island from where large numbers of birds are caught. There is no report of the birds caught in the area based on regular sampling. The magnitude of the catch can be understood only by collecting detailed data on the occurrence of the birds in the nets. However, the remoteness of the bird catching areas may be one of the difficulties in collecting the data.

As the coastal birds occur in flocks and are trapped enmass there is danger of the whole stock getting depleted. Further it has been recently observed that the distant migratory birds like *Sterna s. sandvicensis* also visit this area for wintering (Lal Mohan, 1983 in press). Therefore detailed studies are required on the coastal birds of south east coast of India.

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POPULATION FLUCTUATIONS IN SOME ORNAMENTAL FISHES AND INVERTEBRATES OFF SRI LANKA

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ABSTRACT

The present level of exploitation of ornamental fishes and some of the invertebrates exportes from Sri Lanka are outlined, indicating fluctuations and depletion for some resources. The need for a rational management policy for their exploitation, habitat preservation and species conservation through also translocation of species are discussed.

INTRODUCTION

THE term ' ornamental ' when applied to certain living fishes and invertebrates is used in preference to such adjectives as ' exotic ', ' tropical ' or ' pet ' in several publications.

Since Sri Lanka is a tropical country and the term ' exotic ' has been applied to fishes introduced into freshwater bodies, *e.g. Sarotherodon (Tilapia) mossambica* (Peters) the National Aquatic Resources Agency in this country which has a special section working on small fishes, invertebrates and plants in the Pet Trade, has formally adopted the term ' ornamental ' to mean forms not intended for food.

Ornamental fishes from Sri Lanka, and later, invertebrates, began to be exported from about 1930. At first in small numbers by professional collectors operating off passenger and cargo steamers calling at the Port of Colombo and later by air.

By the late 1950's the Government took notice of this growing trade and later, the Chamber of Commerce published statistics relating to it (Table 1).

As in most developing countries, a Fishery causes diminution of certain form sharvested and in due course Laws relating to conservation are formulated.

TABLE 1. *Exports of Ornamental Fishes, water plants, invertebrates etc. from Sri Lanka (after data provided by Ceylon Chamber of Commerce)*

Year	Quantity (in k.g.)	Value (in Rupees)
1978	64,337	10,545,605
1979	146,949	12,112,446
1980	159,950	17,422,950
1981	138,969	30,752,539
1982	35,449	25,640,022
1983	38,920	28,261,759

Whereas Legislation applicable to the Food Fishery has been in force for many decades there is no provision for the conservation or protection of any specific marine fishes or invertebrates.

With the increase in demand for ornamental marine fishes and invertebrates, a fishery developed for their supply, involving many people ranging from field collectors, boat-owners, rentors of specialised diving apparatus stockists and contractors.

It is estimated that the daily turnover in the business of supply to exporters is in the region of Rs. 50,000, with the main centre being Colombo.

The bulk of species collected for this Trade comes from the fishing effort of divers. A leading exporter estimates that 95% of his stocks are diver collected, while the balance is obtained as a by-product from the Food Fishery.

The increase in numbers of divers, coincident with the rise in beach-oriented tourism brought about a new awareness of the ornamental fishes in Sri Lanka coastal waters. This awareness also took the form of a fear of over-depletion, even extermination of some species, mainly by conservationists in both private and official sectors.

Together with views expressed by non-nationals and publications in popular foreign journals, some pressure was exerted on the Trade and the collectors involved, some of it published in the Press.

The climax of this movement occurred in February 1980 when the Ministry of State, without warning, imposed a total ban on the export of all ornamental fishes, invertebrates and plants. The resultant confusion, which was short-lived, due to representations made by the exporters, collectors and consultants, caused a fair financial loss to all people connected with the Trade.

This paper discusses the causes to which depletion of some forms is applicable and also touches on some notable population increases or explosions which had a mixed effect on the fisheries involved.

Much of the information is from personal experience during the period when the author was involved in the Trade as collector, stockist and exporter.

Thanks are due to Mr. M. Atton of the Ceylon Chamber of Commerce for material so freely given, Mr. Ranjith Bandula of Aquarium Seaking, a former exporter, Mr. Sirisena Wanniaratchi of Ocean and Tropical Fish Export Co., Mr. Roger Ratnayake of Samudra Aquarists, Mr. Cedric Martenstyn, Mr. Trevor Ferdinands and the late Mr. Joe Rajapakse, all divers and collectors of very high proficiency. Others, too numerous to mention, have provided the author with data relating to locations, techniques and populations without which this paper could not have been written.

The ornamental fish trade

Table 2 is a reproduction of an export price list typical of most Sri Lankan dealers.

Apart from printer's mistakes and inaccurate nomenclature coupled with trade names for certain species, it gives a good indication of the variety of forms in the trade. The specimen provided is already outdated in that some new species are currently in the trade, due to a change in the pattern of demand, improved collecting techniques and even new discoveries.

Properly named and identified, the actual number of species on this list would exceed 300.

The fact that many species are now less evident in accessible location can be attributed in part to the collection for export, just as much as food fishes are in general, less abundant than in the past.

As in the Food Fishery, the collectors of ornamentals have moved farther afield and improved techniques to meet the demand.

TABLE 2. *Price List of Marine Fish and Invertebrates from Sri Lanka*

Item No.	Price in Dollars U.S. each		Item No.	Price in Dollars U.S. each	
S.F. 1	*Abudefduf* All species	0.20	S.F. 52	*Dascyllus carneus*	0.20
S.F. 2	*Acanthurus lineatus*	2.50	S.F. 53	*D. trimaculatus*	0.20
S.F. 3	*A triostegus*	0.50	S.F. 54	*D. aruanus*	0.50
S.F. 4	*A. leucosternon*	4.00	S.F. 55	*Dendrochirus zebra*	2.00
S.F. 5	*Amphiprion melanopus*	0.50	S.F. 56	*Diploprion bifasciatum*	2.00
S.F. 6	*A. polymnus*	0.50	S.F. 57	*Epinephelus flavocaeruleus*	6.00
S.F. 7	*A. sebae*	0.60	S.F. 58	*E. fuscoguttatus*	2.00
S.F. 8	*A. xanthurus*	0.50	S.F. 59	*Fissilabrus dimidiatus*	0.50
S.F. 9	*Antenarius* sp.	2.50	S.F. 60	*Forcipiger longirostris*	5.00
S.P. 10	*Anthias squamipinnis*	2.00	S.F. 61	*Gaterin lineatus*	1.00
S.F. 11	*Aspidontus rthinorhynchus*	0.50	S.F. 62	*G. pictus*	2.00
S.F. 12	*Balistes aculeatus*	1.25	S.F. 63	*G. orientalis*	1.00
S.F. 13	*B. rectangulus*	1.25	S.F. 64	*Gaterin albovitatus*	2.50
S.F. 14	*B. bursa*	1.25	S.F. 65	*Gomphosus varius*	1.50
S.F. 15	*B. ringens*	1.00	S.F. 66	*G. coeruleus*	2.50
S.F. 16	*B. undulates*	2.00	S.F. 67	*G. virdiscens*	3.00
S.F. 17	*B. veridescens*	1.00	S.F. 68	*Grammistes sexlineatus*	2.00
S.F. 18	*Balistoides conspicillum*	40.00	S.F. 69	*Halicheres centiqundrous*	2.00
S.F. 19	*Canthigaster margaritatus*	0.75	S.F. 70	*Hemitaurichthys zoster*	6.00
S.F. 20	*C. jactaror*	1.50	S.F. 71	*Heniochus acuminatus*	1.00
S.O. 21	*C. valentini*	1.50	S.F. 72	*H. permutatus*	2.50
S.F. 22	*Cantropyge multispinis*	1.50	S.F. 73	*H. singularis*	2.00
S.F. 23	*Cephalopolis argu*	3.00	S.F. 74	*Holacanthus xanthurus*	2.00
S.F. 24	*C. boernak*	1.00	S.F. 75	*Holocentrus diadoma*	1.00
S.F. 25	*C. miniatus*	7.00	S.F. 76	*H. leo*	4.00
S.F. 26	*Caranx speciosus*	1.50	S.F. 77	*H. samara*	1.50
S.F. 27	*Chaetodon collaris*	1.25	S.F. 78	*H. rubrum*	1.50
S.F. 28	*C. auriga*	1.00	S.F. 79	*H. xantherythrurus*	2.50
S.F. 29	*C. citrinellus*	1.50	S.F. 80	*Kuhlia taeniura*	0.25
S.F. 30	*C. ephippum*	4.00	S.F. 81	*Lactophrys cornutus*	2.50
S.F. 31	*Chaetodon falcula*	4.00	S.F. 82	*Lutianus decussatus*	1.50
S.F. 32	*C. plebius*	1.50	S.F. 83	*L. dodecanthus*	1.50
S.F. 33	*C. pictus*	1.00	S.F. 84	*L. kasmira*	1.00
S.F. 34	*C. trifasciatus*	1.00	S.F. 85	*L. sebae*	4.00
S.F. 35	*C. vagabundus*	1.00	S.F. 86	*Macolor niger*	10.00
S.F. 36	*C. chrysurus*	4.00	S.F. 87	*Muraena concolor*	1.50
S.F. 37	*C. meyerii*	2.00	S.F. 88	*M. nebulosa*	1.50
S.F. 38	*C. lunula*	1.75	S.F. 89	*M. tesselata*	3.00
S.F. 39	*C. melanotus*	2.00	S.F. 90	*M. sebra*	3.00
S.F. 40	*C. unimaculatus*	3.50	S.F. 91	*Myripristis murdjan*	1.00
S.F. 41	*C. guttartisimuss*	1.50	S.F. 92	*Naso litturatus*	3.50
S.F. 42	*C. kleini*	1.50	S.F. 93	*N. brevirostris*	1.00
S.F. 43	*C. triangulus*	3.00	S.F. 94	*Naso unicornis*	2.00
S.F. 44	*C. ornatissimus*	3.00	S.F. 95	*Odonus niger*	1.50
S.F. 45	*C. xanthocephalus*	2.00	S.F. 96	*Ostracion lentiginosum*	1.00
S.F. 46	*C. megaprotdon*	1.00	S.F. 97	*O. cubicus*	2.00
S.F. 47	*Chromis caeruleus*	0.50	S.F. 98	*O. sabae*	2.50
S.F. 48	*Coris gaimardii*	1.25	S.F. 99	*O. gibbosus*	2.00
S.F. 49	*C. aygula*	4.00	S.F. 100	*O. tubiculatum*	1.50
S.F. 50	*Diodon hystrix*	2.50	S.F. 101	*Oxymonocanthus longirostis*	3.00
S.F. 51	*D. maculatus*	3.00	S.F. 102	*Paracanthurus theothis*	6.00

Item No.	Price in Dollars U.S. each		Item No.	Price in Dollars U.S. each	
S.F. 103	*Paracirrhites forsteri*	2.00	S.F. 114	*Plotoses anguillaris*	0.25
S.F. 104	*Pomacanthus imperator* (small)	6.00	S.F. 115	*Promicrops lanceolatus*	2.50
S.F. 105	*Pomacanthus imperator* (large)	4.00	S.F. 116	*Psuedobalistes fuscus*	6.00
S.F. 106	*P. asnularis* (small)	2.00	S.F. 117	*Pterois radiata*	4.00
S.F. 107	*P. annularis* (large)	3.00	S.F. 118	*P. miles/antennata*	2.00
S.F. 108	*P. semicirculatus* (small)	1.00	S.F. 119	*P. volitans*	1.00
S.F. 109	*P. semicirculatus* (large)	2.00	S.F. 120	*Polkadott wrasse*	1.50
S.F. 110	*Pomacentrus melenochir*	0.20	S.F. 121	*Thalassma lunare*	1.50
S.F. 111	*P. caeruleus*	0.20	S.F. 122	*Zebrasoma velifera*	4.00
S.F. 112	*Platax orbicularis*	1.50	S.F. 124	*Z. xanthurus*	2.00
S.F. 113	*P. teira*	2.50	S.F. 125	*Zanclus cornutus*	1.25

Tropical Marine Invertebrates

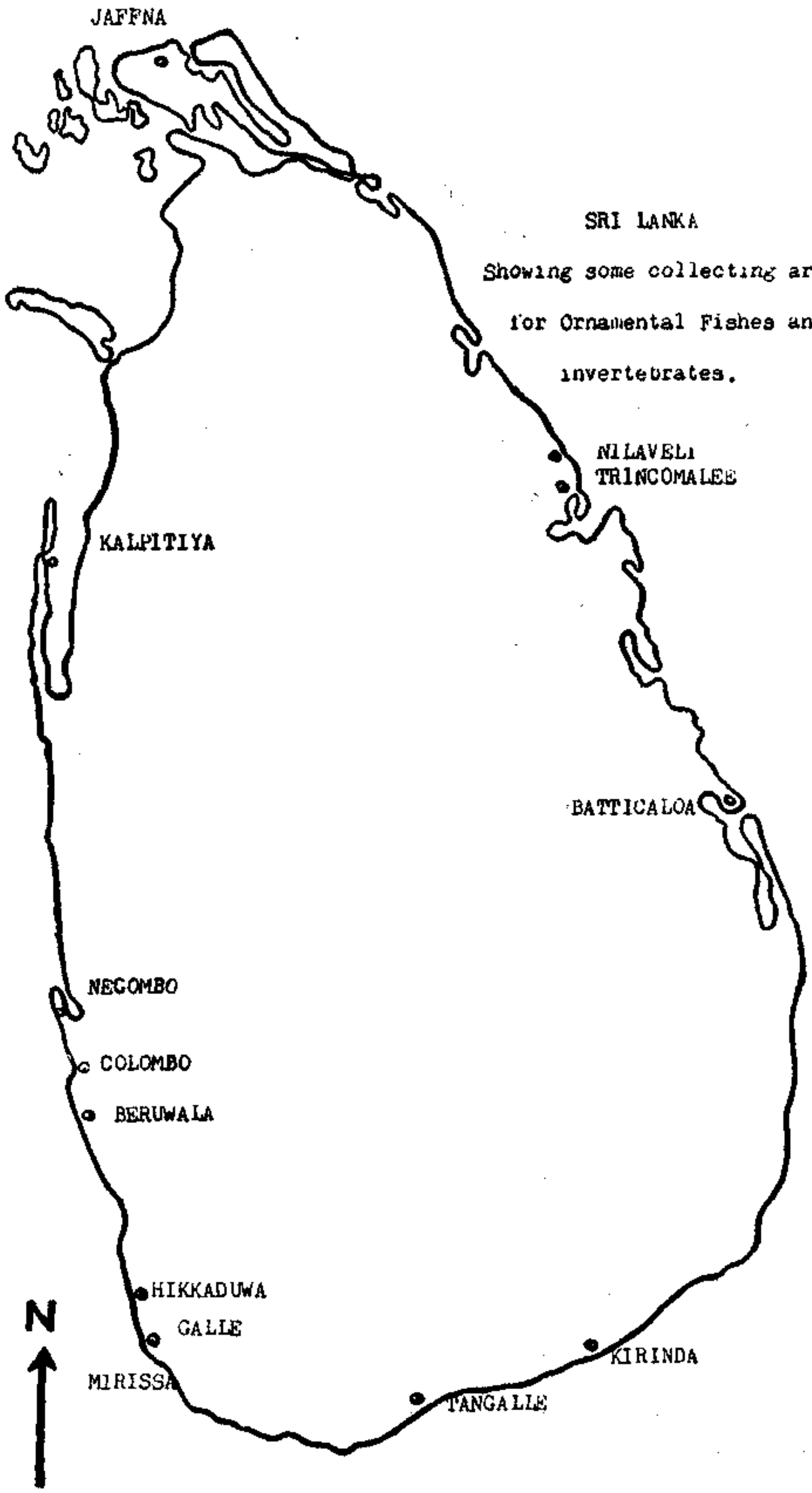
Item No.	Price in Dollars U.S. each		Item No.	Price in Dollars U.S. each	
1.	Anemone (*Discosoma* sp.)	2.00	22.	Ophiuroids	0.10
2.	Anemone (*Stoichactis* sp.)	1.50	23.	Cowris (*C. arabica, C. tigris, C. mauritiana, C. vitellus*)	0.50
3.	Anemone (*Cerianthus* sp.)	1.50			
4.	Painted shrimps	1.50	24.	Cowris (*C. ocellata, C. erosa, C. errones, C. caurica*)	0.25
5.	Coral shrimps	0.50			
6.	Mantis shrimps	4.00	25.	Fiddler crabs	0.20
7.	Cleaner shrimps	0.75	26.	Crabs (All varieties)	0.20
8.	Spiny Lobster (*P. dasypus*)	1.50	27.	Stenopus shrimps	0.75
9.	Spiny Lobster (*P. versicolor*)	1.00	28.	Tube worms	0.75
10.	Spiny Lobster (*P. japonicus*)	1.50	29.	Tiger Cowris	1.50
11.	Starfish Red	0.50	30.	Egg Cowris	2.00
12.	Starfish *Pentaceros* sp.	2.00	31.	All Cowris	0.75
13.	Starfish *Pentaceros* sp. Yellow	1.00	32.	Octopus	2.00
14.	Starfish *Asterias* Green	0.25	33.	Orchid shrimp	2.50
15.	Corals Fungia	0.10	34.	Sea urchin	1.00
16.	Corals Astraea	1.60	35.	Sea pencils	1.00
17.	Corals Lithothamnion	0.50	36.	Dancing shrimp	0.50
18.	Corals Red Big Polyp	1.00	37.	Sea cucumber	1.00
19.	Red Coral Crab	1.50	38.	Sea plants	1.00
20.	Subella worms	0.75	39.	Sea lilies	0.50
21.	*Hippolysamata grahami*	1.75	40.	Slugs assorted	0.50

There is undoubtedly a diminution in populations of species in demand.

Generally, the trade starts in late autumn around October, reaches a climax by mid-December, recedes for the festive seasons in Europe and U.S.A. until mid-January when it picks up until summer, when by late May and June there is a poor demand.

International Trade in Tropical Aquarium Fish, published in Geneva in 1979 by the International Trade Centre UNCTAD/GATT provides a wide range of data. Sri Lanka rates 6th in Asia as a supplier to Germany (Table 6, Page 47). In 1973 Sri Lanka was the 8th most important supplier to U.K. in terms of value (Table 8, page 55).

It is, therefore, evident that the Ornamental Fish Trade is of considerable importance to a developing country with need for foreign exchange and that more effort should be applied to increase production yet conserve stocks of wild species.



SRI LANKA

Showing some collecting areas for Ornamental Fishes and invertebrates.

According to leading exporters, the proportion of marine fishes and invertebrates in the business, which consists also of freshwater, and brackishwater fishes, water plants and bulbs, is about 75% in value and 50% in volume. Of the total marine forms shipped 30% are estimated to comprise invertebrates.

Invertebrates involve Coelenterata, Annelida, Crustacea and Mollusca. Export of dead corals for ornamentation was banned by law several years ago.

Whereas in the past the mortality of marine forms at all points was considerable, and consequently invoked a great deal of adverses criticism, improved techniques have now resulted in an estimated 2% mortality which is acceptable to all concerned.

It is observed and widely reported mortality of only ornamental species that aroused observers who urged for various bans on collecting and trade. Such recommendations in respect of food fishes have never been made although many food fishes are indeed ornamental especially in their juvenile stages e.g. *Promicrops lanceolatus* (Bloch), *Lutianus sebae* (Cuvier and Valenciennes) *Plectorhynchus albovittatus* (Rüppell) and *Gnathanodon speciosus* (Forskål). It is debatable as to whether these in juvenile form and not more than 20 cm. in length are a more economical harvest in terms of hard currency than the mature and adult sizes which are caught for food in the local market (The export of food fishes from Sri Lanka is banned by law).

From personal observation it appears that fewer of the first three species appear in fishermen's catches than in establishments of live fish exporters which may be an indication of the evasiveness in the last case, those collected are the very few small individuals that accompany swimmers and divers and some large fishes and are taken by chance. Large *Gnathanodon* are taken by the thousands for food in the 2 to 10 kg sizes with nets and lines.

On the other hand, very large numbers of ornamental fishes are deliberately fished as bait for the Tuna and Skipjack Fishery. Whereas a few of them are sold to collectors by the fishermen, the majority are 'lost' at sea. Exporters argue that the better prices obtained for these live bait-fishes should discourage their use as bait, and substitute species of less attractiveness be taken. Such selective methods are hardly considered by the fishermen who are always in a hurry to collect any suitable bait and fish for the tunas in the shortest possible time, and as long as they are on the feed within range of the boats.

Very predominant in live-bait collections are such species as *Anthias huchti* (Bleeker) *Dascyllus trimaculatus* (Rüppell) and *Chromis caeruleus* (Cuvier and Valenciennes) which have a ready market as ornamentals.

As regards invertebrates, exporters are forbidden by Law to collect, store or ship live *Panulirus* which, in the legal large sizes form part of a very lucrative sea food export industry.

A more significant example is the collection and consumtpion for food of an anemone (*Stoichactis sp.*) in the Jaffna area. Skin divers spear them in shallow areas, and the commensal *Amphiprion sebae* (Bleeker) either swim away to other anemones or are eaten by predators (personal observation). It is thus observed that to draw a fine distinction between food and ornamental species of fishes and some invertebrates is impossible.

A fishery comprises all commercial species and if conservation is contemplated or planned, it should extend to every form in a biosphere. There have been suggestions made in the past that in a so-called 'underwater National Park' only certain methods of commercial fishing for food be permitted, which was not accepted.

Population decline in Fishes

A general and widespread drop in fish populations, mainly of food fishes,is evident in a developing country like Sri Lanka where the major part of the population consumes fish.

For several years there has been a shortage of fish with considerable volumes imported in dried and canned form to supplement local catches.

More latterly the drop in populations of ornamental fishes was evident, particularly in the more accessible areas. An increase in tourist arrivals and an added awareness of underwater life for recreational purposes focussed more attention on this aspect and thus a few conservation measures were adopted.

Hikkaduwa coral reef was declared a sanctuary and more latterly the Pigeon Island come plex off Nilaveli on the East Coast.

Unfortunately enforcement is problematical and there are still visible diminutions in populations of fishes and invertebrates (mainly living reef-building corals) in these areas.

Precise field studies on population drops of certain species remain to be done. Even collection figures are not precise for many reasons, not the least of them being the reluctance of stockists to divulge exact locations and sources in a competitive business.

The reported lessening of populations are, unfortunately attributed solely to collectors, because their activities are visually evident and attract all types of observers on shore. Some observers with conflicting business interests like underwater guided tours are the first to blame collectors only, and they urge the ban on exports only, expecting restoration of former population densities of some species.

But although precise counts and other data must await future research on the subject, there are more evident factors responsible for the overall drop in populations.

(*a*) Habitat removal is a very serious problem in Sri Lanka whereby dead and living material from the coastline and shallow sea is removed in increasing quantities for the building trade, for the tourist souvenir trade, and to some extent for the export trade.

The removal of corals, living or dead is a major problem, but the removal of sand is also contributory, indirectly or directly, to a change in fish and invertebrate populations.

The collection of anemones e.g. *Stoichachtis* and *Radianthus*, on which a few species of *Amphiprion* are dependent is, in fact, habitat removal. The *Amphiprion* cannot survive without host anemones; anemones are able to survive and multiply without *Amphiprions.*

(*b*) Pollution of coastal waters from canals, drains, sewage outlets etc. is an increasingly serious problem. All marine fish are affected and most forms which are sedentary are killed, together with pelagic larvae and fry, larger species leave the area.

(*c*) Reduction in salinity by intrusion of freshwater during periods of unusually heavy rainfall, cyclones and floods kills most sedentary forms. Purely marine fishes leave the area and return gradually if salinity is restored to its normal level. The recent construction of groynes at river mouths where in the past sand bars formed and blocked them, has had a mixed effect. The former temporary inflow of freshwater only during periods of rainfall which had a slight effect on most fishes and invertebrates affected, was made permanent. But at times of drought and high tide, there is the reverse effect of saline water being pushed upstream with adverse effect to users on the banks and to irrigation of crops.

(*d*) Overfishing for food fish in illegal ways (use of explosives and poisoning) is an extremely serious problem on the East and North-East coast affecting most vertebrates and invertebrates. Recent fishing methods for which Regulations have yet to be framed are possibly the most destructive to certain reef-dwelling species of fishes of no special food value. Set-nets laid on reefs for *Panulirus* kill and damage some fishes and reduce breeding populations. The most significant victim of these nets in the West coast centering around Negombo is *Pomacanthus annularis* (Bloch) the juveniles of which are in great demand and fetch attractive prices alive.

The fishermen often leave behind the dead fishes of little edible value which they claim attract *Panulirus* to the nets.

The use of traps on or close to reefs, mostly in the North-East coastline brings in catches of mainly Siganids, Scarids, *Odonus niger* (Ruppell) and several species of *Chaetodon*. Although field collectors for ornamental fishes are able to obtain some alive, the main catch is taken for food of very low value comprising adult or semi-adult ornamentals such as *Heniochus acuminatus* (Linnaeus), *Chaetodon falcula* (Bloch), *Chaetodon auriga* (Forskål), *Acanthurus leucosteron* (Bennett) and *Zanclus canescens* (Linnaeus) for which high prices are payable on live delivery.

The beach-seine fishery, increasing every year, accounts for many species of no food value but of considerable export importance such as *Tetrasomus gibbosus* (Linnaeus), *Lactoria cornuta* (Linnaeus) and *Diodon holacanthus* (Linnaeus) which are thrown away alive or dead. In a few areas some are kept alive for collectors but most succumb to injury.

Thus it is evident that population drops in many species of small ornamental fishes are caused by food fishing and not only by collection for export.

Population increases in Fishes

Observers and collectors agree that at the start of a season with calmer conditions and improved visibility, populations, especially juvenile, of many species are in relative abundance compared to the previous season's end.

According those in demand are collected and some which prove elusive survive. At the same time, other forms of fishing for food fish also take their toll.

Towards the end of the season certain species are very scarce.

The breeding seasons of some species take place during or before the collecting seasons. It is assumed that consequent to the increase in strength of coastal currents in the rough weather and consequent turbidity of the water, larvae and juveniles of pelagic egg-layers move greater distances and have a better rate of survival from predators.

The breeding of some species takes place regularly during the calm and clear season, and experienced collectors benefit accordingly, moving to locations for the purpose of exploiting the increased stocks.

Pterois volitans (Linnaeus) appears in small sizes from 2 to 6 cm in September, often in sheltered harbours, rocky estuaries and river mouths and along boulder-strewn shores.

Pomacanthus semicirculatus (Cuvier and Valenciennes) appears in large numbers and small sizes with juvenile colouration in May, off the East coast.

Pomacanthus imperator (Bloch) juveniles appear off the East coast in early September and those of about 2 cm which are not collected at this time are permitted to grow to over 5 cm during the rough and turbid months of October to February, and then taken in March.

Lutianus sebae (Cuvier and Valenciennes) is a food fish, taken with lines in deep water off

Trincomalee, and its pelagic larvae settle with an urchin (*Diadema*) where collectors obtain it in sheltered areas from 2 to 10 metres deep.

In addition to these examples of seasonal increases, there have been population explosions in recent years which were unexpected and were of great benefit to the Ornamental Fishery. It is not known as to what caused these explosions and when they are likely to re-occur.

In 1972 there was a sudden occurrence of *Diodon holacanthus* (Linnaeus) on the West coast and some specimens of about 6-10 cm were found all over reefs and on sand bottoms. The Ornamental Fishery harvested many but since the demand is limited for this species, collecting terminated by February. Huge populations were caught in seines and destroyed. Specimens of less than 6 cm are never found by collectors and probably live in deeper waters below 30 metres.

In 1975 collectors reported unusually large concentrations of young *Odonus niger* (Rüppell) on both East and West coasts in depths of 8 metres and more. Since this fish has a limited demand the usual quota was taken to fill orders. Fishermen with lines took large numbers in the 8 to 12 cm size. But in 1976 a sudden mass mortality of this species took place and thousands floated up off the West coast. The fact was reported in the Press but no work was done as to how and why this happened.

In 1977 a rather poor crop was reported and by 1978 the observed populations appeared normal (personal observation).

The most profitable and unusual population in recent years was that of the very desirable and high-priced *Balistoides niger* = *B. conspicillum* (Bloch and Schneider) in 1981 when dozens appeared on reefs of from 10 to 20 metres on the East coast. Whereas the average total catch each season would be less than 50 specimens per season, this explosion yielded over an estimated 500 of from 4 to 8 cm sizes.

Since this species is known and observed to defend its eggs laid in caves and fissures, the collectors very rightly agreed not to take adults in the future, as they used to, hoping for repeated harvests of this nature.

POPULATION INCREASES IN INVERTEBRATES

As in the case of fishes, most invertebrates taken by divers for the ornamental Fish Trade appear in comparatively greater abundance at the start of each season.

The relatively prolific Sabellid worms appear in good numbers and many are collected, together with small starfishes (*Fromia sp.*) many species of cowries (*Cypraea*) *Radianthus* and *Stoichactis* anemones and small, colourful crustacea (*Hippolysmata*, *Stenopus* and *Lysmata*).

There appears to be a steady supply to meet the demand for most of these, but the main noticeable population explosion in recent time (1984) has been a phenomenal increase in populations of *Lysmata debelius* (Bruce) off both East and West coasts in fairly deep water (20-40 metres).

Skilled diver/collectors with breathing gear risk respiratory complications to collect this species for which high prices are paid. In November 1984, one establishment had over 5,000 in stock.

VARIATIONS IN COMPOSITION OF FISH POPULATION

With intensive collection of some species and rejection of others unsuitable for the trade, seasonal imbalances are observed, especially towards the end of a period of clear and calm weather. No adverse results have been reported such as infection and diminution of some species (*Epinephelus, Scarus, Acanthurus*) from a lesser population of *Labroides dimidiatus* (Cuvier and Valenciennes) which are constantly collected for export and which feed on parasites of the larger species.

If species suitable for bait are over fished, the predatory forms feeding on them merely move to better areas.

A very significant observation in areas close to river and canal mouths and newly constructed harbours is the increase in brackishwater species. Whereas before groynes were constructed to keep open mouths of canals and small rivers perennially the brackish populations were negligible, they have recently established themselves close to or within the rivers and canals. Of brackish species, at least two are in constant demand for the export trade, *Monodactylus argenteus* (Linnaeus) and *Scatophagus argus* (Linnaeus).

It is thus evident that population density and composition in any habitat varies with the seasons and with exploitation by man. In order to obtain a less variable situation there should be a total ban on all forms of fishing with a close study of all prominent species in a specific area for a period of at least five years before any conclusions are arrived at.

Re-stocking of impoverished areas

Certain locations off Sri Lanka have had population increases through accidental and deliberate addition of refuge and shelter in coastal waters.

Shipwrecks are well-known refuges for many species of fishes and invertebrates and larger ones such as the 'Hermes', an aircraft carrier sunk by the Japanese off Batticaloa, is now an important F.A.D. (Fish Attracting Device) around which a fishery for resident and pelagic species of good food value exists.

Similarly, shipwrecks in shallower water up to 35 metres are excellent areas for collecting ornamental species such as *Cephalopholis miniatus* (Forskal) *Anthias squamipinnis* (Peters), most *Chaetodons*, *Pomacanthus*, *Heniochus acuminatus* (Linnaeus), and *Pterois volitans* (Linnaeus).

Smaller metallic objects in sandy bottoms such as anchors of fishing craft, dumped machinery and automobile bodies are often visited by collectors and provide good crops of juveniles.

Fisheries harbours recently constructed off Sri Lanka where formerly no reefs or rocky outcrops existed, now provide sheltered water and refuge for many ornamental species in considerable numbers. A minor fishery for these as well as food fishes now exist in and close to small harbours in places like Beruwala, Galle, Hikkaduwa, Mirissa, Tangalle, and Kirinda.

All these population increases have been through natural means, *viz.*, visitation by roving parent or juvenile stock which took refuge and remained accordingly, and also through pelagic eggs, larvae and fry being brought in by tides and currents.

No deliberate and planned re-stocking has ever been done in Sri Lanka in coastal waters as was attempted in Hawaii since 1976. Randall and Kanayama (1972) describe successful introductions of food-fishes into Hawaiian waters beginning in 1955 with considerable benefit to the fishing industry.

Similar stocking of impoverished areas off Sri Lanka can be done with some Indo-Pacific ornamental species provided the initial period is one of fishing prohibition in the areas re-stocked.

Species now virtually non-existent due to coral removal, such as *Dascyllus aruanus* (Linnaeus), *Chromis caeruleus* (Cuvier and Valenciennes) and *Dascyllus trimaculatus* (Rüppell) can be introduced into accessible area like Hikkaduwa Sanctuary from area farther North like Kalpitiya where corals are still abundant and these species found with them.

If such introductions prove successful it may be possible to introduce species not found off Sri Lanka but abundant in the Maldives, Andamans and Nicobars. Although Munro (1955) includes *Amphiprion percula* (Lacépède) in his work on Fishes of Sri Lanka it has never been collected or seen but there is no reason why introduced populations cannot establish themselves with *Radianthus* anemones, abundant off the East coast, and breed.

Conclusions and Recommendations

The Ornamental Fish Export Industry of Sri Lanka is an important aspect of the Fishery and not only brings in foreign exchange but also income from tourism.

The discovery of species new to Sri Lanka (e.g. *Lysmata debelius* Bruce, *Balistoides conspicillum* (Bloch and Schneider) and *Centropyge flavipectoralis* (Randall and Klausewitz) has been due to the skill and enthusiasm of professional diver/collectors working for the ornamental fish exporters.

Old-fashioned and conventional collections for recent works on fishes have not shown several species which modern divers have observed in the waters off the Andaman and Laccadive Islands.

Better and more organised control in order to increase production and income from resident populations which if conserved, and in specific areas protected, will continue to provide the mainly juvenile sizes in demand.

An increased production can also be achieved by training fishermen in the food fishery to handle ornamental species with greater care and thus provide live specimens which fetch better prices.

Apart from the existing regulations pertaining to habitat removal (coral collections and collection, pollution etc.) more detailed regulations should be formulated to control the percentage of certain invertebrates (e.g. anemones which are preferred by *Amphiprion*) exported, in order to keep the populations stable.

Re-stocking certain locations with species from remote areas is feasible and desirable, and some experimentation in re-stocking with different species from tropical Indian Ocean areas such as the Maldives and Andamans is worthwhile.

The immediate need is to exercise more effective measures to conserve the coastline and all habitats necessary for survival and breeding of ornamental species and to regard the dimination of such species in the light of all those factors responsible and not only the Ornamental Fishery.

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FIDDLERS ON THE RETREAT ?*

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ABSTRACT

Since 1953, the author and his collaborators have studied the behaviour and ecology of fiddler crab (genus *Uca*) and have also taken into account the number of individuals and number of populations in certain *Uca*—habitats of SW-Europe, NW-Africa, Central and South America and India. Since the mid-sixties, a definite decline in both these parameters has been noticed, and some once ' classical ' *Uca*-biotopes have become virtually void of fiddlers. The paper lists such examples and tries to explain the probable causes of such fiddler retreats.

INTRODUCTION

IN view of the proverbial population density of individuals on typical fiddler crab banks—explorers of the colonisation age were astonished at the mud banks virtually being honeycombed by crab holes—and the perfect ecophysiological adaptation of the about 90 *Uca*-species, one would think that there is no need to extend to them terms of endangered, environment threatened and the like. Such population densities can exceed 140 inhabitants per square meter (W. Müller, 1982), and the total number of individuals in a given colony can easily amount to more than several millions. Also, *Uca* seems to be perfectly adapted to various types of habitat from muddy clay to sandy stretches, from highly saline to strongly brackish and almost fresh water, from flat open beaches to densely vegetated habitats, as grass lands and mangrove forests. Furthermore, to underline this aspect of a successful construction of animal evolution, the sophisticated visual and vibrational communication systems must be mentioned allowing the fiddlers to transmit messages of attraction and aggression, of love and aversion. Some of such communication systems and their effects have been studied by cinematography and may be witnessed in the respective films held at the disposal in the international Encyclopaedia Cinematographica, Göttingen, Western Germany. Further treatises on these and related problems of fiddlers' behavioural ecology are listed in the references at the end of this paper.

Here we shall deal only with alterations and deteriorations of once happy fiddler communities and their probable causes. Fiddlers being subject to the tidal regimes of their habitats have only a limited time budget: between the two tides, i.e. at the most six hours per day. Within this time an individual has to go through the vital routine of a successful male: feeding, fighting, waving, courting, copulating, and hole digging, from which duty a female can skip only the waving and courting. During all these activities the fiddlers are active on the surface (barring the brief subterraneous period of copulation in some species), and are exposed to a number of predators. To the more cunning of these, making prey in the quasi-monocultured crowds of fiddler aggregations seems a relatively easy affair, and ucologists have enumerated such predators

* Dedicated to Professor Dr. B. Rensch, my Guru of the early days, on the occasion of his 85 th birthday on January 22, 1985.

from the crab-eating raooon (*Procyon cancrivoros*), rats, grackles (*Cassidix mexicanus*), crows (*Corvus splendens*) and even domestic hens down to fishes and crabs (*Ocypode*).

In view of such a wide range of predators and their sometimes very elegant preying techniques one would think that a marked predation effect should be noticable. That, however, has so far not been proved, and some colonies have been scrutinized over decades, mainly in Spain and Morocco (*U. tangeri*). Neither have minor oil spills nor even adioactive fall-out apparently done any permanent damage to *Uca*-colonies.

More recently, man has become the enemy number one of *Uca*, and that does not refer to the commercial harvesting of *tangeri*-claws in Southern Spain (Altevogt, 1959). This age-old practice which is unique throughout the fiddler world, is a careful method of taking only the large waving claw of the larger males which gets autotomized at the grip of the harvester and letting the animal loose to regenerate a new claw for the next harvesting season.

Man's recent detrimental influence on *Uca* is of another kind:

1. by permanent (and, at a time, even small) oil pollution
2. by polluting the *Uca*-habitats with human garbage and waste water and
3. by blocking the tidal influence.

1. Oil pollution from oil piers and terminals has brought down colonies of *U. annulipes* and *urvillei* to almost zero in the Cochin backwaters which we have followed up through the years. The same applies to colonies of *U. panamensis, beebei* and *terpsichores* near Balboa (Panama) comprising also that classical colony studied as early as 1941 by Crane. My collaborator W. Müller has witnessed this decline in 1982 and 1983 and is sure that it is due to the permanent oil pollution in the harbour area.

Harbours as such, be they teeming with plying fishing boats and crafts under sail and a few mechanised vessels, can even be a boon to some *Uca*-species as can be seen in the flourishing colonies of many villages on India's coasts harbouring active colonies mainly of *U. annulipes* and *triangularis.*

2. Such colonies can also be strongly affected if man dumps his garbage and other waste material from his unclean(ed) urban civilization on the fiddlers' banks. The effect of this worldwide vice is at least twofold:

(i) There will be a change in the texture of the substratum so important for the construction of holes in which the crab can safely survive the period of high tide and which serve as the vital centre of above-ground courtship in practically all *Uca*-species and for underground copulation in a good number of species. Garbage heaps and beach stretches covered by waste material offer a loose substratum only which does not allow reasonable building activity.

(ii) Garbage ooze alters the chemical features of the substratum so that finally that evil smelling mass results which harbours only rats, mice and moulds. Deplorable examples of such anthropogenic effects on *Uca* can be found on the beaches of Goa and Bombay. (*U vocans, urvillei, annulipes*), and of Southern Spain (*U. tangeri*). Waste water of industrial origin is responsible for the depletion of *Uca*-colonies in the Bay of Cadiz (Spain: Rio Domingo Rubio, Rio Guadalete, Rio San Pedro).

3. The tidal regime of a *Uca*-bank does not warrant the existence of a flourishing fiddler colony favourable as it is for replenishing the table of nutritive epistratum material for the mud sifters. There must also be an offshore scheme of favourable currents bringing back

the larval stages washed out into the sea at spawning time of the berried females and spending certain periods out there and then coming back to the shore. This recruitment of the young generation is an absolute must and must be guaranteed by a range of perfectly balanced environmental factors as bottom currents, kind of substratum etc. If this aqueous system is (partly) blocked, say by harbour constructions, dams etc., detrimental effects will result, which show up in a declining percentage of juvenile stages in the colony concerned.

We have quite a number of such dying and dead colonies on our rosters. They range from that first example of *U. tangeri* in the type locality near Tangiers where we witnessed the disappearance of the last three specimens in 1965, as a result of the construction of a store wall blocking the harbour lagoon from the sea and leaving the young no chance so that the colony was doomed.

Due to harbour constructions, colonies of *U. stenodactylus, stylifera, latimanus* and others have dwindled to zero in Potrero and Playa del Coco (Costa Rica), which W. Müller has followed up in 1982 and 1983. Strong decreases of juvenile percentages have also been found by K. Müller (since 1976) in *tangeri*-colonies of Lagoo (Portugal), the Rio Barbate (Spain) and several (former) estuaries on the Atlantic coast of Morocco (K. Müller, 1981, 1983) in most of which the percentage of juvenile stages has become less than 1%. One can easily fortell the future of such cut-off fiddler colonies.

Finally there is that remarkable example of Trinidad fiddlers on the banks of the Diego Martin River, where "nearly everything had changed 'in the name of progress'. The quiet world of the mangroves of Cocorite Swamp, the maze of the sandy mud flats of the river mouth swarming with crab life—everything was gone" (Hagen, 1978). This author refers especially to *U. major*, a fairly rare species on the island of Trinidad where he had earlier spotted two colonies of 50 and 30 individuals, respectively, and 3 apparently displaced males near Mucurapo Point. Here again, waste water plus human building activities seem to have been the cause for the fatal disappearance of *U. major* except for 16 adult males lonely and forlornly waving their conspicuous claws to attract the females, but there were none any longer.

For *Uca*, we do not yet want to join the chorus of that sometimes exaggerated chant of the Red Data Book fans as there are fiddlers still around us in almost any tropical country. But this happy experience can change rapidly as we do not know enough about the web of ecological factors guaranteeing the existence of a fiddler colony, and the factors leading to declining numbers mentioned in this paper may only be fractional. What we should do, then, is to study fiddler and other shore crabs in so far unspoilt habitats as for instance, in our mangroves. As these rich habitats seemed almost forgotten by science, we have formulated some recommendations on mangrove at the Symposium on Estuarine Biology here in Cochin in 1971, and I think that this ought to be renewed and urgently stressed to the relevant governmental bodies.

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APPENDIX

Selected List of Films on the Behaviour and Ecology of *Uca*. Species produced by the Institut für den Wissenschaftlichen Film Göttingen, Nonnenstieg 72, D-3400 Göttingen.

(These films are on loan or for sale at the a.m. Institute).

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RARE AND ENDANGERED MARINE MOLLUSCS—A REVIEW

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ABSTRACT

The review makes a survey on marine molluscs which have become rare or endangered due to over exploitation or pollution. Marine molluscs are used as food resource, for mother of pearl products, for making ornaments and in the shell trade. Because of over-fishing many edible molluscs, mainly bivalves are endangered in their natural habitats, but protected in many countries by law or by farming. In the past years with increasing tourism many large and beautifully coloured shells have become endangered by over-collecting, especially in coral reefs. Some marine molluscs, endangered in different parts of the world such as *Strombus gigas, Charonia tritonis, Doridella batava, Hippopus hippopus, H. porcellanus, Tridacna crocea, T. derasa, T. gigas, T. maxima* and *T. squamosa* have been listed in the IUCN Invertebrate Red Data Book.

INTRODUCTION

The molluscs with more than 120,000 species, living at present represent the second largest phylum after the arthropods in the animal kingdom. Unlike some other invertebrates they are relatively well known taxonomically. The occurrence of a calcareous external shell in most of the animals provides a good basic for taxonomic work. According to the present knowledge, the number of recognized species are likely to be as follows :

	Caudefoveata	Ca. 70	
Aculifera	Solenogaster	Ca. 150	
	Placophora	Ca. 1000	
		Ca. 1220	species
	Monoplacophora	7	
	Gastropoda	Ca. 100,000	
Conchifera	Scaphopoda	Ca. 350	
	Bivalvia	20,000	
	Cephalopoda	Ca. 750	
		Ca. 121,327	species
Mollusca in total		Ca. 122,547	species

The molluscs have a marine origin and in recent times with the exception of majority of the Gastropod Pulmonata and some groups of Bivalvia (freshwater-mussels and prosobranchs) the majority of the Mollusc species inhabit marine biotopes. In the marine environment the molluscs occur from the brackishwater zones, mangroves and the uppertidal zones down to the deep waters. They occur on rocky shores, in the different phytal habitats, in coral-reefs and also on and in soft bottoms, such as gravel, sand or mud and also in the pelagial of the open oceans.

Of all invertebrates, molluscs probably have been and till are highly valued by man. In the stone age they were used as a major food source (Kjoekkenmoed dinger : accumulation of shells of *Ostrea, Mytilus, Cardium* in habitats of the stone-age man in Northern Europe). Even today molluscs are an essential component of the nourishment of people, especially of coastal areas. For different tribes the molluscs form the main source of protein, for instance of Melanesia, Polynesia, Japan and West-Indies.

In the early times marine shells, particularly sharpedged bivalve shells, were used as tools in places, such as the Andaman islands in the Bay of Bengal, by the aborigines (Negritos).

Sharp edged and pointed shells were used also as weapons. Some high turreted shells, such as *Charonia tritonis* (Triton's trumpet), (Pl. I A) were (and are) used as musical instruments.

In India the shell of *Turbinella* (*Xancus*) *pyrum* (Sacred Chank) (Pl. IB) is an essential item in Hindu temples. The pearl oysters (*Pinctada* sp.) and other nacre producing species namely (*Trochus niloticus*, *Turbo marmoratus* and *Haliota* sp are also much sought after by man.

The author thanks Mr. Erhard Wawra (Natur-historisches Museum Wien) for the photographs included in the paper. The figured shells are from the collection of the Museum in Vienna.

External Factors, Endangering The Marine Molluscs

Marine Molluscs do not appear, at the moment, to be endangered in the same sense as are many birds, mammals and freshwater molluscs. Only very few marine species of molluscs have become extinct because of the activities of man. This is mainly because the distribution of the marine molluscs is either very extensive over hundreds of kilometres, or in the case of a few highly endemic species, at least over extensive areas. Bathymetric ranges in sublittoral species give additional protection. According to Abbot (1972) ' only less than 1% of the total death of marine molluscs is due to the activities of man '. At first commercial fisheries account for the greatest reduction of molluscan populations. Second come the pollution and other environmental changes and third the shell collectors.

Commercial fishery : According to the 1980 Year Book of Fishery Statistics of the FAO (1981) world nominal catches of molluscs totalled 49,51,718 tonnes, including 9,72,885 tonnes of oysters (*Ostrea edulis*, *Crassostrea virginica*), 6,13,965 tonnes of mussels (*Mytilus*-species), 3,64,173 tonnes of scallops (Pectinidae), 11,76,771 tonnes of clams (Vaneridae, Solenidae, Myacidae and others) and 15,72,098 tonnes of cephalopods.

The oysters constitute 25% of world mollusc production (Gulland, 1971). According to Kline (1977) the annual worldwide oyster consumption may be increased to more than 2.3 million tonnes by the year 2000 A.D. In the Mediterranean 12, species of gastropods, 50 bivalves and 13 cephalopods are currently exploited. In the Carribbean and Western Central Atlantic 38 species of bivalves, 4 of chiton and 4 of gastropods are collected commercially. Stevenson (1981) has reported that the major commercial fisheries are for oysters (*Crassostrea virginica*) in the USA and Mexico, scallops (*Argopecten gibbus* and *A. radians*) in the USA and Ark clams (*Arca zebra*) in Venezuela. The Queen Conch (*Strombus gigas* (Pl. I C) now reported as ' endangered ' in the Red Data Book, is particularly important in the Caribbean. Cephalopods are highly values in Southern Europe, South East Asia and South America. 70% of the world catch is made up of squid, 17% of octopus and 10% of cuttlefish. Japan accounts for half the catch, Spain, Thailand and the Republic of Korea taking most of the remainder (Hotta, 1976). In Philippines, the Pearl boat (*Nautilus* sp.) is caught at the rate of about 1,00,000 specimens a year mainly for their shells.

There was a time when edible molluscs, such as oysters, blue mussel and others, abounded in the shallower parts of the coasts. In the end of the 19th and beginning of the 20th Centuary the catch of edible molluscs diminished alarmingly on the natural beds. The beds were overfished. Governments introduced a minimum legal size for edible molluscs and even closed some beds for several years. But these measures came too late, for revival of the formerly rich natural beds which did not occur. But which new co-operation between Governments and the farmers of edible molluscs real management begins after many years of mismanagement of the natural beds of edible molluscs. Another important purpose for commercial collection of marine molluscs is the production of mother-of-pearl with the shell of some species. It is used for decorative inlay work, buttons, jewellery and other ornamental articles. The most valuable mother-of-pearl is obtained mainly from 4 species: *Pinctada maxima*, *P. margaritifera*, *Trochus niloticus* and *Turbo marmoratus*. But sometimes also from other species of the genus *Pinctada* and the species of ablalone, *Haliotis* are collected. Currently there is an annual demand of about 6,000 tonnes of unprocessed *Trochus niloticus* shell alone ! According to a report of Bouchet and Bour (1980) export in 1978 from New Caledonia was about 1900 tonnes, more than 30% of world production. Growth of *Trochus* is quite fast for the first 2-3 years (up to a size of 8 cm base diameter) then it becomes very slow. After 10 years it attains a size of 12 cm. Even a landing of 1000 tonnes has the risk of causing a sharp drop in the next year. In some countries the capture of *Trochus* shells is restricted to sizes between 6-12 cm. But in the South of New Caledonia the populations of *Trochus niloticus* as cited by Bouchet and Bour (1980) are already over-exploited and all shells are caught before reaching 9 cm. This species (and party *Turbo marmoratus*) is exported also from Indonesia, the Solomons and other Pacific Islands. In the Andaman Sea (Bay of Bengal) *Trochus niloticus* is exploited since 1900 (Srinivasa Rao, 1937). From 1929 until the Second World War they were fished commercially by professional divers of the Japanese Fishery Company. Before these exploitation the beds were virgin grounds and it was comparatively easy to pick up shells in shallow waters. But after only 3 years of commercial fishing the populations in the shallower regions between 5 and 10 metres were greatly diminished in numbers that the Japanese had to extend oprations to 15 metres and beyond. However, continued commercial fishing of *T. niloticus* near the Andamans since 1929 had reduced quantities of *Trochus* fished from 500 tonnes to less than 40 tonnes in one season, although the period of fishing had been doubled. The rate of collection per diver had fallen from 20 in 1933 to 2-3 in 1935. During the year (1939-1945) the commercial fishing was stopped and the natural beds recovered.

Since 1948, the rate of collection is controlled by the Government. Philippines, India (Tamil Nadu), Indonesia and several South Pacific Islands export large quantities of mother-of-pearl from different species of the genus *Pinctada* (Pearl oyster). Several coral reef inhabitants have been completely depleted. For example: Salvat (1981) pointed out, that since 1810 more than 1,00,000 tonnes of *Pinctada margaritifera* have been exported from the Tuamotu atolls in French Polynesia. This exploitation had led to a general depletion and it is the same story as regards the Cook islands. The whole production of mother-of-pearl in French Polynesia declined from 1329 tonnes/year in 1924 to 204 tonnes/year in 1963 as a consequence of commercial overcollecting. For biological and ecological reasons these species would need many closed years to recover its natural abundance. Some species of the abalone (genus *Haliotis*) are mainly collected in New Zealand and used for decoration and jewellery. The collection is now strictly restricted by Government law to protect the natural stock.

Commercial fishing of the Sacred Chank (*Turbinella* (*Xancus*) *pyrum*) (Pl. I B) in Tamil Nadu in the Bay of Bengal (Indian Ocean) had been conducted from time immemorial under the control of the State. The chanks are in demand for the bangle industry in India and for the devotees of the Lord Vishnu. Nagappan Nayar and Mahadevan (1967) informed that the annual catch of chanks delivered at Tuticorin alone ranged in 1967 from 6 to 10 lakhs.

Shell collecting has been a popular hobby for centuries. The ornamental shell trade is now a major industry, centred in the Philippines which exported 3500 tonnes of ornamental shells in 1979. The import of USA increases from just over 1000 tonnes in 1969 to about 4400 tonnes in 1978 and there are currently an estimated 1000 shell dealers (Abbot, 1980). Other major consumers are Japan and the European countries. The species most in demand are the big colourful gastropods from the Indo-Pacific and Caribbean, such as the Queen Conch (*Strombus gigas*) (Pl. I C), the Tiger Cowry (*Cypraea tigris*), the Nautilus (*Nautilus pompilius*, *N. macromphalus*) helmet shells, different scarce, cowries, cones and volutes. Bivalves are not so much in demand with exception of some scallops, or the capiz shell (*Placuna placenta*). The Philippines has exported in 1979 nearly 3.5 millions capiz shell articles (Wells, 1982).

With the increase of tourism on the coasts of tropical countries and islands in the last decades the demand on shells went up rapidly. Results of investigations about the shell trade and the endangered species are known from some countries. Evans, Knowles, Pye-smith and Scott (1977) report on the over-collecting of shells on the Kenya coast. Some popular and accessible sites of molluscs are almost denuded and collecting has shifted already to more inacessible sites. Commercial collectors completely devastated parts of the shore and reef shell life. There had been a serious decline in the number of molluscs on the shore. Species which have suffered badly included cowries, helmet-shells, stromb shells and rock shells. Only some relatively inacessible places on the coast and many uninhabited islands were still rich in shell-life. Group of collectors rowed out to the reef at lower water and systematically combed the area for molluscs. Some expeditions dynamited parts of the reef and lorry-loads of shells were taken regularly to the tourist centres of Mombasa. Since 1954 the number of the cowries declined (*Cypraea caputserpentis*, *C. caurica*, *C. histrio*, *C. isabella*, *C. vitellus*, *C. kieneri*, *C. lamarcki*, *C. mauritiana*, *C. talpa*). Other species offered in great numbers by dealers are *Cypraea annulus*, *C. arabica*, *C. diliculum*, *C. erosa*, *C. helvola*, *C. lynx*, *C. mappa*, *C. onyx*, *C. tigris*, *Ovula ovum*, the helmet shells *Cassis cornuta* and *C. rufra*, Neptuns trumpet *Charonia tritonis*, the harpshell *Harpa major*, the stromb shells *Lambis crocata*, *L. lambis* and *L. scorpion*, the vase shell *Mitraria episcopalis* and the Queen Conch *Strombus gigas*. There are also large stocks of cones, olives and auger shells. The bivalves are represented by different species, mainly by *Cardium pseudolima*, *Tridacna elongata* and *T. gigas* (Pl. II D) and finally the Cephalopods by shells of *Nautilus* spp. Many of these shells are exported to Mediterranean countries, where they are sold to the tourists during the summer months. *Cassis rufra* is exported to Italy, where the orange nacreous layer of the shell is used in the manufacture of cameo bottons. In view of the great demand for shells in other countries the dealers in Kenys have to rely on supplies from relatively inacessible places or on imports from other African and Asian countries.

Kenya Government has now been prepared to legislate to restrict shell-collecting. But it cannot be enforced without patrolling the whole coast. A better way of restricting collecting is to limit the sale and export of shells and the establishment of marine parks, which are patrolled regularly.

In the South Pacific (New Caledonia), the value of export of shells is estimated by Bouchet (1979) to be more than US $ 1,00,000. In this region there are three endemic species of Volutidae, they being *Cymbiolaca thatcheri* (Cheterfield Island), *C. deshayesi* (North New Caledonia) and *C. rossiniana* (Island of Pines). The last species is very rare and only about 100 specimens are taken during a year, the value being about US $ 120. The cowries have no endemics, but curious are variations with 'melanisme' and 'rostration' in the South of New Caledonia. This black and deformed shells are in great demand and the value goes up to US $ 1000 for each shell. Over exploitation in this area has made the species more and more rarer. As in Kenya, fishing was executed during day with dynamite, Eaude Javel and poison destroying the whole reef. Where the snails come out during night from the parts of the reef which are not destroyed they are collected with light. Since 1967, the destructive fishing is forbidden by law. About 100 species of Conidae are known from New Caledonia, but only 4 species are endemics, *viz.*, *Conus lienardi* (south New Caledonia), *C. cabritii* (New Caledonia), *C. optimus* (New Caledonia) and the famous *C. lamberti*. Very few specimens of the last speices have been collected in the last century. One specimen of the species was caught in 1984 which was handed over to an aquarium (ch. Pollabauer, *pers. comm.*). The value was about US $ 1800. Some local races of the species such as *Conus marmoreus crosseanus* (Island of Pines), *C. marmoreus sufflueus* (Coast of Bourail) and *C. moluccensis merleti* (New Caledonia) also occur. Bouchet (1979) suggest to establish small marine parks of some dozen hectares for these rare species and races near the capital of Noumea for an efficient control. At the Polynesian Islands since long time shells of *Pinctada margartifera*, *P. maculata*, cowries, cones, *Cardium* species, *Carithium rugosum* are used. Salvat (1967) highlights the importance of the marine molluscs in the atolls of French Polynesia. With the development of the tourism in French Polynesia, especially in the Island of Tahiti, the shell trade has increased immensely. Some dozens of tonnes of shells are transported during a year from the atolls to Papeete, the capital of Tahiti. Small shells are also transported in large bags which are used for necklaces. For example, several tonnes of *Cardium fragrum* are exported from the atolls of Reao and Tureia to Papeete every year. Nearly every tourist leaving Tahiti would have some kilograms of shells as souvenir in the baggage. Many international Airlines, leaving Tahiti with tourists, include these weight in the transport freight and let free four or five seats. Most of the shells used for necklaces are collected from the shores and therefore poses no danger for the living populations. However, some species, particularly cowries and cones, are collected alive by the divers. It is therefore clear, that with continued collection of living molluscs, the survival of several rare species because threatened. Salvat (1967) cited *Turbo setosus* and *Lambis truncata* as examples.

Abbot (1970) reports that some marine species of molluscs are locally over-collected on the Atlantic coast of America. (*Strombus gigas*, *Cassis madagascariensis*, *Pleuroploca gigantea*, *Crytopleura costata*, *Cyphoma gibbosum* and *Melogena corona*). Of these species *Strombus*, *Cassis* and *Pleuroploca* have become comparatively uncommon, but certainly not extinct. Keen (1970) states that the trochid snail *Norrisia norrisi*, feeding on the blades of the giant kelp in South California, is in precarious state. The kelp beds have markedly diminished by pollution and sea urchins. The littorinid snail *Algamorda newcombia*, restricted to the Humboldt Bay at Northern California, feed on the lower stems of the marsh succulent *Salicornia* or on muddy substrate. With the installation of sawmills in these area in 1940/1950 most of the snail have disappeared on account of the sawdust that blanket their habitat. By 1968 the old sawmills have been abandoned and the new factories are converted to a type that do not produce sawdust. This may help *Algamorda* to regain its former status. However, it is the truely estuarine species, which require brackishwater and extensive mud flats, that appear to be in danger of extinction locally. This is due to the destruction of the tidal flats by land reclaimation and the change of the salinity of the water by channeling the runoff from the rivers of the area into the estuaries. Brackishwater molluscs are vulnerable to pollution and habitat disruption on the coasts. Hundred of highly endemic species, especially the minute brackish Hydrobiidae, are in great danger. They serve as food for shrimps, crabs and fishes and with their extinction at least a small fraction of the food chain of the estuaries is modified. Estuarine and littoral habitats are great source of seafood. Man must examine critically every 'improvement' that would affect his own food supply.

As mentioned above, pollution can be an important factor that reduce populations of molluscs. Pollution from industrial wastes, from pesticides and from oil spill has already considerable effect on the marine fauna and as it increases, can cause enormous havoc and great hazard to the whole marine eco-system, including molluscs, especially in the shallow bays. But very little is known about the effects of pollution on marine molluscs. Oil on the shore and in the intertidal zone can kill molluscs by smoothering or poisoning and filter feeders and detritus feeders may ingest and accumulate dispersed or sedimented oil. Hartog and Jacobs (1980) have studied the effects of the sunken tanker 'Amoco Cadiz' oil spill on an eelgrass (*Zostera marina*) community at Roscoff (France). On 30th March, 1978 the area of study was struck by the oil slick of the 'Amoco Cadiz' (2,16,000 tonnes of crude oil and 4000 tonnes of busher fuel). The results of sampling before the oil spill and after the accident show clearly that the oil slick had a profound but selective influence on the various animal groups. The effect on the Amphipoda was spectacular, but the Gastropods were little affected. Most of them are bound to the bottom and only some of them crawl on the *Zostera* leaves. Most of the species found before the oil spill were found also later. Only some species, such as *Gibbula cineraria* and specially *Cingula somicostata* were not or very rarely found after the oil pollution took place. George (1976) observed the damage caused by oil and chemicals discharged from ships to *Pinctada margaritifera* stocks which was cultured in the Dongonab Bay in Sudan.

List of Rare and Endangered Marine Molluscs

Dance (1969) pointed out that a 'rare' shell is one which has proved desirable to many or few ; that is in short-supply either in nature or in the market. But large number of marine molluscs, known to science is not required for man for food, commercial trade or collection. Therefore, very few or nothing is known about the rarity or endangered status of most of the marine species of molluscs. The following is a list of marine molluscs that are in great demand in the market.

Aculifora : (Solenogastres and Caudofoveata) are the worm-shaped molluscs known only since the last century. Many new species have been described in the recent years. The Caudofoveata are present in the surface of muddy bottoms down to 2200 m depth. The Solenograstres are mostly free-living as epizoic and parasitic animals on Cnidaria. The pollution in coastal areas can endanger these forms. Placophora or chitons are living mostly on the rocky shores of the coasts, some also in deeper waters (down to 4300 m depth) or in coral reefs. They are not commercially important and are endangerd only in areas of pollution on the coast or in coral reefs under destruction.

Conchifera : Living *Monoplacophora* were discovered along with the species *Neopilina galathea* in 1952 by the Danish 'Galathea'—Expedition from off the Westcoast of Central America in depth of 3590 m. Between 1958 and 1967 several other species were found and

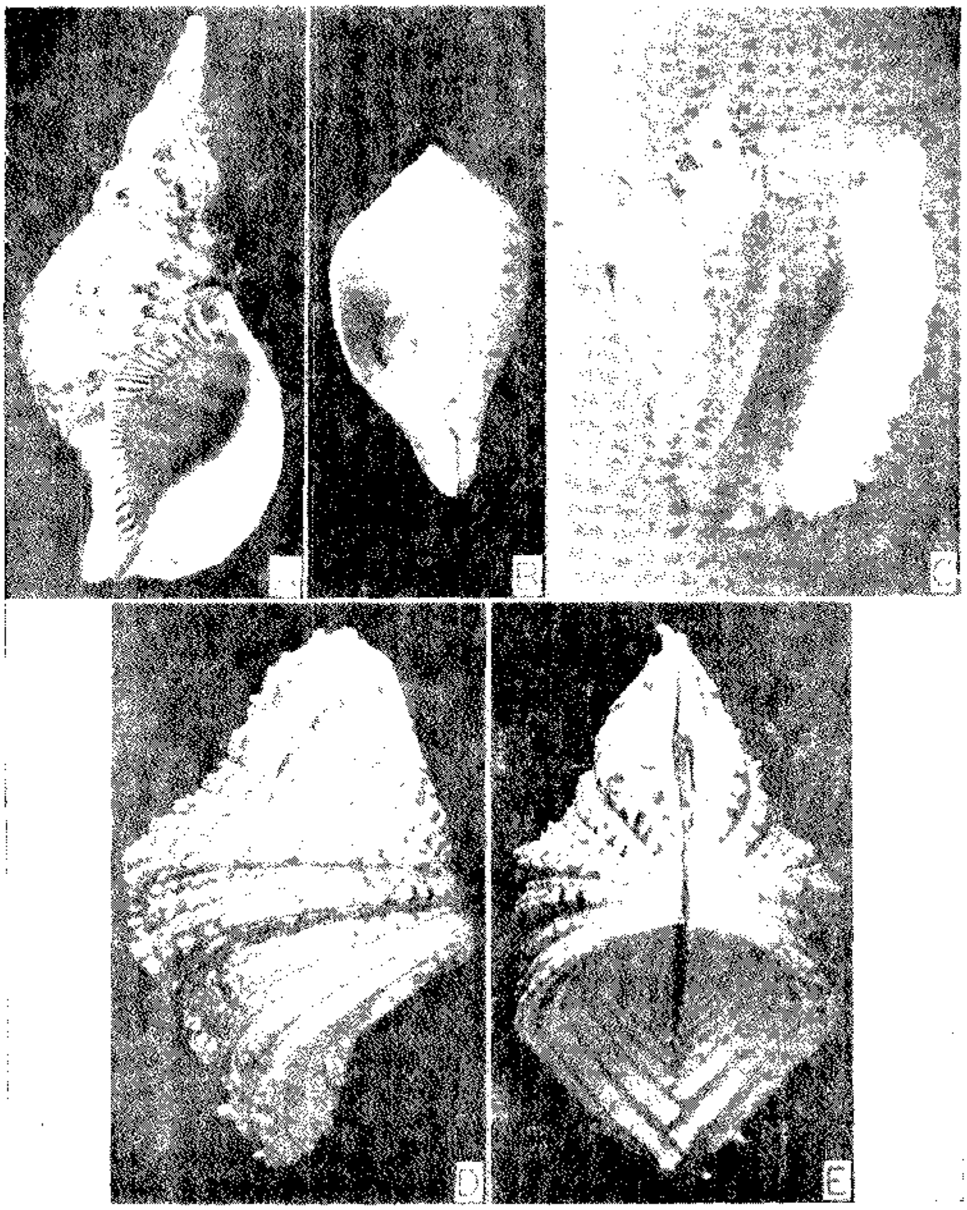

PLATE I. A. *Charonia tritonis* (Triton's Trumpet) Height : 35 cm ; B. Left-handed specimen of *Turbinella* (= *Xancus*) *pyrum* (Sacred Chank) Height : 15 cm ; C. *Strombus gigas* (Queen or Pink Conch) Height : 20 cm ; D. *Hippopus hippopus* (Horse's Hoof, Bear Paw or Strawberry Clam) Diameter : 35 cm and E. *Hippopus hippopus* viewed from above.

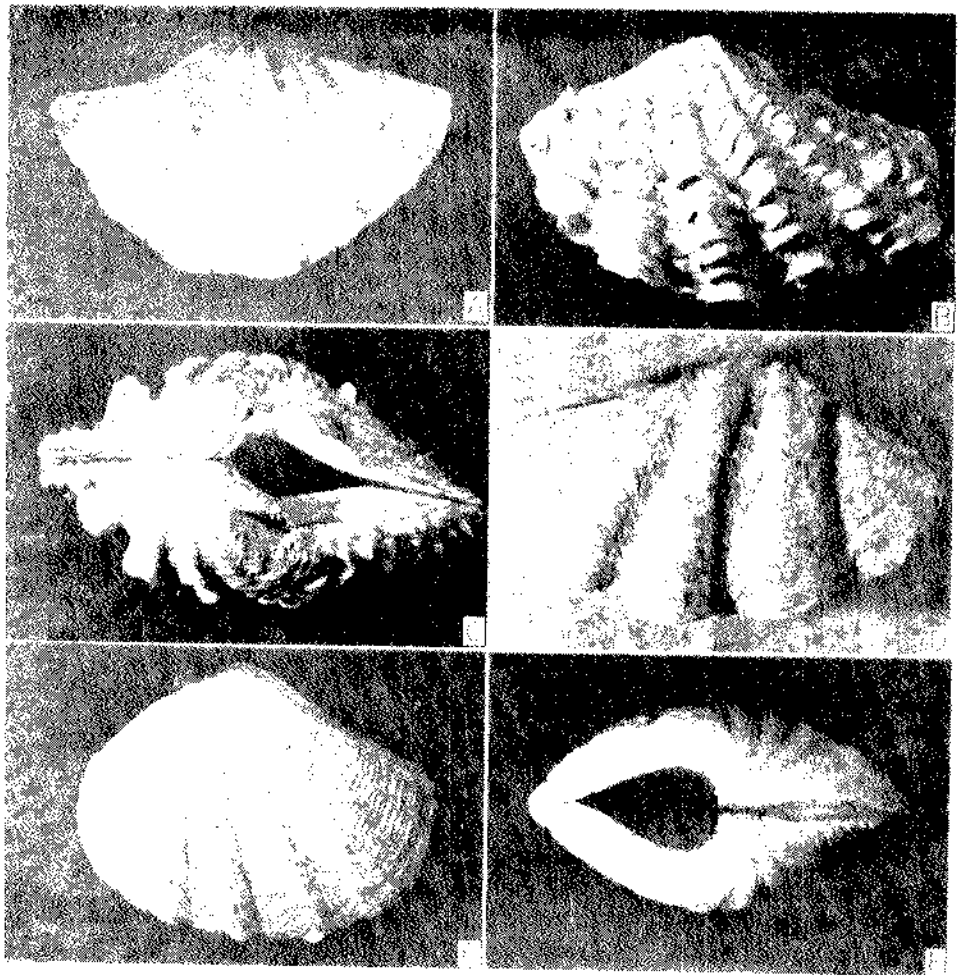

PLATE II. A. *Tridacna derasa* (Southern Giant Clam) Diameter : 45 cm ; B. *Tridacna maxima* (Small Giant Clam) Diameter : 35 cm ; C. *Tridacna maxima* viewed from above ; D. *Tridacna gigas* (Giant Clam) Diameter : 80 cm ; E. *Tridacna crocea* (Crocus, Saffron coloured or Boring Clam) Diameter : 15 cm and F. *Tridacna crocea* viewed from above. All photographs in Plates I and II by F. Wawra (Natural History Museum, Vienna) until now 7 species have been recognised. The recent species are all deep-water forms on muddy bottom. In such deep-sea environments they are not endangered by pollution and collection.

Gastropods are the largest group of marine molluscs. More than the half of species of gastropods belong to *Prosobranchs* (around 55,000 species) majority of which live in marine habitats. *Archaegastropoda* (Pleurotomariidae), the slight-shells are known as 'living fossils'. They inhabit deep-waters and some of the recent species such as *Entemnotrochus adansoni*, the rarest and largest slit-shells from West Indies, *Perotrochus quoyana* also from the West Indies, the first living slit-shell known; and *Pleurotomaria rumphii* from vertical cliffs near Taiwan are very rare.

Trochidae : The Son shell or Imperial Sun Trochus (*Astrea heliotropium*) from New Zealand is greatly required by collectors, but scarce. *Mesogastropoda* (Scalidae), *Epitonium* (*Scala*) *scalare*, the previous wentletrep was found, several times and it was every collector's aim to own a large one in perfect condition.

Strombacea : About 52 species are known, some are scarce, such as *Strombus listeri* of the Indian Ocean and *Strombus taurus* of the SW-Pacific. The famous *Strombus gigas*, the queen conch of the West-Indies is well known food for the inhabitants of these islands, but the supplies are dwindling and specimens are now rarely to be found. This species is in the list of endangered marine molluscs in the Red Data Book (Wells, Pyle and Collins, 1983): The Wentletrep Conch *Strombus scalariformis* is known only from one specimen, caught in 1833. The spider conchs are constituted by 9 species. The Giant Spider Conch *Lambia truncata* is eaten by native people of the islands of the Indo-Pacific. A rare species is *L. violacea*, the violet spider conch of Mauritius and Eastern Indian Ocean (Not more than 100 specimens are known to be caught). *Strombus listeri* is the rarest and most desirable species from the Indian Ocean. Several specimens had been dredged in 1965 in fairly deep water in the Eastern Indian Ocean (Dance, 1969). Another rare shell is the famous *Tibia martinii* from Philippines and Indonesian Archipelago which was sold at US $ 100 in 1967.

Cypraeacea : The cowries are the jewels among the marine molluscs ever since early man had used these shells as ornaments and trade goods. About 180 species are recognised, but in the last decades more new species have been described, such as *Cypraea porteri* in 1965. Some very rare species such as *Cypraea leucedon* or *Cypraea valentia*, the *Prince* Cowries living in deep-waters are only known from the stomach of fishes. The White-spotted Cowrie *Cypraea guttata* found in the Solomons were sold at more than US $ 2000. It would be safe to say that within the last hundred years man has collected over a million pounds of the Money Cowries, *Cypraea moneta* and *C. annulus*, yet they continue to flourish. The most required species is the famous Golden or Orange Cowrie, *Cypraea aurantium* of the South Sea near Fiji. Less than a thousand specimens have been collected until now. The species live in recessed, submarine caves on the front of the reefs and they are difficult to collect even with Scuba diving. Dance (1969) has listed seven rare species of cowries. *C. aurantium* and *C. broderipii*, are deep water forms, known only from the stomach of the South African 'Natal Mussel crusher' a fish, of *Cypraea valentia* from the deep-water of the Torres Strait, only 6 specimens were known until 1967. Two specimens of *C. leucodon*, the famous *C. nivosa* from the Indian Ocean, *C. guttata* from New Guinea (16 specimens are known) and *C. fultoni* were also found only in the stomach of deep water fishes from south Africa.

Tonnacea : Cassididae : *Morum dennisoni* is a Western Indian Ocean deep water species and very scarce until today, *M. mathewsi* is only known from the stomach of a Brazilian deepwater fish.

Cymatiidae : *Cymatium ranzani* from the Western Indian Ocean is very little known, but perhaps overlooked by collectors. The Triton's Trumpet or Giant Triton, *Charonia tritonis* has a large attractive shell which is popular with shell collectors and has had a long history of use in the Indo-Pacific as a trumpet. It is found on coral reefs and appears to be rare throughout much of its wide range. In some places this is over exploited. The populations could have been reduced also as a result of the accumulation of toxic residues from pesticides and other pollutants in the tissues of specimens, particularly since this species is a predator of high trophic status. The species is listed by Wells Pyle and Collins in the IUCN Invertebrate Red Data Book (1983).

Neogastropoda : *Muricacea :* Man's interest in this group, aside the fantastic spiny ornamentation and the edible qualities, was spurred by the discovery that the juices from the animal could produce a very permanent and colourful red-purple dye, so called royal tyrian purple. Hundreds of small genera are known. Rare species according to Dance (1969) are *Murex alabaster* from Taiwan and the Philippines, *Murex barclayi* from the Indian Ocean (only 6 specimens are known) and *Murex (Pterynotus) loebbecki* from the China Sea and Japan. *Murex elongatus* is known since 1786 and has wide distribution in the Indo-Pacific, but difficult to obtain. In the last few years skin-divers have learnt to distinguish the adapted shell from the coral on which it is found. *Murex beaui* of West Indies is a common form in shallow waters.

Buccinacea : *Busycon coarctatium* from the Gulf of Mexico has been dredged in large numbers in the past years from very deep-waters. The curious and scarce *Hemifusus (Thatcheria) mirabilis*, discovered in 1877 near the Philippines was until 1940 known as 'calariform monstrisity'. In this year again several specimens were fished out in Japanese waters and now it is a common species.

Volutacea : Olividae : *Ancilla vernedi*, the 'Queen of the Ancillariae' is only known from 2 specimens. Mitridae : *Vexillum denisoni* from the Philippines is also known only from few specimens and *V. stainforthii* known to be widespread in the Western Pacific is still coveted and difficult to obtain. Vasidae : 30 species of the Vase shells or chanks are known to occur. Well known is the Sacred Chank *Turbinella (Xancus) pyrum* from Southern coast of India and from Sri Lanka. The Chanks are without veliger-stages and are unable to swim to new territories and therefore their areas of distribution are very restricted. The rarest of all in *Vasum crosseanum* from the Seychelles (3 specimens known) and *Vasum sansibarensis* with 6 known specimens.

Harpidae : The harp shells include about 12 species. The Imperial Harp, *Harpa costata* is a rare species from Mauritius (about 100 specimens have been collected). *H. gracilis* from Eastern Polynesia is also very scarce.

Volutidae : *Volutorbis abyssicola*, found in 1848 in the African waters is a living fossil. The rare *Neptuneopsis gilchristi* was taken from South African waters. The artistocrat in the world of shells is *Festilyria festiva* from the fairly deepwaters of East-Africa. About 12 shells are known and the highest price ever obtained was US $ 2,175. *Lyria lyraeformis* of East Africa, was very scarce formerly but enough specimens are now turned up in fish nets off the coast. *Lyria beaui*, a deep-water form of the Caribbean is almost scarce and about 6 specimens are caught so far. *Scaphella junonia* which was found in the Gulf of Mexico was highly priced for long, but now it is known to be fairly common. Other rare species in great demand are *Aurinia kieneri* from the Gulf of Mexico.

Volutoconus bednalli the most beautiful of all voluts of North Australia, *Aulica aulica* from the Philippines, *Aulica chrosostoma* from Indonesia and *Provocator pulcher*, known only from 2 specimens from the Kerguelen Islands.

Marginellidae : The largest species of this group and still very scarce is *Afrivoluta pringlei* from South-Africa.

Conacea : Conidae : About 400 species are described and there may be as many as 200 species coexisting in relatively small and similar habitat. Since fifty years some particular areas had been found by SCUBA divers for these species which were considered to be rarer but are now collected in high numbers and the fishing has almost attained the level of endangering the species. Some of the species once thought to be rare but found to be abundant later are : *Conus nobilis* from the Sulu-Sea, *Conus thalassiarchus* from Palawan island and also the famous *Conus gloria-maris*, *Conus excelsis* and *Conus bengalensis*. The 'Glory of the Sea' which became rarer after excess collection gradually revived with the discovery of more than 150 specimens in the Solomons by SCUBA divers (Abbot, 1972). Until 1964 about US $ 2000 were obtained for large specimens. Dance (1969) listed *Conus thomae* from the Moluccas, *C. cervus*, probably from Indonesia, *C. crocatus* very rare from the Western Pacific, *C. gloria-maris*, *C. milneedwardsi* from the Indian Ocean, *C. excelsis* from the New Hebrides, the rarest of the cones and remarkable for the height of their spire and for their striking markings, as rare and endangered species, *C. adamsoni* from the Central Pacific and *C. dusareli* from Mauritius (only one specimen has been obtained from the stomach of a deep-water fish) are also rarer. *Opisthobranches* are exclusively marine. About 13,000 species have been described. Only one species *Doridella batava* from the family Cormabidae of the order of Gymnosomata is listed in the IUCN Invertebrate Red Data Book (1983). The *Zuidersee doridella*, (the sea slug, is small only 5 mm in length and lives in brackishwater. It is believed to be endemic to an area centred on the former Zuidersee in the Netherlands. The closure of the Zuidersee caused its disappearance from most known localities, including its type locality and it may now be extinct. But it is to presume that many other of the mostly very small species of Opisthobranches are endangered, specially by pollution or due to the extinction of their favourite food (cnidaria for Aeolidiacea or sponges for Doridacea). The most species of sea-slugs are highly specialised and live in restricted habitats and any change of ecological parameters can endanger their survival. But no information at the moment is available on them.

Bivalvia : *Filibranchia :* Anisomyaria : Mytiloidea : Mytilidae : *Mytilus edulis*, the Blue Mussel, is consumed in high quantities, the natural beds are mostly abandoned, but the modern cultivation methods guarantee the annual production of about 500 million pounds, 40% of which comes from Netherlands and France. Pectinoidea : Pectinidae : The edible scallops are the choicest of shellfishes. The world production is around 300 million pounds of meat/year (41% from USA, Japan ; 10% each from Europe and Australia). The most required species in USA (Abbot, 1972) are *Placopecten magellanicus*, *Pecten caurinus*, both caught by large diesel-powered vessels, scraping the bottom with paired large scallop dredges. *Argopecten irradians* is caught from the shallow waters. Pectinidae are fished in Southern Australia, Japan and in the Mediterranean.

Spondylidae : The Thorny Oysters (*Spondylus regius*) which was considered a very rare shell at the beginning of the century are some times collected by shell-collectors of the Southeast Asia.

Eulamellibranchia : Heterodonta : Cardioidea : Tridacnidae : The Giant Clams of the genera *Hippopus* and *Tridacna* are registered as endangered in the IUCN Invertebrate Red Data Book (*Hippopus hippopus*) (Horses Hoof or Bear Paw Pl. I D, E), *H. porcellanus* (China Clam), *Tridacna crocea* (Crocus, saffron coloured or Boring Clam Pl. II E, F), (Southern Giant Clam Pl. II A), *T. gigas* (Giant Clam Pl. II D), *T. maxima* (Small Giant Clam Pl. II B, C), *T. squamosa* (Scaly or Fluted Clam). The Giant Clams are restricted to limited areas of the Indo-Pacific. Recently there has been large scale commercial exploitation, particularly by the Taiwanese, of the larger shells for both shells and meat. Certain aspects of their biology and the ease with which they can be harvested made them highly vulnerable to over-exploitation and populations have declined in many areas, such as Palau Islands, Great Barrier Reef, Southern Japan, Western Indonesia and Philippines. They are still abundant in Marine Reserves and inaccessible habitats. In some regions the collection is controlled by local administration or the export is limited or prohibited. Giant clams would appear also to be suitable for mariculture.

Lucinoidea : *Fimbriidae : Fimbria sowerbii* is one of the few coveted bivalves. Veneroidea : Veneridae : The Qualops or Chowder Clams are highly required as edible clams, such as *Mercenaria mercenaria, Tivela stultorum, Saxidomus* (*Butter Clam*) and Protothaca (Littleneck Clam). The USA is importing *M. mercenaria* worth of about 10 million US $/year (Abbot, 1972). It is grappled from the bottom by long-handled tongs or dredged by larger vessels using power winches and large steel-mesh bag. *Mya arenaria* is harvested in shallow waters by means of boats rigged with an escalator that digs and delivers the washed clams to the surface. The boats are controlled by law in USA to 40 bushel/boat/day. Around US $ 3 million of *M. arenaria* are harvested a year in USA. The Surf Clam *Spisula solidissima* is protected by law, limiting the fishing to a special area near New Jersey (USA) from where about 40 million pounds of meat are harvested in a year. About 10 million specimens of the Razor Clam, *Siliqua patula* are harvested a year in USA. The famous Butter Clam, *Saxicava*-species has suffered a drastic decimation due to over-collecting. The catch of the littleneck Clams, *Protothaca* species and the Geoduck Clam, *Panopea generosa* (weight : up to 4 kilogram) from the soft mud bottom is limited in USA by law to only a few specimens/person/week. In Malaya the annual catch of the *Anadara* Clam is estimated to be about 25 million pounds. In Europe about 74 million pounds of cochles are harvested. *Pholadomya candida* from the Caribbean is considered as 'Living fossil', the closely related shells are all extinct. Only few specimens from deep-waters were found.

Cephalopoda : Tetrabranchia : Nautilidae : The genus *Nautilus* with few species is distributed in the Indo-Pacific, mostly in deeper-waters during the day and swim up to the surface during night. They are eaten in some Pacific Islands, such as the Loyalty Islands, but most caught for the shell-market. In the Philippines more than 1,00,000 specimens/year are sold. It is to be presumed that over collection will reduce this species. Dibranchia : Decabrachia : (squids) are caught by jigging, a procedure used to attract and ensnare the squids. In USA one fisherman land up to 1,200 squids/hour (Abbot, 1972). *Illex illecebrosus* is harvested at the rate of 10,000 tonnes/year, *Loligo pealii* at about 1,500 metric tonnes/year in USA. The Japanese land over a 5,00,000 tonnes/year and the spanish about 8,500 tonnes/year. Octobrachia : *Octopus* species are caught in the Mediterranean and particularly in Japan, at about 100 tonnes/year.

Protection of Endangered Marine Molluscs by Law and Management of Marine Species by Mariculture

The over-collecting of some species of marine molluscs, caused by fishery and shell market was stopped in many countries in the last decades by law. Several habitats are declared as protected areas and marine parks. They are regularly controlled by special wardens. For many species a total ban on collection has been imposed (*Pinctada margaritifera* in Tahiti, Fiji, New Caledonia and in Japan, *Trochus niloticus* in some countries on the Indo-Pacific coasts). Another step is the definition of minimum size for the protected species to guarantee the survival and reproduction. Orders have been issued to change the collecting areas. In USA there are laws to protect the species namely, *Haliotis* (abalone) *Siliqua, Saxidomus, Venerupis, Mercenaria, Spisula, Mya, Ensis, Schizothaerus, Hinnites* and some other edible species. In the West-Indies *Strombus gigas* is protected and in many countries of the Indo-Pacific *Charonia tritonis* and the giant clams of the family Tridacnidae genus *Hippopus* and *Tridacna* are protected. The formulation of Washington convention is to protect endangered animals, listed in the IUCN Red Data Book. Many countries have signed this Convention. Although molluscs, especially gastropods and bivalves, have attracted attention since prehistoric times, cultivation of marine molluscs has centered largely on few species mostly commercially important bivalves. As in other marine invertebrates, the problems connected with the rearing of larvae has posed challenges to the cultivation of molluscs. Larvae tend to be less tolerant to environmental stress and to poor nutrition than the later life-cycle stages.

Several bivalves are presently farmed with a high degree of success and specific culture systems for oysters and clams are being developed. Long-term growth of juvenile and adult bivalves in closed sea water systems have been studied (Kinne, 1977). Using a recirculation system *Crassostrea virginica, C. gigas, Mercenaria mercenaria, Mytilus edulis, Ostrea edulis* and *Tapes semidecussata* have been reared under controlled dietary conditions. The following bivalves in addition to the species already mentioned are cultivated in Japan: *Anadara broughtonii, A. subcrenata, Atrina japonica, Filvia mutica, Mactra sachalinensis, M. sulcataria, Meretrix lusoria, Platinopecten yessoensis, Sinovacula constricta* and *Tapes japonica*. Although less than some 3% of the edible mollusc species known have been kept in culture, the information at hand is considerable. Kinne (1977) states, that with the modern culture techniques it should be possible to cultivate many more endangered marine molluscs to make them available for biological studies and as food organisms.

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EFFECT OF OIL SPILLED IN NOWRUZ PLATFORM IN THE PERSIAN GULF ON THE ENDANGERED BENTHIC ORGANISMS

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ABSTRACT

In order to search the effects of Nowruz Platform's oil spilled into the Persian Gulf, two sea trips were taken on Oct. & Nov. 1983. The results of this showed that the stations No. 3, 4, 5 located at the highest polluted area, and other stations were either less or had no pollution at all. Some benthic organisms were found in all the stations. Some species were distributed only in clean area. It was also observed that in clean stations the varieties of different species were much more than the polluted area. Most of the live Bivalvia in the polluted area were *Nucula* sp. This study also reveals that Echinoderms, Coral reefs, crustaceans and vascular plants in comparison with other benthic Organisms were more sensitive.

INTRODUCTION

THE Persian Gulf is a marginal sea measuring some 1000 km in length and 200-300 km in width, covering an area of approximately 226,000 Square Kilometres. Its average depth is Ca. 35 m, and it attains its maximum depth of Ca. 100 m near its entrance—the straits of Hormuz (Purser, 1973). It is virtually surrounded by arid land and connected to the Indian Ocean by the 60 km wide straits of Hormuz.

The Iranian shores of the basin are essentially linear and rocky, with narrow coastal plains associated with the estuaries of a number of small rivers which drain into the gulf from the adjacent Zagros Mountains. The Persian Gulf lies between the latitudes 24°-30°.30' N and has an arid sub-tropical climate. The absence of Oceanic buffering permits marked variations in water temperature and salinity (Purser *et al.*, 1973).

From the point of view of live organisms, the Persian Gulf, has a variety of plants and animals in it including *Penaeus semisulcatus* that is valued, as food. Besides, there are also varieties of commercial fin fishes and, medicinal plants in the persian Gulf.

The Middle East is currently the world's largest oil production area (*Ca.* 30%) and is likely to remain so with an estimated 55% of the world's proven oil preserves; and the great majority of Middle East Oil is transported by pipeline and/or ship to other parts of the world.

At present, the great majority of oil entering the sea in the Gulf is surface slicks, and for the foreseeable future tanker spills, tanker washings and pipeline breaks. Further, the current urbanisation, industrialisation and offshore production programmes throughout the Middle East indicate an increase in chronic discharges and suggest that in the future more attention should be directed to their environmental effects.

The enclosed nature of the main receiving bodies of the Gulf in conjunction with little water exchange with the Indian Ocean (as a result of evaporative losses) considerably reduces dispersion potential for pollutants compared with the open ocean and many coastal regions. Golob (1980) estimates *Ca.* 3.1% of the total world Oil import to occur in the Gulf, but in view of the confined nature of the water body this represents an input of some 47 times more per unit area than the world average.

Nowruz Field is located north-west of Kharg Island. The facilities in Nowruz field consist of main production Platform, living quarter and satellite wells. Crude from satellite wells flows through submarine flowlines into the production facilities and is then pumped to onshore process plant and storage.

Nowruz crude with API gravity of about 21 degrees (Sp. gr. 0.93), considered as a heavy crude, contains sweet gas (Olfat, 1984).

On January 27, well platform No. 3 in Nowruz field was severely damaged by Iraqi air attacks, and caused the flow string to brake from the sea bed, at the depth of 85 ft, resulting in severe oil and gas leakage into the sea. Leakage was estimated to be 2000 barrels of oil and 700,000 cubic feet of sweet gas a day.

Air attacks to the main production platform continued, so on March 2, Platforms No. 5 and 6 sustained most damage with two wells uncontrolably on fire. Approximately 7000-8000 barrels of crude oil a day was discharging from each platform. It was hard to control the oil spill from the wells. Nevertheless, with serious and hard efforts after three months, well No. 3 came under control on Sept. 18, 1983 ; but the other wells still continued to burn. On the basis of one estimation about 500 barrels of oil entered into the sea per day. On May 22, 1984 another burning well came under control, and at the time being only one of those wells still is burning.

The total oil which is pouring out into the sea from the damaged wells of the Nowruz field from the beginning till the end of May 1984 (16 months), is estimated to be about 1,000,000 barrles (1,60,000m^3) or 150,000 metric tons (Olfat, 1984). This amount is 2.5 times the oil which was the share of offshore oil Production in Polluting the seas of the world in 1978.

Material and Method

After the No. 3 Nowruz well came under control, in order to search the effects of oil spilled and to determine the level of pollution, two sea trips were taken on Oct. & Nov 1983. In these trips 8 stations were selected. The aim of the said trips was for analyzing and identifying the benthic Organisms. To take sample from sediment, van veen grab sampler was used, and all organisms, substrat and oil were studied carefully. The samples were washed over sieves and the fraction larger than 150μ retained. The samples were preserved for subsequent study using Formalin. From the stand point of quality and quantity, the samples were analyzed and identified in laboratory as follow :

Abundance of Benthic Organisms (+++) many, (++) moderate, (+) scarce, (—) none. The results of the study can be seen in Table 1. In addition, in order to study the level of costal pollution some samples from the Buschire Coast were also taken.

Conclusion

On the basis of the studies, the distribution of pollution of oil spilled from Nowruz platform can be explained as follows :

The distance of first 20 km from the center (Nowruz's Well No. 3) was the highest polluted area. Beyond that area about 50 km was also polluted but not as high as the first 20 km.

TABLE 1. *The list of organisms and the related sampling stations in the areas under investigation*

Station No. 8	Station No. 7	Station No. 6	Station No. 5	Station No. 4	Station No. 3	Station No. 2	Station No. 1	Organisms/Spieces
1	2	3	4	5	6	7	8	9
								A. GASTROPODA
+	—	++	—	—	—	—	—	*Fissurella salebrosa*
—	—	+	—	—	—	—	—	*Scutus unguis*
++	+++	+	+++	++	++	+++	+++	*Umbonium vestiarium*
+	—	++	—	—	—	—	+	*Diodora* sp.
+	—	+	+	—	—	+	++	*Architectonica laevigata*
++	+++	—	+++	++	+	++	—	*Heliacus variegatus*
—	+++	—	++	++	++	++	++	*Rhinoclavis kochi*
+	+	—	—	+	++	+	—	*Niso venosa*
++	+++	+	+++	++	++	+++	+++	*Cypraea* sp.
++	+++	—	+	—	—	++	+++	*Natica* sp.
—	++	—	—	—	—	—	—	*Mitrella blanda*
+	++	—	—	—	—	+	++	*Ancilla castenea*
+	++	—	+	—	+	++	++	*Calyptraea edgariana*
—	+	—	—	—	—	+	—	*Bullia tranquebarica*
+	+++	+	+	+	++	+	+++	*Salinator fragilis*
+	++	—	+	—	++	++	++	*Pyramidella mitralis*
+	++	—	+	—	+	++	+++	*Atys cylindrica*
—	—	—	—	—	—	—	+	*Planaxis sulcatus*
—	+	—	—	—	+	—	—	*Telescopium telescopium*
—	++	—	+	—	—	—	—	*Monilea* sp.
+	+++	—	++	+	++	+	++	*Ovula ovum*
+	++	—	+	—	++	—	—	*Siphonaria lacinotsa*
—	++	—	—	—	—	—	—	*Pisania rubiginosa*
—	+	—	—	—	—	—	—	*Monilea obscura*
+	—	++	—	—	—	—	—	*Diodora funiculata*
—	—	—	++	—	—	—	+	*Turritella torulusa*
+	—	++	—	—	—	—	+	*Cymatium* sp.
+	—	+	—	—	+	—	—	*Bursa granularis*
+	++	—	—	—	—	—	+	*Patella* sp.
—	—	—	—	—	—	—	+	*Litorina* sp.
+	+++	—	+	++	+	++	+++	*Capulus* sp.
—	+	—	—	—	++	—	++	*Gastropoda* sp.
								B. BIVALVIA
+	—	++	—	—	—	—	—	*Amygdalum japonicum*
—	—	++	—	—	—	—	—	*Chlamys* sp.
—	—	++	—	—	—	—	—	*Spondylus exilis*
+	++	—	—	+	+	+	++	*Diplodonta ravayensis*
+	+	—	—	+	—	—	+	*Sanguinolaria cumigiana*

TABLE 1 (Contd. . . .)

Station No. 8	Station No. 7	Station No. 6	Station No. 5	Station No. 4	Station No. 3	Station No. 2	Station No. 1	Organisms/Spieces
1	2	3	4	5	6	7	8	9
+	+++	—	+	++	++	++	+++	*Laevicardium* sp.
+	++	—	—	—	—	—	++	*Pandora unguiculus*
—	++	—	—	—	—	—	—	*Pinna muricata*
—	—	+	—	—	—	—	—	*Donax scalpellum*
—	—	+	—	—	—	—	—	*Laternula navicula*
—	—	+	—	—	—	—	—	*Triphora cingulata*
+	+	—	—	—	—	—	+	*Apolymetis* sp.
+	++	—	—	—	+	+	++	*Callista lilacina*
—	++	—	—	+	—	+	++	*Paphia gallus*
—	+	—	+++	++	++	++	+++	*Bassina callophyla*
++	+++	—	+++	+++	+++	++	+++	*Dosinia ceylonica*
+++	+++	++	+++	+++	+++	+++	+++	*Marcia opina*
++	+++	+	+++	+++	+++	++	+++	*Ctema divergens*
—	+	++	++	+	—	—	++	*Meropesta nicobarica*
—	+	—	—	—	—	—	+	*Trachycardium lacunosum*
—	+	—	++	—	—	+	++	*Mactra lilacea*
+	—	—	—	—	—	—	+	*Semele sinensis*
—	+	—	—	—	+	+	++	*Tellina inflata*
++	+++	—	+++	++	+++	++	+++	*Phacoides* sp.
+	+	—	+++	++	++	+	++	*Cavolinia longirostris*
++	+++	+	++	+++	+++	++	++	*Nucula* sp.
+	++	—	+	—	—	+	++	*Corbula* sp.
++	+++	+	++	+	++	++	+++	*Cardium* sp.
—	++	—	—	—	—	—	+	*Barbatoa fusca*
++	+++	+	++	+	+	+	+++	*Venus* sp.
—	+	+	—	—	—	—	+	*Arca* sp.
								C. SCAPHOPOD
—	—	—	+	—	—	—	+	*Dentalium octangulatum*
								D. ANNELIDA
++	+++	—	—	++	+	—	+	*Polychaetae* sp.
—	+	—	—	—	—	+	—	*Polymnia* sp.
								E. DECAPODA
+	—	—	—	—	+	—	+	*Decapoda* sp.
								F. OPHIUROIDEA
—	—	—	—	—	+	—	—	*Ophioderma* sp.
								G. ECHINOIDEA
+	—	—	—	—	—	—	—	*Echinometra mathaei*
								H. HEXACORALLIA
—	—	++	—	—	—	—	—	*Astroides* sp.

We should add that in addition to Oil Pollution there are other sources of pollution. For instance, the coastal pollution of Buschire could not be considered directly as the result of the impact of Nowruz oil spilled ; but after the Nowruz catostrophe an increase in the level of coastal pollution was obvious. Therefore, we may conclude that in the stations No. 3,4, 5 which were located in the first 20 km the level of pollution was high, but in the stations No. 1, 2, 7 and specially No. 6 which were located beyond the mentioned area the lavel of pollution was either less or there was no pollution at all. Before describing the results of studies it is worth to analyze the effects of spills in the marine environment.

As a general rule, oil spilled at sea can be dispersed and degraded by several processes : evaporation, emulsification, dissolution, dispersion by droplet formation and absorption to particulate matter, Photo-chemical oxidation, and biodegradation both before and after the shoreline stranding. The first two processes to consider after an oil spill are evaporation and dissolution. These processes are simultaneous and competitive, their relative importance depends on the nature of the oil, wind velocity, sea state and water temperature. Theoretical, laboratory and field studies have shown that hydrocarbons containing up to about 12 carbonatoms are lost from a surface slick within a few hours, only a small percentage of light hydrocarbons enters the water column (Serge Berne and Guy Bodennec, 1984).

Oil may reach the seabed from effluents, slicks or oiled shores. Both naturally or chemically dispersed oil may be absorbed on to particulate matter and sink to the seabed, or in cases of severe intertidal contamination there may reach sub-tidal areas.

Two main factors interact to govern the fate of hydrocarbons in sediments : firstly the penetration of oil, which is decided by the permeability ; secondly, the power of sediment to retain hydrocarbons, which is know as primary oil retention. These two parameters are directly controlled by the granulometry of the sediment, in particular by the mean grain size and the standard deviation. Other factors exist which affect the fate of hydrocarbons temperature has a considerable role to play and the amounts of water and organic material present in sediments exert an important effect.

Such tainting may affect many species of commercial importance but, following the cessation of pollution, it is usual for hydrocarbons in the tissues to be reduced to low, levels within 30 days (RCEP, 1981). However, release times are different for different hydrocarbons and organisms. For example RCEP (1981) has summarized information on crustaceans as follows :

Crustaceans that are mobile, such as lobsters and crabs, generally inhabit the sub-tidal zone and are not as subject to direct contact with oil as are the inter-tidal molluscs and the attached, crustacea, like barnacles. However, heavy mortalities have been observed during large spillages where the oil has become dispersed in the water column in shallow waters. There are reports of sub-lethal effects, for example, crude oil in sea water at a concentration of 0.9 PPm (the level of oil in the water of the region under study has been reported by Aidan, 1984 to be about 1.9 PPm.) was observed to depress the appetite and alertness of adult lobsters and thus interfere with feeding (GESAMP, 1977). As is the case with other marine organisms, eggs and larvae are particularly sensitive to oil in the water and the lethal threshold for lobster larvae appears to range between 2 PPm and 30 PPm. In some cases, invertebrate mortalities may have an indirect effect on other species. For example intertidal mud flats rich in worms and crustaceans often form important bird and fish feeding grounds. They could be rendered useless for this purpose following a large spill of fresh oil.

Subtidal invertebrates form a major portion of the diet of many commercial fish species.

According to the results obtained from our studies, substrat of all sampling locations (with exception of No. 6 station) were formed from sand-mud including some oil patches. The Station No. 6 had a hard substrat and no signs of pollution could be seen in it, and all coral reefs seemed totally natural.

Among the benthic organisms different species which were distributed in all stations were present (*e.g.*) : *Marica opima*, *Dosinia ceylonica*, *Phacoides* sp., *Ctena divirgens* and *Umbonium vestiarium*. These are not considered as an indicator organisms, but there are some species that usually prefer to live in clean water and rocky and hard substrata such as *Scutus unguis*, *Fissurella salebrosa*, *Diodora funiclata* and *Astriodes* sp. In clean stations the varieties of different species were much more than in the polluted area, *i.e.*, in station No. 4, 23 species were identified, whereas 47 species were found in station No. 7. In the polluted region a limited member of species of live Bivalvia were seen, but the most important was *Nucula* sp.

This study also reveals that Echinoderms and coral reefs and crustaceans in comparison with other benthic organisms are more sensitive. This result also has been obtained by RCEP, 1981 which has been stated ' Echinoderms, including seaurchins and starfish, are nearly all sensitive indicators of clean water, they may be killed in large numbers by toxic oil '.

At the time of study we considered a lot of dead vascular plants that had been piled along the polluted coast which for sure were the result of oil spills. This is because the vascular plants may be damaged or killed by light toxic penetrating oil or by smothering layers of heavy oils.

Since oil from Nowruz platform, is heavy in consistency a considerable amount of it would have been sedimented. In station No. 4, main content of the sea bed was 655 mg/kg wet wt. (Aidan, 1984). As we know influences of oil in substrat causes anaerobic conditions and this decreases the level of oxidation. Being anaerobic the substrats benthic organisms stop growing and start smothering.

In this study it was found that there was enough oxygen in the water mass, but in all polluted stations a lot of H_2S was in the sediment that could be distinguished by its smell. Further work is necessary to distinguish between and assess the scale of the biodegradation of oil and related aspects.

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THE ROLE OF HEMICHORDATE *PTYCHODERA FLAVA* IN THE PRESERVATION OF SPECIES DIVERSITY IN THE GULF OF MANNAR, MARINE PARK

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ABSTRACT

Observations were made on the cleavage pattern of fertilized eggs of the common fouling polychaete, *Hydroides elegans* when challenged with various concentrations of extract of *Ptychodera flava*. It was observed that the extract at lower concentrations promoted cleavage whereas at higher concentrations it inhibited cleavage. Further, it is reported that the variation in the potency of the extract may depend upon the reproductive status of the animal. The ecological implications of the results are discussed in detail. It is suggested that the population of *P. flava* may form a territory on account of the nature of the chemical constituent emanating from its body. It is also suggested that the faunal paucity within the habitat of *P. flava* area may be directly related to the activation/inhibition property of its chemical metabolites. It has been pointed out that the preservation and propagation of *P. flava* is central in declaring the Gulf of Mannar as a National Marine Park.

INTRODUCTION

THE Gulf of Mannar zone, with its species richness, has been considered as an ideal reserve wherein research and public education can be fostered. The protection and preservation of the diverse resident species of the area is closely linked with the successful implementation of the management guidelines of the Gulf of Mannar Marine Park (GMMP). One of the significant features of GMMP is the presence of a string of 21 islands of which the Krusadai Island has been pronounced as the 'Paradise of Biologists'. During the past decade, periodic visits were made to Krusadai to study some of the less known aspects of the protected species of the Hemichordate *Ptychodera flava*. In attempting to study its ecological and respiratory responses to tidal cycle (Azariah *et al.*, 1975), it was observed that *P. flava* may possess bioactive properties (Azariah *et al.*, 1978). On this basis, intensive work was carried out to characterize the ecological implications of the presence of *P. flava* in the Gulf of Mannar zone. Rao (1954 a, b) while working on the biomass of *P. flava* observed an acute paucity of faunal diversity in the habitat of *P. flava* in contrast to the faunas richness of Gulf of Mannar area. In this context, the work of Azariah *et al.* (1978) showed that the sea water extracts of *P. flava* adversely affected the growth of diatoms, *Cyclotella meneghiniana* and *Amphora coffeaeformis*. On the basis of the above two reports it is reasonable to infer that the presence or absence of an organism in the habitat of *P. flava* will be linked with the tolerance capacity of an organism in question, to the effects, if any, of the body secretions of *P. flava*. It is hypothesized that the secretions of *P. flava* may interfere with the embryonic development of other marine species so as to eliminate their colonization within its habitat. The present study attempts to evaluate the validity of the above hypothesis.

Material and Methods

The experimental approach followed in the present study is similar to the procedural details outlined elsewhere (Azariah *et al.*, 1978). The extracts of hemichordate, *P. flava*, collected during the months of June and September, were used to assess the potency of the extract as well as seasonal variation, if any, in the potency due to the breeding status of the animal. From the mother extract which is considered as 100 % (1 adult hemichordate 100 ml of sea water vide Azariah *et al.*, 1978), various working solutions of the following concentrations were prepared—1 %, 5 %, 10 %, 20 %, 30 %, 40 %, 50 %, and above by diluting the mother extract with filtered sea water.

The early developmental stages of the common fouling polychaete, *Hydroides elegans* inhabiting the harbour waters were chosen as a suitable material for bioassay studies to assess the potency of the extract of *P. flava.* As the embryonic stages of *H. elegans* took about 2 hours to reach the trochophore larval stage the experiment could be carried out with much ease.

H. elegans were separated from other fouling organisms and were maintained in aerated aquaria, gametes used in the experimental study were obtained from recently collected hydroides. By changing the sea water abruptly or by breaking the outer calcareous tube, the worms were induced to spawn. Eggs and sperms were collected separately and used soon after collection. Using a haemocytometer, the number of eggs liberated per animal was counted and were pooled. A known number of eggs were introduced to the medium containing 5 ml of the extract and they were fertilized with one drop of sperm suspension. The experiment was conducted using sea water of 32 ‰. Soon after fertilization, an aliquot of 0.1 ml was pipetted out to a glass slide at an interval of every 5 minutes and the appearance of various embryonic stages were monitored. Care was taken to ensure uniform distribution of eggs before sampling by gently aerating the medium. The number of unfertilized eggs, 2 cell, 4 cell, 8 cell, 16 cell stages and above were counted under the field of a microscope. A total number of 10 experiments were conducted in each concentration and their average was taken for analysis. It may be mentioned that counting of cells upto 16 cell stage was easier and the other stages above 16 cells were grouped as 32 cell stage. No attempt was made to count upto trochophore larval stage.

Experiment 1

Early development of H. elegans *unchallenged by the extract of* P. flava (Fig. 1 to 5, control).

Data presented in Table 1 indicate the time taken for normal development in the absence of any extract of *P. flava.* From the data, three parameters were studied : (1) the time of first appearance of each stage after fertilization and also the time distance between the first appearance of two consecutive stages, (2) the time course analysis to assess the peak occurrence of each stage, and (3) the maximum percentage occurrence of each stage.

Cleavage occurred between 20 and 25 minutes after fertilization. A peak percentage occurrence of 2 cell stage was noticed at about 40th minute after fertilization, the percentage being 38. The second cleavage resulting in the formation of 4 cell stage occurred at about 25-30 min from the start of the experiment or 5-10 min after the occurrence of 2 cell stage. Maximum percentage of 4 cell stage (23 %) was observed between 45 and 55 min. The 8 cell stage occurred between 35 and 40 min and reached a maximum percentage of 21 % at 50th min. The percentage values fluctuated till about 75th min. The 16 cell stage occurred between 45 and 50 min and a maximum percentage was recorded at 70th min and continued until 90th min. The next stage, 32 cell and above was seen to occur between 60 and 65 min and a steady increase (48%) was observed till the close of the experiment.

10 min after the appearance of 4 cell stage. 16 cell stage appeared between 40 and 45 min or 5 min after the occurrence of 8 cell stage.

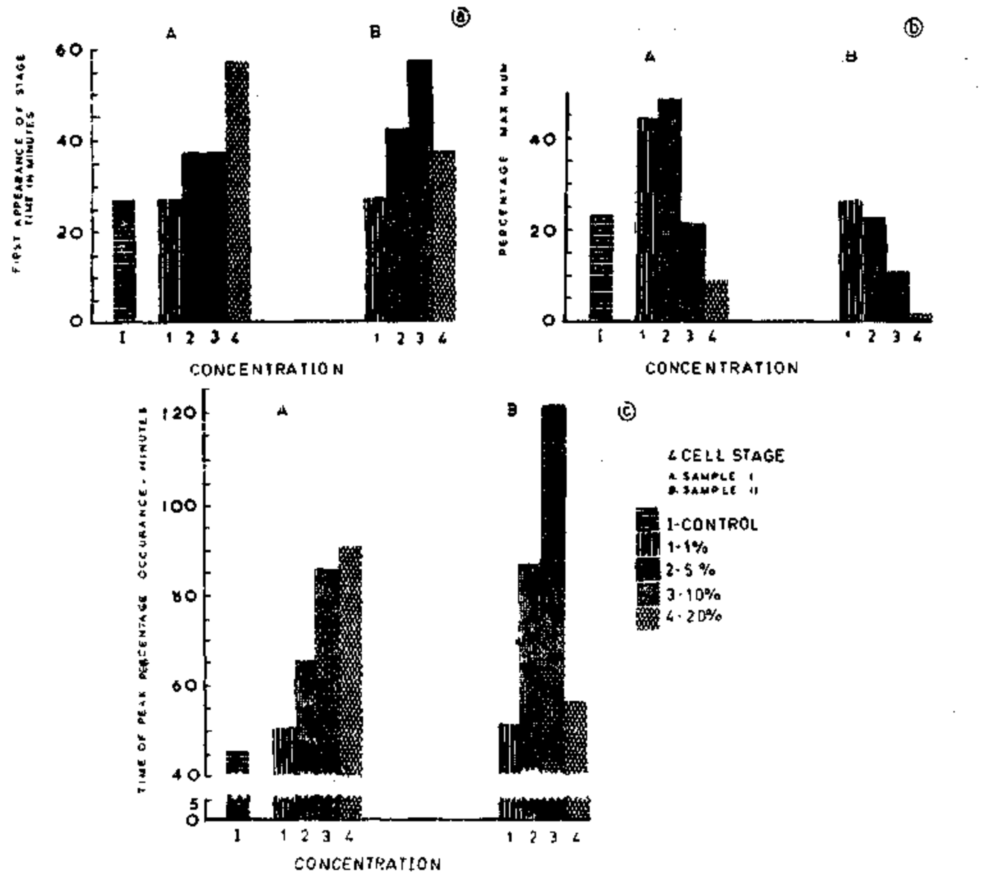

FIG. 1. Summary representation of the effect of the extract of *Ptychodera flava* on the early development of *Hydroides elegance* at the 2 cell stage : *a*. First appearace of the stage, *b*. maximum percentage recorded and *c*. time at which the maximum percentage occurrence.

Experiment 2

Early development of H. elegans *when challenged with* 1% *concentration of extract of* P. flava (Figs. 1-5).

It is seen from the Fig. 1-A that the 2 cell stage appeared between 20 and 25 min and 4 cell stage occurred at about 25-30 min after the occurrence of 2 cell stage. Similarly the 8 cell stage appeared after about 35-40 min or

The next advanced stage was noticed between 50 and 55 min or 10 min after the occurrence of 16 cell stage.

Following are the significant variations between the treated and untreated samples of early embryonic development. There is no difference in the time of appearance of 2 cell and 4 cell stages. In the case of 2 cell stage, the time of occurrence of peak percentage was preponed by 5 min and the peak occurrence of 4 cell stage was postponed by 5 min with corresponding decrease and increase in peak percentage of occurrence of each stage. In the case of 8 cell stage, there was no difference between the control and the experimental. There was a minor shift in the occurrence of peak percentage of this stage. However, in all the 3 stages, the percentage of occurrence was higher than that of the normal development. The results obtained on the 16 and 32 cell stages were interesting in that there was reduction in the time of appearance of the stages. The 16 cell stage and the 32 cell stage appeared 5 or 10 min earlier than the control experiments. In the case of normal development, the 16 cell stage appeared at about 45 to 50 min after fertilization whereas in 1% concentration of extract, the 16 cell stage appeared between 40 and 45 min. Similarly, the time distance between the appearance of 8 and 16 cell stage was 10 min in the normal development whereas it was reduced to 5 min when challenged with 1% concentration of the extract. Similar variations were noted in the next stage of development as well. The 32 cell stage occurred 5 min earlier with maximum occurrence of 82%. The above data indicate that not only the normal development of *H. elegans* may proceed unhindered when challenged with 1% concentration of *P. flava* extract but also register an increase in the percentage occurrence of 32 cell stage.

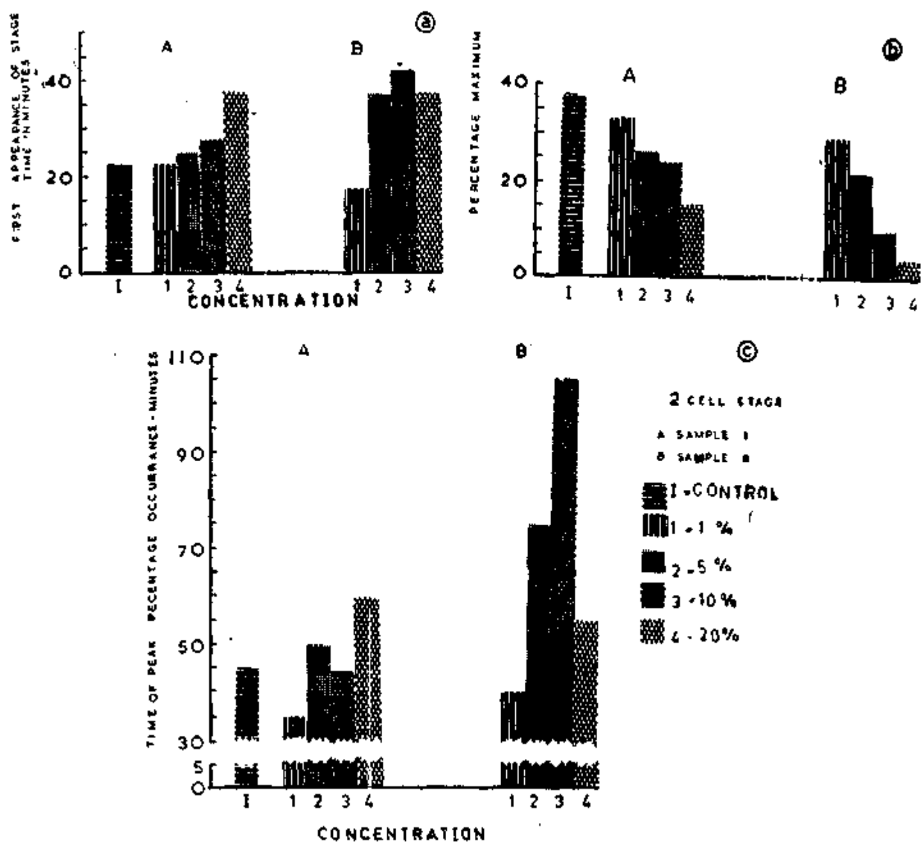

FIG. 2. Summary representation of the effect of the extract of *Ptychodera flava* on the early development of *H elegance* at the 4 cell stage: *a*. — *c*. as under FIG. 1.

TABLE 1

Developmental stages	Unfertilised eggs		2 cell		4 cell		8 cell		16 cell		32 cell	
Time sequence			Time in minutes									
Experimental concentration	A	B	A	B	A	B	A	B	A	B	A	B
Unchallenged Normal-control	20—25 / 22.5	—	20—25 / 22.5	5 (40/38%)	25—30 / 27.5	5 (40/23%)	35—40 / 37.5	10 (50/21%)	45—50 / 47.5	10 (70/39%)	60—65 / 62.5	15 (Steady/48%)
1%	20—25 / 22.5	—	20—25 / 22.5	5 (35/33%)	25—30 / 27.5	5 (50/45%)	35—40 / 37.5	10 (60/32%)	40—45 / 42.5	5 (75/44%)	50—55 / 52.5	10 (Steady/82%)
5	20—30 / 25	—	20—30 / 25	(55/26%)	35—40 / 37.5	10 (65/49%)	30—55 / 52.5	15 (75/29%)	55—60 / 57.5	5 (95/24%)	60—65 / 62.5	5 (120/58%)
10	25—30 / 27.5	—	25—30 / 27.5	5 (50/25%)	35—40 / 37.5	10 (85/22%)	50—55 / 52.6	15 (95/16%)	80—85 / 82.5	30 (115/14%)	85—90 / 87.5	5 (0/1%)
20	35—40 / 37.5	—	35—40 / 37.5	5 (65/15%)	55—60 / 57.5	25 (90/9%)	65—70 / 67.5	10 (0/6%)	100—105 / 102.5	35	Nil	Nil
30	Nil	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
40	Nil	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
50	Nil	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

A : The range of time duration for the first appearance of a stage from the start of the experiment. The average is given in the denominator position.

E : Time duration between the first appearance of two stages. The time of peak occurrence and maximum percentage occurrence of a stage are given in the paranthesis.

Experiment 3

Early development of H. elegans *when challenged with* 5% *concentration of* P. flava *extract* (Fig. 1-5).

The 2 cell stage appeared about 29 to 30 min after the start of the experiment. The peak percentage was observed after a delay of 15 min. The time distance increased to 20 min, when compared to the time taken in control experiments. It is evident that this level of concentration of the extracts, tends to retard cleavage without adversely affecting the development of eggs.

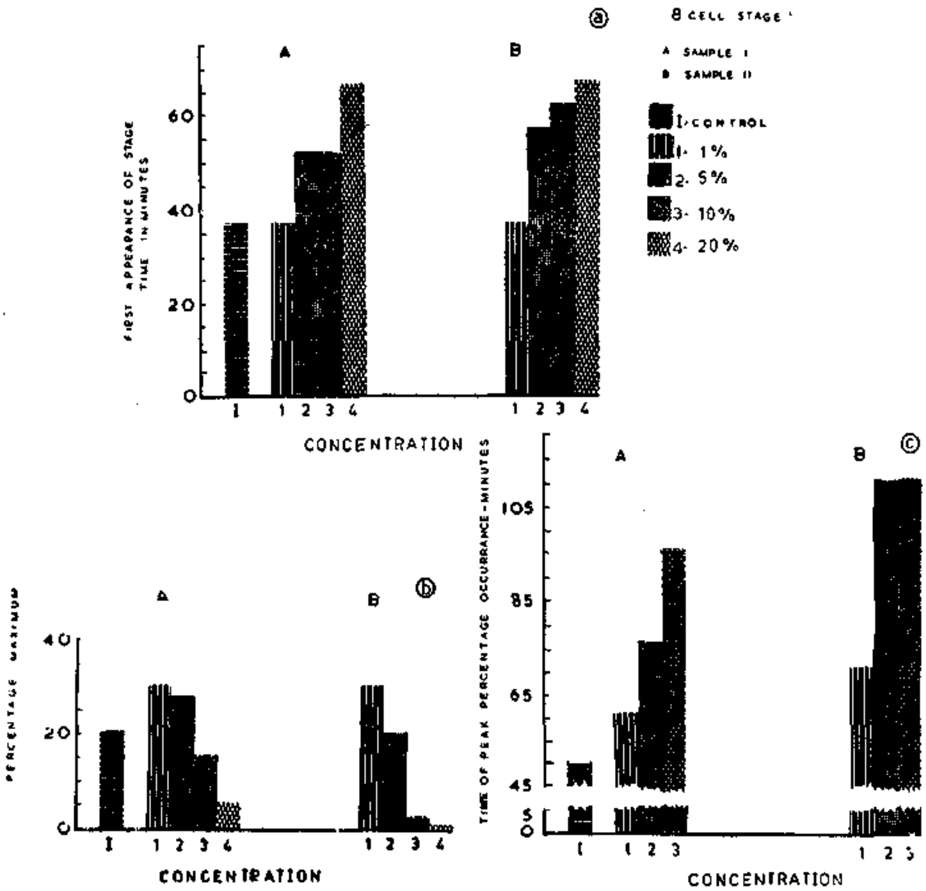

FIG. 3. Summary representation of the effect of the extract of *P. flava* on the early development of *H. elegance* at the 8 cell stage: *a.* — *c.* as under FIG. 1.

4 cell stage appeared about 35-40 min later. There is a time lag of 10 min when compared to the occurrence of 4 cell stage in experiment No. 2. Similarly, there was a time lag of 5 min between the appearance of 2 cell and 4 cell stages. However, when compared to the effect of 1% concentration, the occurrence of There was not much appreciable change in the percentage occurrence of 4 cell stage. The 8 cell stage appeared with the time distance of 15 min from the start of the experiment. When compared with the occurrence of similar stages in 1% concentration and in the control experiments, there was a time lag of 5 min

TABLE 2

Developmental stages	Unfertilised eggs		2 cell		4 cell		8 cell		16 cell		32 cell	
Time sequence	Time in minutes											
Experimental concentration	A	B	A	B	A	B	A	B	A	B	A	B
Unchallenged Normal-control	$\frac{20-25}{22.5}$	—	$\frac{20-25}{22.5}$	5 (40/38%)	$\frac{25-30}{27.5}$	5 (45/23%)	$\frac{35-40}{37.5}$	10 (50/21%)	$\frac{45-50}{47.5}$	(70/39%)	$\frac{60-65}{62.5}$	(15/40%)
1%	$\frac{15-20}{17.5}$	—	$\frac{15-20}{17.5}$	5 (40/29%)	$\frac{25-30}{27.5}$	10 (50/27%)	$\frac{65-40}{37.5}$	10 (70/31%)	$\frac{45-50}{47.5}$	10 (85/35%)	$\frac{55-60}{57.5}$	10 (120/81%)
5%	$\frac{35-40}{37.5}$	—	$\frac{35-40}{37.5}$	5 (75/22%)	$\frac{40-45}{42.5}$	5 (85/23%)	$\frac{55-60}{67.5}$	15 (110/21%)	$\frac{70-75}{72.5}$	15 (115/15%)	$\frac{85-90}{87.5}$	15 (120/23%)
10%	$\frac{40-45}{42.5}$	—	$\frac{40-45}{42.5}$	5 (105/10%)	$\frac{55-60}{57.5}$	15 (120/11%)	$\frac{60-65}{62.5}$	5 (105/3%)	$\frac{105-110}{107.5}$	45 (120/3%)	Nil	Nil
20%	$\frac{35-40}{37.5}$	—	$\frac{35-40}{37.5}$	5 (55/4%)	$\frac{35-40}{37.5}$	55 (0/2%)	$\frac{115-120}{67.5}$	80 (120/1%)	Nil	Nil	Nil	Nil
30%	Nil	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
40%	Nil	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
50%	Nil	—	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil

A : The range of time duration for the first appearance of a stage from the start of the experiment. The average is given in the denominator position.

B : Time duration between the first appearance of two stages. The time of peak occurrence and maximum percentage occurrence of a stage are given in the paranthesis.

in the time between the first appearance of 4 cell stage and 8 cell stage. The time of occurrence of peak percentage value was delayed by 5 min with less appreciable change in the percentage maximum of the stage. The 16 cell stage appeared about 55-60 min after the later which was about a lag of 10 min when compared to the effect of 1% concentration. The time duration of the occurrence of stage as well as the peak occurrence and maximum percentage values were similar to normal values. The 32 cell stage occurred after 5 min

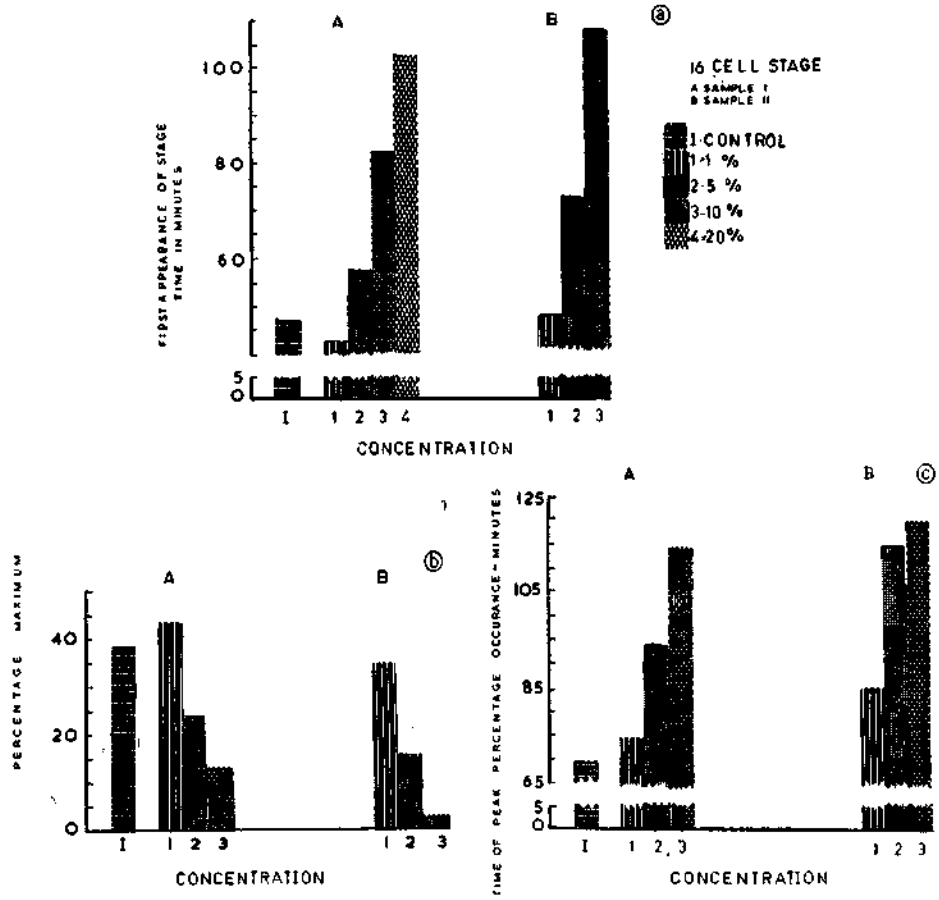

FIG. 4. Summary representation of the effect of the extract of *P. flava* on the early development of *H. elegance* at the 16 cell stage : *a.* — *c.* as under FIG. 1.

start of the experiment which was about 15 min of time lag when compared with that of 1% concentration. There was no change in the time of first appearance of 8 cell and 16 cell stages. However, the peak of maximum development was delayed by 20 min with a reduction in the peak concentration to about 24%. The 32 cell stage appear edabout 60-65 min from the first occurrence of 16 cell stage. It may be inferred that 5% concentration produces a retardation of development.

Experiment 4

Early development of H. elegans *when challenged with* 10% *concentration of* P. flava *extract* (Fig. 1-5).

It may be seen from the Table 1 that there was no significant difference between time of first appearance of 2 and 4 cell stages when challenged with 5% and 10% concentrations of the extract respectively. However, maximum percentage of occurrence was delayed by 20 min from that of 5% concentration, the maximum percentage being 22% and 49% in the case of 10% and 5% concentrations respectively. There was a reduction of about 50%. There was no marked change in the appearance of 8 cell stage but the occurrence of maximum percentage was delayed by 20 min and the maximum percentage was as low as 16%. In the case of 16 cell stage, there was a time delay of 25 min in its occurrence. There was also a time delay of 20 min in the occurrence of maximum percentage of 16 cell stage, the maximum percentage was as low as 4. The 32 cell stage appeared at about 85-90 min after fertilization. Although the time duration between the first appearance of 16 cell and 32 cell stages was only 5 min the development was arrested in that the maximum percentage of occurrence was only 1%. The results of this experiment is significant in that the percentage of unfertilized eggs was very high with retardation in cleavage. The adverse effect of the extract was significantly noticed at 32 cell stage.

Experiment 5

Early development of H. elegans *when challenged with* 20% *concentration of* P. flava *extract* (Figs. 1 to 5).

From the results (Table 1), it is seen that there was a time delay of 10 min in the first appearance of 2 cell stage with reference to the normal development. Similarly, there was a time lag of 15 min in the case of 4 cell stage and the time distance between the first appearance of 2 and 4 cell stages was delayed by 15 min. The maximum percentage occurrence of 4 cell stage was as low as 9%. Although the 8 cell stage appeared at about 65 to 70 min after fertilization, there was a pronounced inhibitory effect on the cleavage of cells. The 16 cell stage appeared at about 100 to 105 min after fertilization. There was a total inhibition of cleavage and other advanced stages beyond 32 cell stage were not noticed.

Experiment 6

Early development of H. elegans *when challenged with* 30%, 40%, 50% *and above concentrations of* P. flava *extract.*

When the eggs of *H. elegans* were challenged with 30% and above concentrations of extract, there was a total inhibition of development. This may suggest that the extract of *P. flava* is totally bioactive so as to inhibit early embryonic developmental stages.

Series II

Extract prepared during September-late breeding season.

Experiment 1

Early development of H. elegans *when challenged with* 5% *concentration of* P. flava *extract* (Figs. 1 to 5).

It is significant to note that there was no appreciable variation in the pattern of development when challenged with an extract of 1% concentration. However, when challenged with 5% concentration, the appearance of 2 cell stage was delayed by 15 min together with a delay of 35 min in the time of peak occurrence of the stage. Similar delay was noticed in the case of 4 and 8 cell stages. However, there was no appreciable change in the maximum percentage occurrence of cleaving eggs of this stage. Further, there was a significant delay in the first appearance of 16 and 32 cell stage. There was also a shift in the time of occurrence of the maximum percentage (Table 2). This response is comparable to the response evoked by 10% concentration of the extract of *P. flava* prepared in the month of June. It may be inferred that the potency of the extract prepared during the late breeding season is higher than the potency exhibited by the extract prepared in the month of June—the early breeding season.

time at which they occurred. Further, beyond 16 cell stages, the cleavage of the eggs was arrested. The maximum number of eggs in the 8 and 16 cell stages amounted only to 3%. The above observation suggest that the extract is more potent than the one prepared in the month of June, when the animals were in the early reproductive phase.

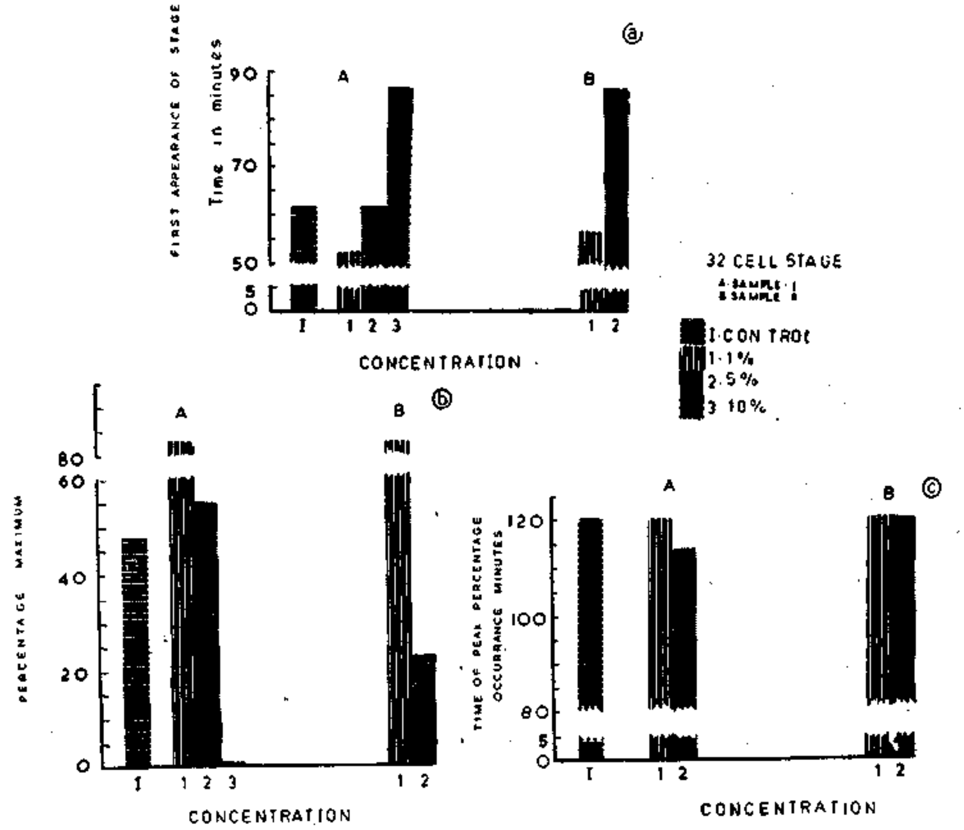

FIG. 5. Summary representation of the effect of the extract of *P. flava* on the early development of *H. elegance* at the 32 and above cell stages: *a.* — *c.* as under FIG. 1.

Experiment 2

Early development of H. elegans *when challenged with* 10% *concentration of* P. flava *extract* (See Figs. 1 to 5).

Observations made on the cleaving response of the eggs when challenged with 10% concentration of the extract indicated that there was a significant delay in the appearance of all the stages followed by a decrease in the maximum percentage of each stage and also the

Experiment 3

Early development of H. (legans *when challenged with* 20% *concentration of* P. flava *extract* (Figs. 1-5B).

A significant inhibition of cleavage was observed when challenged by a concentration of 20% of the extract. Although, the first occurrence of 2 and 4 cell stage was slightly advanced, the maximum percentage concentration was as low as 4%. In general, the results of the experiment indicated that the extract produced an inhibitory effect on the cleavage of the eggs. The inhibition was total after 8 cell stage.

Experiment 4

Early development of H. elegans *when challenged with* 30 % *and above concentrations of* P. flava *extract.*

In these concentrations, there was no development and the inhibition was total.

DISCUSSION

In an ecosystem, the adaptive value of an organism is indicated by its individual fitness leading to group success. The foregoing results indicate that *P. flava* maximizes individual fitness and group success leading to successful colonization of the habitat. The chemical constituents emanating from the body of P. *flava*, in low concentration, enhance and favour cleavage of *H. elegans* but inhibits cleavage at higher concentration. Such a pattern of acceleration and inhibition of cleavage processes recalls similar pattern observed in the growth of two diatoms namely *Cyclotella meneghiniana* and *Amphora coffeaeformis* when challenged with the extracts of *P. flava*. Ashworth and Carmier (1967) have reported the presence of 2, 6 Dl bromophenol in the body concentration of *Balanoglossus biminiensis*. Preliminary spectrophotometric studies carried out on the chemical characterization of *P. flava* showed similar spectral pattern indicating the occurrence of 2, 6, Dibromophenol in the extract (results — unpublished). Laboratory studies carried out with the help of commercially available organic biochemicals such as 2, 4 dibromophenol and 2, 4, 6 tribromophenol have produced similar results. In the light of the above findings, it is possible that the above compounds may be the active principle which may evoke differential responses in the embryonic development of other organisms depending upon the concentrations at which they occur. In this context, it may be mentioned that herbicides 2, 4, Dicholorophenoxy acetic acid and 2, 4, 5 Trichlorophenoxy acetic acid cause increased retention of fruits and leaves at lower concentration whereas at higher concentrations, they cause weakening and enhance the formation of alscission layer at the base of the petiole where leaf blades are attached to the stem (Odum, 1971).

The ecological implications of the above study are many. The faunal paucity in the habitat of *P. flava* (Azariah *et al.*, 1975) may be due to the fact that the extract of *P. flava* acts as a repellant by inhibiting cleavage of eggs of other marine organisms. It is likely that they may also interfere with other metabolic processes. As a result, the population of *P. flava* exhibits territory formations which is not common among marine invertebrates. Secondly, the apparent contradiction, as pointed out earlier, between the abundance of species diversity in the Gulf of Mannar and paucity of species diversity in the habitat area of *P. flava* may be due to the influence of the chemical factors released by *P. flava*. A situation may be visualized that the active factors emanating from the body components of *P. flava* may exhibit a concentration gradient around the habitat of *P. flava*, i.e. the concentration may be higher around the habitat and may be less due to dilution as it is drifted away from the area inhabited by *P. flava*. It may be suggested that as the dilution factor increases, the active factors may act as growth stimulant as has been reported in this study and in the case of higher concentrations, they may affect species diversity. Thirdly, the potency of the extract is the function of the breeding stages of the animals. The extract prepared during the early reproductive period of *P. flava* was less potent than the extract prepared at the close of the breeding season. This observation provides confirmatory evidence on the results reported in the previous study on the growth of diatoms (Azariah *et al.*, 1978).

It is the contention of the authors that the species diversity in the Gulf of Mannar area is directly and indirectly controlled by the ecologically dominant species such as *P. flava*. In order to assess the species richness, an attempt was made to review the numerical abundance of species as reported in published research papers. Starting with the publication of Thruston's report on the marine fauna of Rameswaram and neighbouring islands in the year 1887, a total number of about 80 papers in the field of taxonomy, bionomics, fisheries and aquaculture were searched for listing out the fauna represented in the area. Out of a total number of 678 species recorded, mollusca was the dominant phylum. Its members comprised about 31.8% of the total species represented in the area. When ranked according to the percentage occurrence of species. Arthropoda (12.5%), diatoms (11.5%), fishes (10.5%), annelida (10.3%), coelenterata (10.2%) were the most commonly represented phyla. Further, phylum coelenterata was represented by the maximum number of orders, which was followed by mollusca and arthropoda. When the number of commonly occurring species were expressed as total number of species recorded, it is seen that it amounts to 13.8% indicating the richness of the fauna. One of the marked features of this study is the finding that relatively less number of studies have been carried out after 1950 which may be due to the following reasons.

(i) the policy and emphasis given by the government regarding research in marine science varied from time to time,

(ii) there is less involvement of research workers from scientific bodies other than government agencies in carrying out scientific investigations on a permanent basis,

(iii) shifting of research personnel of the Government of Tamil Nadu from the laboratories situated in the island to the mainland in view of the hardships encountered during monsoon period and lack of basic facilities,

(iv) uncontrolled exploitation of marine resources and less diversification in occupations relating to the exploitation of marine resources, and

(v) uncontrolled collection of *P. flava* leading to its reduction in population density which may trigger serious ecological imbalance.

In view of the foregoing considerations, it is evident that the island ecosystems from a holistic point of view has never been studied in detail. It is the view of the authors that if a proposal of a marine national park in Gulf of Mannar is to be a success for years to come, preservation and propagation of the ecological dominant species such as *P. flava* must be given a careful consideration.

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ON THE ECOLOGICAL STATUS OF *RUBRICELATUS PIROTANSIS* (ECHIURA: IKEDAIDAE) FROM THE GUJARAT COAST, INDIA

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ABSTRACT

The paper incorporates a brief account including population density of *Rubricelatus pirotansis* from the Gulfs along the north western coast of India. It emphasizes on the habitats of the species and also denotes its status of occurrence in the areas surveyed. The measures are also suggested to save the species from the ruthless plundering mainly caused by certain unserupulus and inexperienced explorers.

INTRODUCTION

THE PAPER communicates important information on the ecological status of *Rubricelatus pirotansis* (Menon and Datta Gupta) from the Gulfs of Kutch and Cambay along the north-west coast of India. The species was, however, treated under different names, *viz.*, *Ikedosoma pirotansis* Menon and Datta Gupta, 1962 and *Prashadus pirotansis* (Menon and Dutta Gupta). It may be noted here that the genus *Rubricelatus* was created and described elaborately by Datta Gupta and Menon (1970). Subsequently, Stephen and Edmonds (1972) transferred the species under report to their genus *Prashadus*. Nonetheless, it is presently retained in the genus *Rubricelatus* on the taxonomical grounds which seem to be more relevant than those furnished by Stephen and Edmonds (1972).

The author is grateful to Dr. B. K. Tikader, Director, Zoological Survey of India, Calcutta for encouraging and permitting to present this paper in this symposium.

HABIT AND ENVIRONMENT

The animals usually protrude their proboscis through burrows chiefly during the hours of intertidal exposure. Proboscis is translucent, greyish white with densely pigmented spots on the ventral surface. In both the Beyt and Pirotan Islands in the Gulf of Kutch, the area of maximum intertidal exposure was observed to stretch along more than one and a half kilometre. The substratum was predominantly muddy, being made up of soft superficial and hard middle layers of 30-40 cms and 30-35 cm of depth respectiely. The next layer of mixed type, consisting of hard mud, sand and gravel is found at Beyt Island and exclusively of coral line sand at the Pirotan Island. Over and above, certain peculiar ecological niches at the Gulf of Kutch consists entirely of muddy substratum of more than one metre thickness and without being delimited into distinct layers, as observed at Bedi, Rosy, Sarmat and Navlakhi; but the population of *R. pirotansis* in such zones was much less abundant as compared to that elsewhere. Conversely, the habitat, as observed at Gopnath along the Bhavnagar coast of the Gulf of Cambay was marked by a typical zone. The substratum, particularly where *R. pirotansis* was found also consists of three layers of fine sand associated with loose sand stones—all being covered with hard mud. The thickness of the superficial layer was about 40 cm while that of the second layer was about 60-70 cm. The depth of the third layer was, however, not measured, since the material was already collected above it.

Population Density

A couple of surveys made both at the Gulfs of Kutch and Cambay revealed the existence of fairly rich marine non-chordate fauna in general and the species under report in particular. As per the statistics taken into account for the latter during three intermittent years, the population density of *R. pirotansis* per sq. metre varied at the rate of 2 : 3 in 1968, 1 : 1 in 1974 and 0.75 : 0.5 in 1977 respectively both at the Pirotan and Beyt Islands. Apparently such areas are excellent for exploiting the general resources amidst the highly favourable association with biotic factors such as living corals and abiotic factors such as muddy beaches. On the other hands the species was very poorly represented at Bhavnagar, Gulf of Cambay, where surveys conducted in 1968 and 1978 indicated number of individuals only at 0.25 and 0.05 per sq. metre, respectively.

Curbing of human interference

Human interference which is unduly ravaging the marine fauna including *R. pirotansis* particularly by untrained collectors, from schools and colleges from different States of India, should to be restricted. It is alleged by the personnel of the Fisheries Department, Government of Gujarat, that often specimen collectors do not even hesitate to apply at random poisonous chemicals including pesticides for benumbing and finally collecting the fauna from the burrows. They often despoil most of the echiuran material while tearing off their extended proboscis by their inexperienced hands. Thus, in order to save this echiuran fauna from their potentially endangered state in nature, proper methods have to be followed for collection. Method of collection from Gopnath, along the Bhavnagar coast has already been discussed (Haldar, 1981). At the Gulf of Cambay the specimen of *R. pirotansis* may be located in the proper habitat by the long extensile proboscis crawling over the mud in search of food; then by digging the muddy substratum for a depth of 1 metre or more around the burrow. The centrally formed coloumn of mud should be gradually and cautiously scrapped off by hand shovel with minimum disturbance until the trunk of the animal is noticed and picked up by hand. The method of collecting the species concerned is, however, a little different at the Gulf of kutch. Here the specimen may be collected by following a rapid course of excavation of the soft muddy substratum, since the water rushing into the excavated space from the surroundings requires immediate removal so as to facilitate their digging and reaching the site of the animal.

Survey by the novice collectors in such spots should, of course, be allowed only under proper care and guidance of trained personnel and should be regulated to prevent complete depletion.

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ECHINODERM FAUNA OF THE PROPOSED NATIONAL MARINE PARK IN THE GULF OF MANNAR

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ABSTRACT

Marine Parks are national assets with a wide variety of uses. They also serve as sanctuaries for endangered marine animals. A full knowledge of the marine parks such as their history, geology, hydrology and its fauna and flora are essential to understand and monitor their valuable resources. The author has collected nearly 100 species of echinoderms belonging to all the five classes from the proposed National marine park area in the Gulf of Mannar. A list of the species is given with comments on some of the species life *Holothuria scabra* and *H. spinifera* which are likely to be endangered as a result of exclusive exploitation.

INTRODUCTION

MARINE parks are national assets and are valuable for their educational and scientific interest, recreational and aesthetic qualities, food resources, genetic resources, industrial chemicals, raw materials, protection against waves and storms, use in construction and also because they represent our heritage (Bakus 1983). A full knowledge of the marine parks such as their history, geology, hydrology and its fauna and flora are essential to understand and monitor their valuable resources.

The author is grateful to Dr. E. G. Silas, Director, Central Marine Fisheries Research Institute, Cochin, for his keen interest and encouragement in the preparation of this paper. He is also thankful to M/s. K. Nagappan Nayar and S. Mahadevan for kindly placing at his disposal the echinoderms collected by them at Tuticorin by SCUBA diving.

MATERIAL AND METHODS

Extensive collections of echinoderms for over seven years during 1963-70 in the Gulf of Mannar were made. The most common method of collection was to search for them in the intertidal region during the low tide. Collections were made on rocky coasts, sandy shores, muddy flats and coral reefs to collect different species of echinoderms which live in different habitats. Mask and snorkel were used on the coral reefs to collect and so study the habits of the animals *in situ*. Dredge collections were made on algal beds using a naturalist's dredge. Trawl nets and shore seines were regularly examined for material which comes from the bottom. The material collected by the underwater survey team at Tuticorin by using SCUBA diving were also examined.

List of echinoderms collected within the limits of the proposed National Marine Park in the Gulf of Mannar are given below. All the species have been collected within 20 m depth. At the end of the paper comments on a few species such as *Holothuria scabra* and *H. spinifera* which are likely to be endangered due to exclusive exploitation are given.

Class : **Crinoidea**

Capillaster multiradiatus (Linnaeus)
Comanthus schlegli (P. H. Carpenter)
Comanthus parvicirrus (J. Muller)
Comaster gracilis (Hartlaub)

Comatella stelligera (P. H. Carpenter)
Heterometra reynaudi (J. Muller)
Lamprometra palmata (J. Muller)
Stephanometra indica (Smith)
Tropiometra carinata (Lamarck)

Class : **Asteroidea**

Luidia maculata Muller & Troschel
Astropecten hemprichi Muller & Troschel
A. indicus Doderlein
A. monacanthus Sladen
A. polyacanthus (Muller & Troschel)
Craspidiaster hesperus (Muller & Troschel)
Anthenea pentagonula (Lamarck)
Goniodiscaster scaber (Mobius)
Stellaster equistris (Retzius)
Siraster tuberculatus H. L. Clark
Asterodiscides elegans (Gray)
Culcita schmideliana (Retzius)
Pentaceraster regulus (Muller & Troschel)
P. affinis (Muller & Troschel)
Protoreaster lincki (de Blainville)
Anodora (Anodora) faouzii (Macan)
Linckia laevigata (Linnaeus)
L. multifora (Lamarck)
Nardoa sp.
Asterina burtoni Gray
A. coronata V. Martens
A. lorioli Koehler
A. sarasini (de Loriol)
Tegulaster ceylanica (Doderlein)
Euretaster cribrosus (V. Martens)
Echinaster purpureus (Gray)

Class : **Ophiuroidea**

Astroboa clavata (Lyman)
Amphipholis squamata (D. Chiaje)
Dougaloplus echinatus (Ljungman)
Ophiactis savignyi Muller & Troschel
O. modesta Brock
Gymnolophus obscura (Ljungman)
Ophiocnemis marmorata (Lamarck)
Macrophiothrix aspidota (Muller & Troschel)
M. longipeda (Lamarck)
M. variablis (Duoan)
Ophiogymna elegans Ljungman
Ophiomaza cacaofica Lyman
Ophiothela danae Verrill
Ophiothrix exigua Lyman
O. accedens Koehler
Ophiocoma scolopendrina (Lamarck)
Ophiocomella sexradia (Duncan)
Ophionereis dubia (Muller & Troschel)
Ophiarachnella gorgonia (Muller & Troschel)

Class : **Echinoidea**

Astropyga radiata (Leske)
Stompneustes variolaris (Lamarck)
Salmaciella dussumieri (L. Agassiz)
Salmacis bicolor L. Agassi
S. virgulata L. Agassiz
Temnopleurus toreumaticus (Leske)
Toxopneustes pileolus (Lamarck)
Tripneustes gratilla (Linnaeus)
Echinometra mathaei (de Blainville)
Clypeaster humilis (Leske)
Laganum depressum Lesson
L. laganum (Leske)
Peronella orbicularis (Leske)
Echinodiscus auritus Leske
E. bisperforatus Leske
Echinolampas alexandri de Loriol
E. ovata (Leske)
Lovenia elongata (Gray)
Metalia sternalis (Lamarck)

Class : **Holothuroidea**

Bohaaschia marmorata Jaeger
Holothuria atra Jaeger
H. edulis Lesson
H. pardalis Selenka
H. leucospilota Brandt
H. scabra Jaeger
H. moebii Ludwig
H. spinifera Theel
H. hilla Lesson
Stichopus variegatus Semper
S. chloronotus Brandt

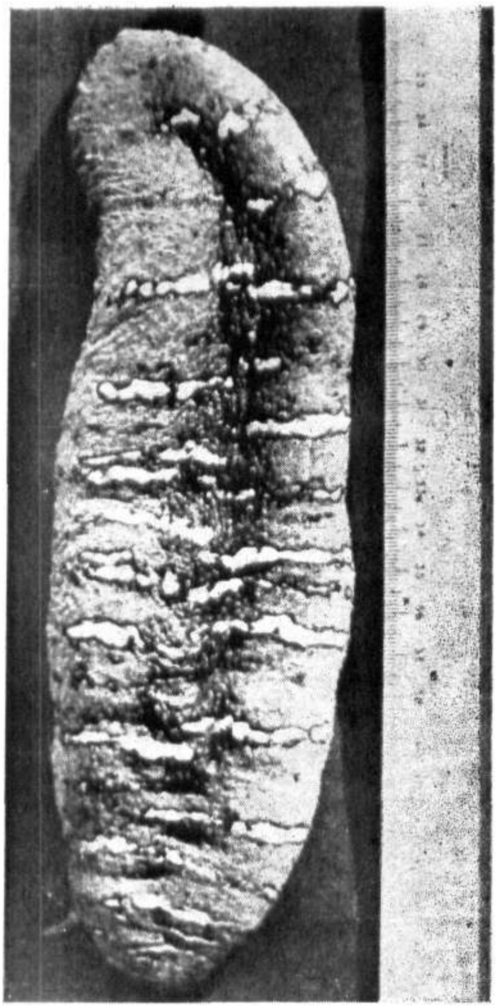

PLATE I. *Holothuria* (*Metriatyla*) *scabra* from the Gulf of Mannar.

Havelockia versicolor (Semper)
Hemithyone semperi (Bell)
Pentacta quadrangularis (Lesson)
Pseudocolochirus violaceus (Theel)
Stolus buccalis (Stimpson)
Psolus sp.
Actinocucumis typicus Ludwig
Phyllophorus (Phyllophorella) parvipedes H. L. Clark
Acudina molpadioides (Semper)
Protankyra sp.
Synaptula recta (Semper)

Remarks

At present only two species *viz., Holothuria scabra* and *H. spinifera* are exclusively used in the preparation of *Beche-de-mer*. Steps to conserve these two species which are likely to be endangered are given below.

Holothuria (Metriatyla) scabra Jaeger (Pl. I)

This is the most important species for the preparation of *Beche-de-mer* in the Gulf of Mannar at present. It grows to a large size of 400 mm. More than 90% of the *Beche-de-mer* is now prepared from *H. scabra*. Krishnaswamy and Krishnan (1967) based on the reproductive cycles of the species have found that it breeds twice in a year once in July and again in October. According to Mary Bai (1980) *H. scabra* breeds biannually, once in March-April and again in September-October. James (1978) has recorded a juvenile of 30 mm length during April from Palk Bay. In order to conserve the resources, catching of *H. scabra* should be banned during the above two months. Normally by October with the onset of north east monsoon the fishing is stopped since *Beche-de-mer* preparation requires good sun light for drying and also during the rainy season the product gets spoilt since it is hygroscopic. So effective measures have to be taken to stop fishing in July to allow them to spawn. Another measure to conserve the specie is to impose a ban on catching of young ones which are below 150 mm in length. The *Beche-de-mer* prepared out of smaller forms is full of sand since it is difficult to make them evicerate. Therefore the quality of the product is much reduced due to small size and sand. By enforcing ban on fishing small sizes we can improve the quality and quantity of *Beche-de-mer* and at the same time allow them to breed and replenish the stock. Another method to conserve the species is to farm them. Experiments conducted by James (1983) can be tried in the Gulf of Mannar after locating the juveniles. It will also be worth attempting the hatchery for this species.

Holothuria (Theelothuria) spinifera Theel

Holothuria spinifera contributes to less than 10% for the *Beche-de-mer* at present. This species is much rare being known only from the Red Sea, Australia, Philippines, Sri Lanka and the Gulf of Mannar and Palk Bay on the Indian side. It grows to a maximum size of 300 mm. The conservation methods suggested for *H. scabra* can be tried for this species also. The reproductive cycle for this species is unknown.

It may be mentioned here that the quality of *Beche-de-mer* prepared from the above two species is low when compared to species such as *Microthele nobilis, Actinopyga mauritiana A. miliaris, A. echinites, A. lacanora* and *Thelenota ananas*. These species are available in plenty in Andaman and Nicobar Islands and also at Lakshadweep. Their introduction in the Gulf of Mannar can be tried. This will not upset the ecosystem since they are found to be distributed in Sri Lanka. This step will not only boost *Beche-de-mer* export but also relieves the stress on *H. scabra* and *H. spinifera* which are now exclusively exploited.

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PEARL OYSTERS IN THE GULF OF KUTCH

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ABSTRACT

Pearl oyster population in Gulf of Kutch has dwindled. Various steps have been suggested to conserve pearl oyster population in the area.

INTRODUCTION

PEARL oysters belonging to genus *Pinctada* Röding are available in the Gulf of Kutch, Bombay, Malvan Bay, Vizhinjam, Madras, Tuticorin, Palk Bay, Gulf of Mannar and Orissa coast (Alagarswami, 1970, 1973, 1974, 1980, 1983 ; Pandya, 1974 ; Mahadevan, 1980 ; Varghese and Patel, 1981 ; Anon, 1983). Among the above cited localities only two, namely the Gulf of Mannar and Gulf of Kutch contributed to the pearl oyster fisheries in the past. The dominant species of pearl oyster in Gulf of Kutch is *Pinctada fucata* (Gould). The last pearl oyster fishery was conducted in 1966-67. Easwaran *et al.* (1969) felt that pearl oyster population in the Gulf of Kutch was thinner but they have not suggested any measures to conserve pearl oyster population. Attempts are made in this paper to highlight some measures to conserve pearl oyster population in the Gulf of Kutch.

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AREA STUDIED

Pearl oyster beds in the Gulf of Kutch stretch from part of Pesitra Kaddas to Mungra Reef opposite Jodiya. The area is known as Halar coast and came under Navanagar State of Jam Saheb in earlier years.

THE NEED FOR CONSERVATION OF PEARL OYSTER IN THE GULF OF KUTCH

Pearl oyster fishery of Gulf of Kutch has been dealt with by Easwaran *et al.* (1969), Hornell (1909), Alagarswami (1970, 1980), Alagarswami and Qasim (1973) and Pandya (1974) of which some authors have agreed that the pearl oyster fishery of the Gulf of Kutch is quite small in magnitude compared to that of Sri Lanka and Tuticorin. The probable reason for this is that the topography of Gulf of Kutch is totally different from that of Gulf of Mannar. All the Kaddas of Gulf of Kutch are exposed during ebb tide and they are covered with water during high tide only, whereas all the Paars of Gulf of Mannar are always submerged under water. So it is but natural that the population may be at a higher density in submerged Parrs than those places where the Kaddas are exposed.

Oysters are scantly distributed in the beds of Gulf of Kutch. The number of Oysters collected during earlier pearl fishing have been tabulated by Easwaran *et al.* (1969). The figures for different seasons in the areas showed fluctuations.

During 1977, Government of Gujarat had sanctioned a small scheme for pearl culture under which Gujarat Fisheries Aquatic Sciences Research Station, Sikka had collected the following numbers of pearl oysters from restricted areas of Gulf of Kutch for experimentations.

Year		No. of oysters collected
1979-1980	..	1781
1980-1981	..	1275
1981-1982	..	2773
1982-1983	..	3713
1983-1984	..	3727
1984-1985	..	3042 (Partial)

Conservation of Pearl Oysters in the Gulf of Kutch

The following measures are suggested for the conservation of pearl oyster resources in the area.

(1) *Sea farming of pearl oysters*

This may be done in two ways. 1. Floating culture : C.M.F.R.I. Cochin has adopted raft culture in the open sea for the first time for growing the pearl oysters at Veppalodai near Tuticorin (Alagarswami, 1974). In the same way the Gujarat Fisheries Aquatic Science Research Station, Sikka has floated two rafts in Vador channel, Sikka for the first time in 1979-1980 for pearl culture. Again, it may be necessary to put rafts afloat in calm and protected areas where lesser disturbances occur in pearl oyster Kaddas around Sikka for mother of pearl oyster culture.

2. *Ground culture :* This may be carried out on Kaddas by creating a breeding reserve or pearl oyster park where adult pearl oysters (brood stock) may be kept. This may encourage natural breeding of pearl oysters in Kaddas. This can also be done by sowing seeds of pearl oysters in demarcated areas of Kaddas.

(2) *Collection of pearl oyster spat*

This may also be done in two ways :

1. *Floating culture :* Nets/clutches may be suspended from floating rafts in subsurface waters to allow settlement of pearl oyster spat.

2. *Ground culture :* Alagarswami (1983) in his review of pearl culture project of Department of Fisheries, Government of Gujarat for the period of 1977-82 has observed that the spat fall on the Kaddas is very sparse. Spat fall may be encouraged by laying spat collectors on a large scale for which one of the most productive Kaddas may be selected.

(3) *Pearl oyster hatchery :*

Pearl oyster hatchery may be established in order to build up adequate stock. If this can be achieved, pearl oyster spats could be released in the Kaddas to enhance natural production of pearl oysters.

(4) *Transportation of pearl oysters :*

Chockalingam (1974), has suggested about transplantation of pearl oysters from Gulf of Kutch to the Gulf of Mannar and *vice versa.* In fact, the population of Gulf of Kutch is smaller, and it may be advisable to transplant pearl oysters from Gulf of Mannar to the Gulf of Kutch. A coordinated programme between Government of Gujarat and Government of Tamil Nadu may be taken up under which interchange of material could also be considered.

If this is not possible, laboratory cultured pearl oyster spat may be brought fromTuticorin to Sikka (C.M.F.R.I. has made a breakthrough in pearl oyster breeding).

If this is also not possible same species of Gulf of Kutch may be transplanted from other countries to Gulf of Kutch in three ways.

(i) Transportation of veliger larvae

(ii) Transportation of spat

(iii) Transportation of adult pearl oysters.

(5) Easwaran *et al.* (1969) and Narayanan (1974) have observed that oysters of Gulf of Kutch breed twice in a year between October and December and March and May. During the course of our operations we have noticed that oysters affair maturity during July-August and October-December. Thus, maturity periods differ. During the current year, we have observed that only the male were ready but females not in condition. According to the local fishermen, spatfall of pearl oyster does not occur every years in nature.

Under the above circumstances, it may be necessary to preserve sperms/ova as it is done in artificial insemination for cattle. This is to preserve sperms and ova maturing at different times. Preserved sperms and ova may be later put together for fertilisation.

(6) *Hybridisation of oyster* :

According to Easwaran *et al.* (1969), the species of pearl oyster of Gulf of Kutch is *Pinctada fucata* (Gould). Pandya *et al.*(1979) have described two records for the area, namely *Pinctada sugillata* (Reeve) and *Pinctada chemnitzii* (Philippi). So hybridisation of different species may be taken up carefully to create a new variety/brood which may have different genetic characteristics.

(7) *New Pearl Oyster grounds* :

For many years natural pearl oyster fisheries have been conducted in the area, but no new fishing grounds have been located. There is need for a detailed survey in the Gulf of Kutch especially in the deeper waters. Underwater photography may be useful to detect new pearl oyster grounds.

(8) Different aspects of the biology of the pearl oysters of the area have to be studied intensively with reference to food and feeding habits, growth, spawning period, spawning habits, larval development and so on. Our present knowledge is very insufficient.

(9) Fouling and boring organisms of the area have to be studied in detail and possible measures of protection against these may have to be developed to ensure high survival rate of the oysters in the farm culture.

(10) Pearl culture activities are being continued at present in Gujarat in which live pearl oysters are cut open to harvest cultured pearls. In fact, we are loosing natural population by doing so. In Japan, operated oysters are reared twice/thrice for pearl production.

(11) *Tissues culture :*

Can be taken up to study its possibilities in the area. If this will be successful only small number of pearl oysters will be required for operation and remaining population of the area can be saved.

(12) *Experiments in other bivalves*

Like the pearl oyster certain other bivalves have lustrous pearly interior part produced by their mantles. Such bivalves can be experimented for pearl culture. The species available are :

Unio margaritiferus (Linnaeus)
Perna viridis Linnaeus
Perna indica Kuriakose and Nair and
Placenta placenta (Linnaeus), etc.

(13) The problem of pollution require careful consideration. Industrialisation is rapidly increasing in and around Sikka. A proper check may have to be exercised by Gujarat Water Pollution Control Board and Marine National Park, Jamnagar so as to save/the present stock of pearl oyster population.

(14) Southern border of Gulf of Kutch is a biological paradise. It is learnt from fishermen that some fishermen apply either D.D.T. or 'Thor Xir' (*Euphorbia*) latex in the creeks and on Kaddas in outgoing and incoming sea water to kill fishes. Because of this, the pearl oysters and other organisms also die. This type of destructive fishing may be banned by the Marine National Park, Gujarat to whom powers are delegated.

(15) Director, Marine National Park, Jamnagar or any suitable agency may be requested to conduct training in conservation of marine biota in various sectors. The training may be given in vernacular language. To cover the whole area a number of technical personnel will be required who will have to be trained first. Radio talks, T. V. Programmes etc. may be conducted in order to create an interest among people.

(16) Problem of poaching may be stopped by the Marine National Park Authority, Gujarat.

(17) The pearl oyster beds will have to be demarcated as mapped areas by fishing.

(18) Unwanted populations of sedentary forms such as *Mediolus striatulus* Henley may be removed. This may be helpful in large scale settlement of pearl oyster spats in nature.

(19) Frequent inspections by the experts of the pearl oyster Kaddas may lead to proper management for the research and help in forecasting.

(20) Habitat improvement study of pearl oyster beds may be taken up.

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PATCHY CORALS OF THE GULF OF KUTCH

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ABSTRACT

Patchy Corals are available in the Gulf of Kutch. They are gradually diminishing. Different measures are discussed for the conservation of the patchy corals.

INTRODUCTION

HORNELL (1909) has given an exhaustive account on the marine zoology of Okhamandal in Kattiawar, but there is no detailed consideration in his report on patchy corals of the Gulf of Kutch. Patel (1976) has highlighted the patchy corals around Poshetra point, Gulf of Kutch. Chhaya and Patel (1977) and Patel (1978) have described corals and coral reefs of Gulf of Kutch, species diversity of Scleratinians around Poshetra Point, Gulf of Kutch and showed possibilities of establishing Coral-based industries in Gujarat. During 1978, Parulekar and Untawale have highlighted in their status report on Pirotan island (Gulf of Kutch) the need for a conservation plan. Thereafter, Pillai *et al.* (1979) have made a reconnaisance survey of the major coastal and marine ecosystems in Gulf of Kutch. Recently, Chavan (1984) has discussed Coral adventure for the area. At present, except the work of Parulekar and Untawale for Pirotan island, no ready reference is available on conservation of patchy corals in the Gulf of Kutch. The author is grateful to Shri Vijay Ranchan, Former Commissioner of Fisheries and Shri A. K. Luke, Commissioner of Fisheries for permitting him to present this paper in the Symposium. He is thankful to Prof. N. D. Chhaya, Deputy Commissioner of Fisheries for his keen interest on the subject.

STUDY AREA

Of all the coastal areas of Gulf of Kutch, the patchy corals are available only along the southern margin. They stretch from west of Okha to east of Jodiya. The area falls under Jamnagar District of Gujarat State.

THE NEED FOR THE CONSERVATION OF PATCHY CORALS

Government of Gujarat has declared part of the Gulf of Kutch as the first Marine National Park of India to protect the marine biota of the area and to create long range interests of conservation. Chhaya and Patel (1977) have reported 44 species of hard corals and 12 species of soft corals from the area. Pillai *et al.*, 1979 has mentioned 26 hermatypic species of corals from the area.

Pillai *et al.* (1979) have reported on the recent mortality of stony corals at Pirotan Island, Gulf of Kutch. If conservation measures are not taken for these they are liable to vanish once for all from the area.

The distribution of these stony corals in the patches, owing to exposure of the area during low tide. This situation is nearly reverse than other coralline areas.

As they are exposed during low tide, one can directly see natural beauties whereas in other places one has to dive to see corals. Because of this, there are great possibilities to develop tourism in the area. These patchy coralline areas are either contiguous to the land or near to the shore. So it is easily approachable.

In the past these coralline areas have allowed commercial activities to some extent such as collection of mother of pearl oyster, scared chank and fishes. Even today chank and fishes are being exploited on a small scale. Rapid industrialisation on the coast of Jamnagar District has added to the pressure of exploiting the natural resources.

The growth rate of hard coral is slow. If they are left undisturbed they will recover in a few years.

Corals have certain biological values. Gulf of Kutch is a cyclone-prone area. Under such circumstances, the presence of corals act as primary barriers to subside tidal waves.

Since the Gulf of Kutch sustains a lot of economic interests and since each unit involved is trying to derive as much benefit as possible it has become necessary to conserve the ecosystem of the area. There is balance in different ecosystems of nature. This is necessary to be maintained.

The ecosystem of the Gulf of Kutch consisting of corals, shallow muddy banks, mangroves etc. serve as nurseries for fishes.

Conservation measures

Various measures in multifarious disciplines are suggested hereunder for the conservation of patchy corals in the area.

1. *Farming of patchy corals ;* This may be carried out by ground culture, because the corals grow on Kaddas of Gulf of Kutch. On each kadda where corals are available at least a small area may be demarcated and termed as 'Coral park' or 'Coral breeding park' where natural breeding would take place after stocking the adult coral colonies. This may facilitate the enlargement of coral population in the areas.

2. From the area where dense populations of corals are available coral colonies may be removed by uprooting them and shifting/transplanting to other suitable sites. Thus, transplantation of corals may be useful to propagate coral population in the areas.

3. Adult coral colonies may be brought to the laboratory cum hatchery where they may be kept for breeding. Young larvae of corals called planulae may be released into coral Kaddas so as to increase natural population of corals.

4. New varieties of corals including precious ones may be transplanted from Lakshadweep, and Andaman and Nicobar groups of islands to the Gulf of Kutch.

5. A study may be conducted to throw knowledge on corals in the deeper waters. Under water Camera and TV may be extremely useful to identify unknown beds of corals in the area.

6. The different aspects of the biology and ecology of corals of the areas may be studied in detail because this will be extremely useful to chalk out future resume management.

7. Along the southern border of Gulf of Kutch, at present M/s. Tata Chemicals at Mithapur and M/s. Digvijay Cement Co. at Sikka are working. An oil terminus has been already established at Vadinar where oil tankers/cargoes of 3-4 lakh tonne capacity berth adjoining the coral areas. There is danger of oil pollution in the area. A thermal project of 120 M. W. capacity is taking shape at Sikka. A fertiliser project will be coming up near by Sikka. A number of salt pans exist in the area along the coast. Because of development of heavy industries there may be chances of air and water pollution in the Gulf.

8. Forest and environment department may be required to introduce conservation training to increase the awareness among people and to create interest to protect corals and other biotic components. They may start some programme like ' Jangagran ' to develop trained hands in conservation. They may be adviced to use different modes of operation by which they can reach the public easily.

9. Collection of corals from the areas may be totally forbidden to stop physical damages to corals. Collection of other marine flora and fauna from intertidal area where corals occur should be stopped.

10. Some areas of corals may be leased to some active fishermen who can look after corals. Government of Gujarat may be requested to introduce some incentive schemes for them. They may be trained in propagation of corals in the areas.

11. Coralline areas will have to be mapped for easy navigation.

12. Some fishermen are known to use D.D.T. or ' Ther Xir ' (*Euphorbia* latex) which are highly poisonous and disastrous. This may be prohibited.

13. Predatory fishes may be fished out.

14. Coral Kaddas may be frequently visited by a team of experts to check environmental effects. A monitoring cell may be created for this under Director, Marine National Park, Gujarat.

15. The effects of pesticides on corals may have to be studied.

16. The utilisation of natural resources if any may be watched carefully by the concerned authorities of Gujarat to balance coral ecosystem with other natural systems.

17. ' Coral park ' and underwater observatories may be set up in suitable areas.

18. Government of Gujarat has given leases to M/s. Digvijay Cement Co., Sikka for exploiting calcareous sea sands by dredging. Dredging in the environs of coral areas should be prohibited with immediate effect.

19. The activities of coastal aquaculture and composite fish culture may be developed along the coast line to divert the attention of fisher-folks.

20. The envisaged Marine National Parks and Sanctuaries may be helpful indirectly to improve the habitat which, in turn, and in due course would enrich the fish and allied fauna of the Gulf of Kutch.

21. Indiscriminate cutting of mangroves from coral supported banks should be stopped.

22. Removal of beach materials should be banned.

23. Fisheries, salt pans, cement manufacture, chemical industry, navigational activities, oil terminus activities and a number of other possible activities that may come up in the area in future may have profound impact on the resources of the Gulf of Kutch. Then may be monitored thoroughly.

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EXISTING AND PROPOSED MARINE PARKS AND RESERVES IN INDIA—A REVIEW

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ABSTRACT

In many of the developed and lesser developed countries the awareness for the creation of Marine Parks and reserves has never been greater than it is today. In India which has a tradition of established Wildlife Sanctuaries and Conservation Projects, the concept of Marine Parks and reserves is new. Nevertheless, we are seized of the urgency of the problem.

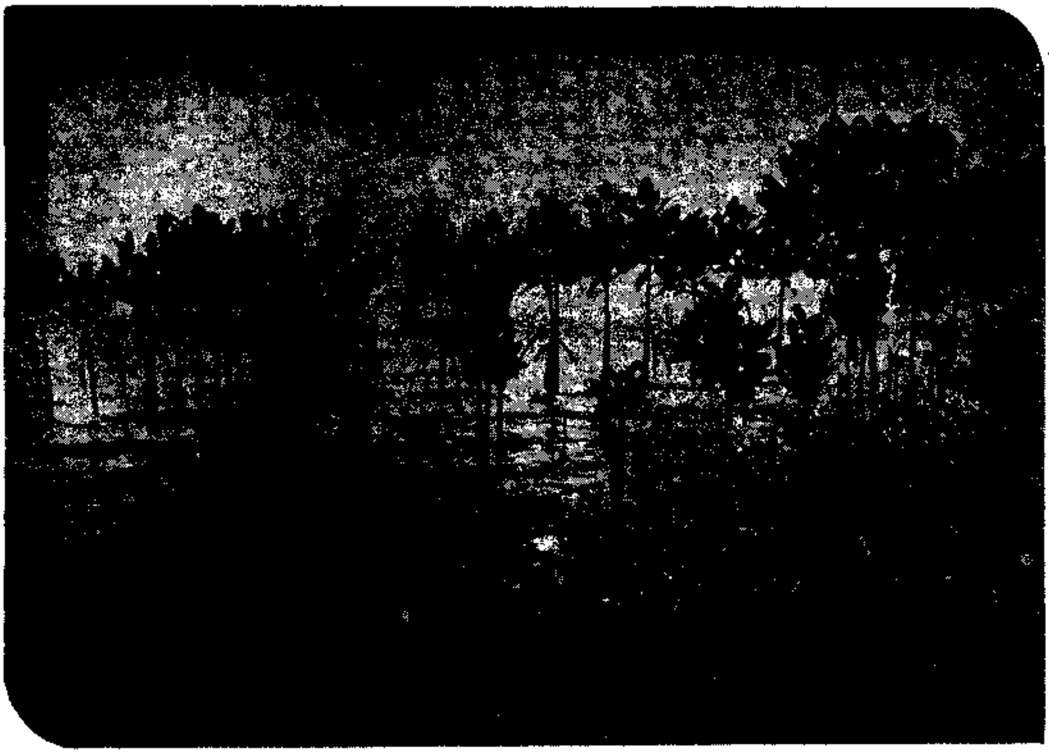
We have a recently established a National Marine Park in the Gulf of Kutch which is still in an incipient stage of development. Two major marine parks have been proposed, one in the Gulf of Mannar, Tamil Nadu and a second along the Malvan-Vengurla Coast, Maharashtra. Some of the wildlife sanctuaries such as Bhitarkanika in Orissa abut on the coastal zone and few of the contiguous beaches which are well known nesting grounds for sea turtles have been included now as protected areas. In the recent past, on the basis of beach surveys a number of potentially important areas of the sea turtle nesting beaches have been identified and possibilities of declaring some of these areas as reserves or for seasonal protection of the habitat needs serious consideration. Similarly, the mangrove habitat needs protection from human depredation in many areas. Sand mining and Coral quarrying has resulted in irreversible damages in some areas. Added to this, industrial pollution, human settlements in the coastal zone, increased fishing, tourism and other activities has brought about large-scale changes in many places including the inshore and estuarine areas. With all these perturbations there is an urgent need for developing a national policy for the setting up of marine parks and reserves. No policy can succeed unless it is an integrated effort taking into consideration interaction with wide ranging human activities such as fishing, land and beach and water use for tourism and agriculture and exploitation of diverse living and non-living resources. It is hoped that this account will help to take stock of the present problems and aid future planning.

INTRODUCTION

THE VAST coastline of India is facing serious problems of stress from human pressures and interference similar to those on land. Rapid industrialisation, human settlement, constrains of man-made engineering works, more intense fishing pressures in coastal and estuarine areas, dumping of unwanted wastes, reclamation of coastal wetlands and deforestation of mangroves and unplanned tourism developm nt are but a few serious threats facing the coastal zone.

The widely increasing pollution problems, extensive destruction and modification of marine habitats in the interest of techno-economic advances and the prodigious over exploitation of renewable resources are definite indications of our heading towards a point of no return in many areas of our country, without concern for the future. Rapid mechanisation processes in the exploitation of marine living and non-living resources with increasing industrial involvement have added to the plethora of difficulties. Because of the conflict of uses in the coastal zone, coast-related island systems

Marine Parks, Sanctuaries, Reserves, Zoos and Oceanariums



and surrounding habitats, many facets of the marine ecosystem and habitats are being increasingly tampered with on behalf of activities such as commercial fishing, navigation, energy exploitation, national defence, recreation and quarrying for industrial needs. Conservation of habitats will thus turn out to be the most biologically non-destructive means of reaching ' Zero habitat loss.' Public opinion protecting nature and endangered species run high (Kellert, 1979).

The enormous range of marine environmental problems pose a serious challenge which has evoked both biocentric and anthropocentric arguments in favour of biospheres, natural preserves, parks, sanctuaries, core areas and buffer zones being established to rehabilitate, reconvert, rejuvenate and retain the pristine glory of the ecosystem and habitats.

The recent example of shelving the ' Silent valley project ' in Kerala because of the adverse

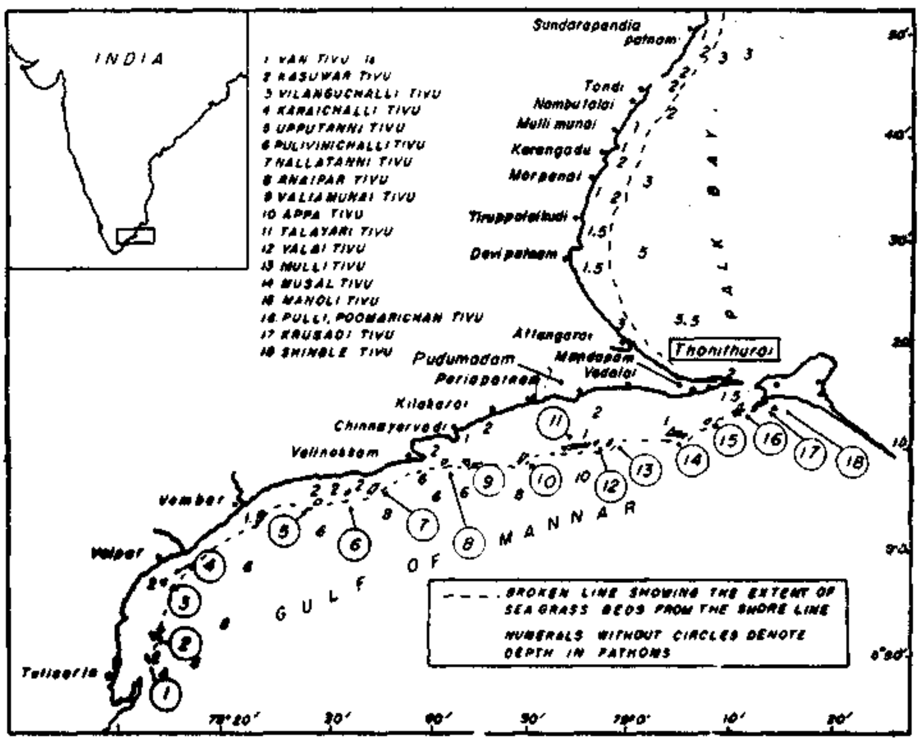


FIG. 1. Map of part of Gulf of Mannar and Palk Bay showing the islands and depth contours.

In recent years, Nature conservaiton of marine resources and habitats has assumed great significance in developing countries in the context of the role of conservation in Socio-economic development and the recognition of its functional role. The other values attached to this are aesthetic and cultural. verdict of conservationists is a standing proof of the concern of the national Government in the wild life preserves and the biogeographic pride of the nation. In this context establishment of National Marine Parks in India is not only a means of preserving the endangered marine species and some of the critical habitats, but also a flexible device for enabling the marine fisheries to be used on a sustainable basis. There are several regions in India with its extensive coastline which need our immediate attention in establishing Marine Parks, reserves and other protective measures.

Eversince the establishment of the first marine reserve sixtyone years ago, several nations have towed the line following the recommendations resulting from base line studies conducted. In recent years, IUCN has provided a set of principles, criteria and guidelines for the selection, establishment and management of marine and coastal areas (IUCN 1980).

National Marine Parks

We now realise that we should give equal importance to the protection of marine and coastal habitats as has been done by us for some of our endangered and vulnerable land habitats and fauna and flora. There is an urgency to identify critical marine habitats and determine whether they should be brought under a system of National Marine Parks and Reserves. Despite the lack of a national policy on this, at least one National Marine Park has been set up in the Gulf of Kutch and two, one each in the Gulf of Mannar, Tamil Nadu (Silas *et al.*, 1977) and one at Malvan-Vengurla, Maharashtra are in the process of being established (Qasim *et al.*, 1980). It is proposed to critically review the situation as it stands today, so that action could be initiated immediately in developing proper conservation and management plans for the existing and proposed Marine Parks and make them functional.

1. Gulf of Kutch Marine Park

Already along the Gujarat Coast a Marine Park zone has come into effect to cover the 42 islands including Priotan Island in the Gulf of Kutch. While Pirotan Island has been the focus of attention in the report submitted by the National Institute of Oceanography which came out with a preliminary survey of the area (NIO, 1978), there is a need for the proper zoning and delineation of the Park and the development of a management plan for the same.

The major problem encountered in the area is the mining of sand for the cement industry and the systematic destruction of the mangrove vegetation in some of the Islands. The area is also important for the nesting beaches of sea turtles, especially the green turtle *Chelonia mydas*. While the Government of Gujarat has appointed a skeleton staff for the management of the Marine Park, a lot remains to be done on every aspect including delineation of the core area and the Park limits and the regulation on various human activities in the Park area. The WWF-India sponsored NIO Project Report cited above needs active follow up.

II. Gulf of Mannar Marine Park

The 'Report on the Survey of the Islands of the Gulf of Mannar by CMFRI for the setting up of a Marine National Park' (Silas *et al.*, 1977) highlights the urgent need for setting up of a marine park embracing 22 islands in the Gulf of Mannar extending from Rameswaram Island to Tuticorin.

More recently the Government of Tamil Nadu has also constituted a Committee on Marine National Park under the Chairmanship of Shri B. Sivaraman, ICS (Retd.) for delineating the marine park in the Gulf of Mannar. The CMFRI with its regional centres located both at Tuticorin and Mandapam Camp has taken a leading role in carrying out surveys of all the islands including submerged areas of the reef and beyond upto a depth of 5 m and terrestrial fauna and flora of the islands. The degree of human interference presently in the proposed park area has been determined and ways and means of phasing some of the activities are under study. We are giving here some highlights of the proposed marine park in the Gulf of Mannar which would be relevant for the Symposium (Plates I and II).

The entire coastline from Tuticorin (lat. 8° 55'-9° 15'N and long. 78° 0'-79° 16'E) to Rameswaram island is sheltered from the fury of wind and waves by the existence of a chain of 20 islands or sand cays of size ranging from 0.95 ha to 130 ha, lying at a distance 5-7 km from the nearest mainland coast. These island formations are of accumulated sand and coral debris over dead coral core and are surrounded by live fringing coral reef consisting of hermatypic corals and boulder reef: pronouncedly on the seaward aspects.

(i) This entire ecosystem is unique in the east coast of India. Nearly 90 species of live corals have been identified here. These harbour a rich variety of coral reef fauna and flora, typical and rare, cowries, cones, volutes, murices, whelks, strombids, chanks, tonnid, and species of oysters.

(ii) Special mention must be made of *Cypreae talpa*, *C. tigrinus C. serpentis*, *Conus amadis*, *C. textile*, *Strombus cananium*, *Murex adustus*, *Veluta lapponica*, *Murex haustellum*. All these are commercially exploited varieties. In this process the breeding habitats are destroyed on account of exploitation all the year round.

(iii) The corals, live branching varieties of *Acropora* spp. and *Montipora* spp., are hacked and taken out for decorative purposes thus decapitating the growing surfaces resulting in decay and subsequent gradual destruction of the fringing reef barrier.

(iv) The spit and wash of the coral reef brought about by the wave action and natural forces which constitute a strong base for marine algal growth are being scoured and collected for lime manufacture. The luxuriant growth of industrially important weeds such as *Sargassum* spp. *Turbinaria* spp. *Gracilaria* spp. and *Gelidium* spp. and *Gelidiella* spp. estimated to be of the order of 5000-7000 tonnes (dry weight) a year are being removed daily by nearly 500 fishermen and women. This creates imbalance in the ecosystem.

(v) Extensive areas abundant with seagrass such as *Cymadocea* spp. *Thalassia* spp. and *Enhalus* spp. found in and around these islands are being disturbed by stake-net fishing and wall-net fishing resorted to by fishermen all the year round.

(vi) Destruction of seaweeds deprive the base of attachment for the rare species of medusa *Leucernaria* (*Halicristis*) sp. which is unique in its occurrence here because it is a form serving as an indicator species for current systems.

(vii) Indiscriminate fishing for *Dugongs*, the most endangered of our mammals, has reduced the population size to the point of endangering their existence in this area. The dugongs find the seagrass beds an ideal feeding ground.

(viii) Depletion of the rich holothurian population, particularly of *H. scabra*, by seasonal collection for Bech-de-mer Industry. The coarse and sandy stretches adjacent to the coral reef are good feeding and breeding grounds for them.

(ix) Indiscriminate tampering with the dead coral reef endangering the rich variety of prosobranch and opisthobranch molluscs.

(x) Large-scale collection of the enteropneust *Ptychodera flava* (Balanoglossus) by specimen dealers has virtually annihilated the population density. This is another unique species occurring in the sandy flats of the northern islands at the head region of the Gulf of Mannar.

(xi) Destruction of the mangrove vegetation lining the water front and swampy inlets, creek and pools of almost all islands has denigrated the areas, biologically upsetting the rhythm of mangrove associated fauna, denying ideal shady hideouts for spawning fish and marine reptile species and depriving the natural nursery grounds for lakhs and lakhs of fry of milkfish, mullets and prawns. Removal of mangrove has also led to erosion in some areas.

(xii) Thoughtless chopping down of the trees in the wooded interior (e.g. *Acacia, Pemphis* trees) has adversely affected the rhythm of arrival of migratory coastland birds for rookery.

(xiii) Island based stake-net operations have entailed heavy destruction by fisherfolk of the marine turtle eggs which are laid seasonally by the olive ridley on the sea-ward sandy beaches of almost all islands. Drift-netting in the zone of arrival of turtles traps the breeders coming for nesting. These have greatly affected the turtle nesting. Besides, this area also has been identified as an important feeding ground for the green turtle and the hawksbill. Increased human activities are at direct conflict with this.

(xiv) The most degrading activity has been the quarrying of live and dead coral boulders of *Porites* spp. for industrial purposes carried on in almost all islands. This has resulted in the disappearance of one or two islets, viz., Manuli east and Poovarasanpatti where only remnants exist now, exposing portions of what remain, during the lowest low tide periods. Removal of nearly 25000 tonnes of corals annually, from the late fifties to 1980, has denuded the area and brought about visible topographical changes in the islands and along the adjacent mainland coast.

(xv) The sea bed of the shallow stretch of water between the islands and coastal mainland are intensively trawled for prawns during seasons, thus adding another new dimension to the disturbance of the habitat since the early seventies.

(xvi) Perch trap fishing near the islands which is a traditional commercial avocation by mainland people at the head of the Gulf is yet another activity which has left its mark in the overall picture of disturbance to the biological ideal of breeding species of grunters, groupers and breams inhabiting the ledges and crannies of the coral reef areas.

A detailed scientific survey of all islands in the Gulf of Mannar conducted by a scientific team of CMFRI during the years 1977-1981 brought to the light unassailable proof on the above aspects to show the destructive forces at work. These have progressively diminished the value of the entire ecosystem from different angles. Therefore, we consider that the establishment of a Marine National Park in the Gulf of Mannar is one of the priority actions to be taken.

The ecological criteria to be applied for selecting the zone as one of the Marine National Parks are thoroughly satisfying in respect of:

(i) *Representativeness* or *Uniqueness* ranking high in priority as the islands are 'one-of-a-kind.'

(ii) *Naturalness*, related to the perturbation by man and loss of naturalness. The area includes sub-climax and transition zones and other areas which undergo natural changes subsequent to their natural disasters.

(iii) *A Natural unit* and buffer zone compatibility conditions are ideal since the area is large and allows dynamic change, biological and physical, viability, defensibility and integrity to be maintained.

(iv) *Diversity* where several habitat types and biotic associations can fall within the system.

(v) *Criticalness* in that important life stages of entire life histories of species are dependant on the area (e.g.) coral formation, molluscs,

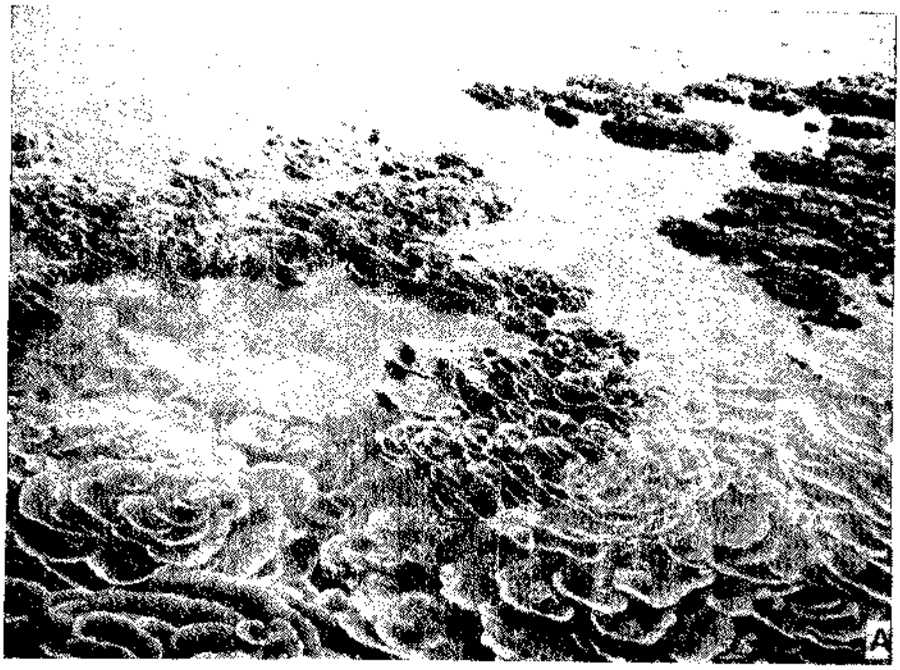


PLATE I. A. Montiporan coral growth on the southern shallow region of Karaichalli Tivu exposed during low tide and B. The sea-anemone amongst dense growth of *Cymadocea* grass.

PLATE II. A. Anchorage at Appa Tivu, northern tip of the island. Two fishing boats beached can be seen. In the foreground are small dunes with *Spinifex* growing on the sand and B. *Avicennia marina* and *Rhizophora mucronata* bushes lining a tidal inlet in Manoli.

breeding, sea algae, seagrass and mangroves as areas of detritus production and conversion. Here endangered species are also considered as also other species of trophic significance.

(vi) *Inclusiveness* covers all habitats. This is an important area for science. Most practical studies of marine bottom community, fauna and flora in the past and in the present pertain to this zone because of scientific interest. The proximity of these islands to user group of scientists is an asset. These values out rank purely tourist or recreational value though these are also very important, particularly Tourism for promoting conservation through education and extension.

(vii) The area is *fragile* and degree of threat is greater due to the proximity to increasing human settlement and development of mainland facilities.

(viii) The *feasibility* aspect is satisfied since, except in one or two islands leased out to private owners, these are regional Government properties and can be brought under jurisdiction of a stable agency. *Redundancy* of the type of control system proposed does not exist. The national and international values rank high as evident from the visits for study by Scientists from distant places all over India and abroad. Krusadai island is internationally well known as a 'Paradise for marine biologists.'

In this context some pertinent points which are worthy of strategic consideration are :

(i) Zoning and principles involved
(ii) Delineation of boundaries
(iii) Developmental programmes
(iv) Management, administration, regulations and policing
(v) Maintenance of control
(vi) Recreational facilities and tourism
(vii) Educational
(viii) Ecological supervision
(ix) Reappraisal and revision

(i) Considering representative areas like Manali island, Hare island, Valai, Mulli, Talayari and Appa tivu for total conservation forming an integral scientific reserve in which utilisation is prohibited and a buffer zone forming the rest of the islands, particularly Krusadai and Nallatanni tivu, are managed for leisure and educational activities, other areas such as Shingle, Pulli, Pullivasal and Manali, Putti, Anaipar, Valyamunai Tivu forming one concentric group can be managed and strictly controlled, the nearer they are to the central core. These form the part of the central biome and combines reserve and utilisation within regional, economic and social framework. Similarly, in the southern area, Puzuhuni challi, Upputanni tivu, Karai challi and Kaswar should be a total conservation area ; and Van Tivu can be strictly controlled. In this, it is unavoidable that all biotopes from shore to open sea are included, (*i.e.*) the littoral ecosystem on account of interdependence within ecosystem of different biotopes.

(ii) It appears reasonable to suggest a distance of midpoint between the island coastline and the mainland coast on this landward side and 5 km from the seaward coast of the island as the boundary for the Park. In certain cases such as Valai, Mulli, Talayari, Krusadai, Pulli and Pullivasal islands the eastern or western aspects being nearer to one another, making it fordable during low tides and easier for policing. It is difficult to define depth as a criterion for the Park and the zone delineation since there are incongruities of depth in different locations which precludes depth contour specification which runs a zig zag course.

(iii) Fortunately the establishment of marine based industries such as Salt and Chemical factories, the thermal stations using salt water circulation as coolant are located far south of the proposed area of the park. But the pollution aspects arising out of these industries such as acid discharge, dumping of fly-ash of coal burnt and fall out pipes leading very hot water from thermal factories should be carefully considered in future and the establishment of such industries in the vicinity of the Park zone should be prohibited.

Similarly the impact of the proposed Sethusamudram project canal within the zone of the park is to be critically gone into since the passage will entail constant dredging, throwing up mud deposits on the reefs and thereby smothering the rare biofauna and flora in addition to destroying the sea-weed and sea grass beds and dugong breeding and browsing habitats. The frequent passage of ships will also disturb the habitat by oil spills and other wastes. The classic instance of progressive disappearance of live coral reef inside Tuticorin harbour and surrounding areas due to increased sea traffic and oil discharge should forewarn of such an eventuality. The introduction of harmful exotic biofouling communities in the area by the passage of ships from one geographical area to another through the medium of the hull harbouring them is another serious matter. The introduction of *Congeria sallei* (*Mytilops sallei*), a serious sessile competitor in the Vizagapatinam harbour is a proof of how prolific settlers can get adopted to a new environment and pose a serious threat to endemic bottom living communities. This again is analagous to the *Modiolus* spp. settling in profusion in the pearl oyster beds in the Gulf of Mannar, smothering pearl oyster spat.

These factors should weigh heavily against the location of the Sethusamudram Channel within the park core area. An alternate routing of the project cutting across the Adam's Bridge needs a critical examination.

(iv) There is a vital question to be solved. A long term national level control with international cooperation is envisaged since creation of Marine National Park in a country cannot be restricted to the narrow domains of regional management alone and uniform policies are to be adopted by a high level authority. Funding and staffing such projects should not be subject to the limitations of the local authorities. This again will be interlinked with many similar measures in future, such as creation of reserves and sanctuaries all along our vast coastline and Bay Islands where guiding principles and yardstick applied are to be uniform. For effective implementation it is advisable that the national body like the Department of Environment, Govt. of India is vested with the responsibility for the overall management of the Marine National Parks and reserves in India including those in the Andaman Nicobars and Lakshadweep islands. The responsibility of the park board is to apply the decisions set out in the master plan as to how various components of the Park are to be managed, within what limits and what infrastructure and with what regulations for the control of human activities. A Committee of investigation and a council of administration (execution) should follow it up. The Council should certainly include in its composition representatives of the State Govt., and of all disciplines and representatives of all private and official local and regional institutions where collaboration constitutes guarantee for success.

Scientific research should be preserved to acquire better knowledge of the ecosystems and to interpret dynamic equilibrium. Periodic survey type of research is needed to measure the environmental quality and checking up key species in the biocoenosis.

(v) It is of paramount importance to train several cadres of competent personnel for handling the conservation programme. Unless specific problems of marine environment are properly understood, the functional efficiency of these people will be weak.

It is quite necessary legislations imposed should be adequate and implemented by coordinated conservation policies with terrestrial Parks and resources wherever possible.

It is essential that a critical marine habitats Working Group be established with associated task force for conducting workshops, on topics of jurisdiction, zonation, conservation economic conflict, tourist interpretation, terminologies, classification and definitions of marine parks, reserve land sea interface and other policy matters.

A Central Authority should carry out the policy, co-ordinating the activities of all governmental, non-governmental agencies with departments concerned with fisheries, coastal zone development, conservation, National Parks, tourism and enforcement.

Educational institutions and fisheries should co-operate on research. Public should be in the advisory panel to contribute their expertise to strengthening an integrated policy.

Reviewing existing information and activities, initiating computer compatible descriptions of areas, with data retrieval system, setting up management guidelines, issuing certificates by means of permits or authorisation and ascertaining the activities are consistent with purposes of permits, administering research grants, maintaining consultative process, including fisheries resources, cultural resources, education and research, national security and exploitation of mineral resources, providing ranger and guide training are some of the responsibilities which can be discharged by this agency.

An Advisory Panel as a Scientific Committee of ecologically oriented scientists, Special interest groups, environmental lawyers and land use planners, can also be included in this with the following functions :

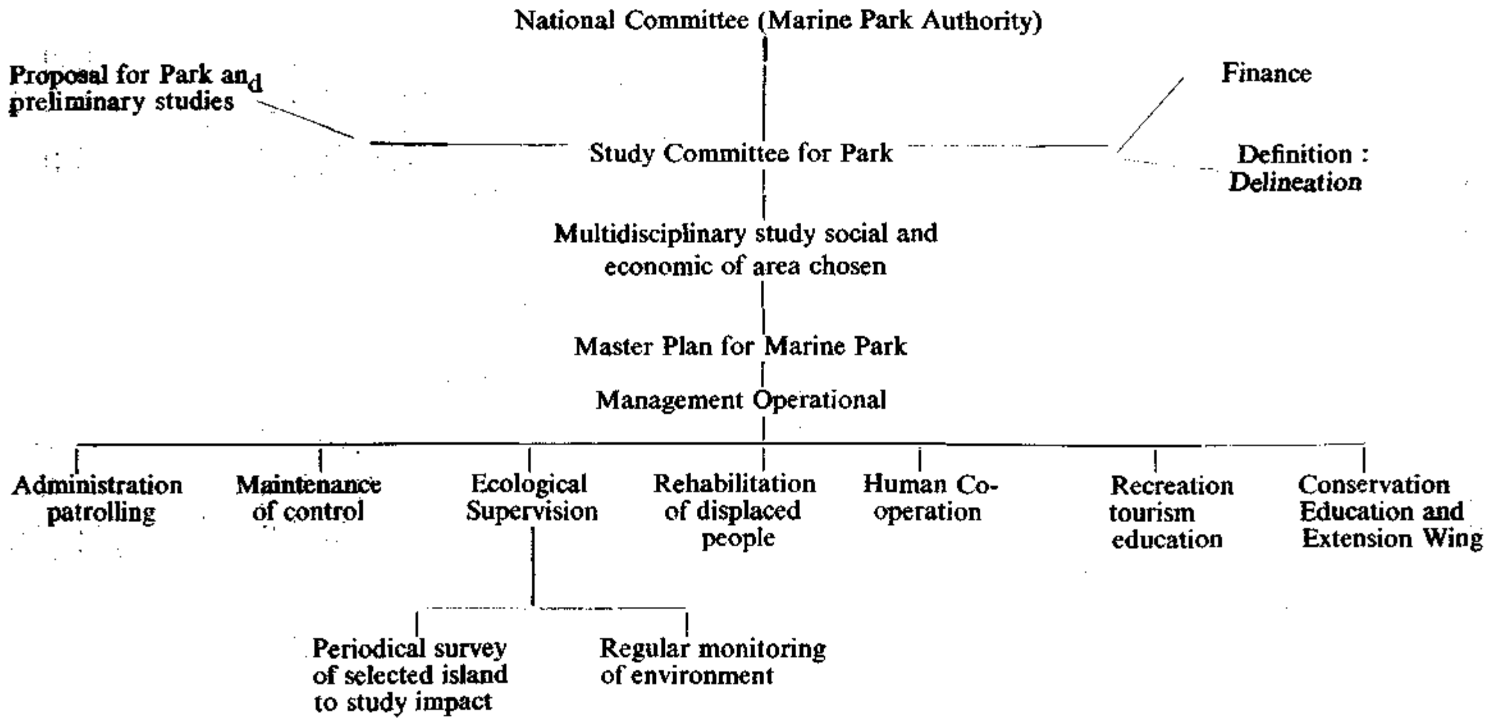
1. Consultation on long term goals.
2. Model guidelines to be evolved.
3. Determination of Research needs.
4. Scientific evaluation, surveillance.
5. Specific functions for each reserve/Park Sanctuary to be recommended.
6. Management programmes to be recommended.
7. Advise on regional problems.
8. Help government in developing National Policy.

The proposed set up can be on the model indicated in the flow chart.

(vi) Recreational tours for hand lining and rod and line fishing may be permitted in selected areas. For tourist to derive the benefits of appreciating the beauties of nature, tours should be organised with bases for stay on the mainland and facilities provided in areas such as Krusadai island, Hare island and Nallatanni tivu for snorkeling and diving. Provision of glass-bottomed boat, inflatable boats, outboard engine fitted boats may be permitted in regulated numbers to facilitate observations. These activities have intrinsic psychological therapeutic value and other vicarious benefits.

The increasing tourism activities are exerting pressures on fragile marine ecosystems and resources all over the world. In India too where tourism is being given great importance in recent years it is bound leave its impact on marine and coastal ecosystems. To cite an example, the promotion of tourism activities in the Pichavaram backwaters (near Cuddalore is resulting in chopping down of mangrove vegetation for motor launch pathways and creating other disturbances which are beginning to leave their adverse effects on the beauty of the area, its productivity and usefulness in sheltering animal communities. The expansion of tourism development activities should be planned in a way compatible with ecological principles and guidelines and this should be chalked out by the National Committee.

The concept, functions and benefits of conservation are insufficiently known by the public and by the planners. Through local, national and international organisations, this communi-


National Committee (Marine Park Authority)
Proposal for Park and preliminary studies
Finance
Study Committee for Park
Definition : Delineation
Multidisciplinary study social and economic of area chosen
Master Plan for Marine Park
Management Operational
Administration patrolling
Maintenance of control
Ecological Supervision
Rehabilitation of displaced people
Human Co-operation
Recreation tourism education
Conservation Education and Extension Wing
Periodical survey of selected island to study impact
Regular monitoring of environment

cation gap can be bridged. Perhaps audio-visual education on this can be adapted towards multiple benefits. Competent specialists can produce films. Initiative from non-governmental organisations should be welcomed and governmental collaboration will ensure greater appreciation by public than when government agency alone tries to administer the systems.

(vii) Such areas protect scenic beauty and enhance areas for enjoyment as well. Public education, training and education of Park officials and specialists, training of managers of environment, area use for higher education and research are very important. Artistic education and sports are two forms. This is a special aspect that should not be lost sight of; culturally the area may not offer anything attractive but this is another item to be reckoned with.

Krusadai appears to be the best suited for education and recreational purpose. In this respect this island can be developed with a possible second choice of Nallatanni tivu where specific zones can be set aside for underwater viewing and swimming, boating, sport fishing, SCUBA diving, and charter boat tours with specified anchor sites. On no account the tourist should be allowed to have staying facilities in any island but only to visit and return. Establishment of an oceanarium cum 'Sea World' at Kundukal Point, Pamban, Rameswaram Island should be taken up as a Centre for tourist attraction.

Visiting Scientists should get all laboratory and field facilities for detailed studies in Krusadai island and Nallatanni tivu and one of the southern islands should be reserved for studies on restoration of the reefs.

(viii) The right should be vested with the Park authorities to intervene and restore the balance of the ecosystem when disruption puts the whole Reserve at risk. This would mean all control measures needed to remove the causes of such forces. For instance the right to quarry corals for industry, collection of coral bits for Klin burning and calcining, collection of seaweeds and shells etc. which are regular activities in the area.

Specific matters

1. *Protection*

This is to guide studies and surveys and guide implementation. This is a highly flexible subject depending on regional diversities and site specific issue. This would naturally preclude rigid approach.

Legislation ultimately aims at a zonation of coastline and takes on itself responsibilities for managing problems beyond the capacity of any single department such as Fisheries or Tourism. We should be sensitive to needs like use of marine areas, resources of people, restoration of damaged environment, preventing further deterioration and other areas of local interest of marine resources exploitation *vis-a-vis* the economy of the people involved.

The subject relating to recreational, interpretive and educational uses needs careful planning and decision. The approach of marine park conservation can be on the model of terrestrial conservation :

Recognition of conservation needs
|
Survey of critical areas
|
Basic resources in selected areas and vicinity
|
Management goal
|
Conceptual master planning with definition of interpretive themes, recreational activities and facilities
|
Environmental monitoring and research
|
Reassessment and revision

III. Development of a Marine Park at Malvan

It has been suggested (Qasim *et al.*, 1980) that the Malvan coast in the Central West coast of India be declared as a Marine Park. The justification given are that it is a clear, unpolluted, healthy area with abundant growth of living corals. From Malvan Bay a chain of submerged and exposed rocky islands extends straight towards south upto 15° 13'N and 73° 27'E. There are several islands including the Vengurla Rocks at the southern tip and Sindurdurg Fort at the northern tip. The algal wealth in the rocky areas here is rich and the entire coast line is a scenic beauty. It has been suggested that a Dolphinarium and marine aquarium can be constructed in the marine land complex at Sindhurdurg Fort which is very near the sea with deep channels outside the fort-wall. This Fort itself is a national monument under the Archaeological survey of India. There is a proposal by the Government of Maharashtra to develop this as a tourist spot with financial and technical assistance.

A detailed document issued by NIO, Goa has delineated the Park area adopting a 'two zone system', a 'Buffer zone' and a 'Core zone'. A five point action plan has been outlined emphasising on creating public awareness, framing of rules and regulations, preparation of illustrated extension literature, collection of base line information on park ecosystem and establishment of a park museum as an educational input.

Regulations to cover the 'Core zone' and 'Buffer zone' have been proposed which will include phasing out activities such as fishing from the core area and minimising human interference in the 'Buffer zone' as well. A Dolphinarium and a marine aquarium are proposed. A fourteen point action plan outlines the immediate development programme for the proposed Park.

Reserves and Sanctuaries

The Department or Environment, Government of India has prepared some guidelines for the development of the beaches and coastal zones. While this has given very specific ideas for management of different situations, a national policy on the management of the coastal zone will be necessary. The increasing pressures on the coastal zone by wide ranging activities has resulted in large scale man-made perturbations and biodegradation of many coastal ecosystems. There is an urgent need to identify areas of priority importance for ecosystem conservation and demarcation as reserves, along the coast as well as estuarine areas. It is not only the threatened habitats such as mangrove ecosystem and saline lagoons and coastal wetlands that has to meet our immediate attention, but some of the known nesting beaches of sea turtle , sea grass beds and coral reef areas. The recent focus on the mass nesting of the olive ridley turtle along the Gahirmatha Coast of Orissa and along other beaches on the east coast as well as sporadic nesting of other species of sea turtles in the Bay islands and along some parts of the mainland coast has drawn attention to the need for immediately declaring some of these areas where man-made perturbations are increasing, as reserves. The recommendations of the recently conducted Workshop on the Conservation of Sea Turtles held at Madras in February, 1984 focuses attention on specific areas along the coast as well as in the Andaman Nicobar and Lakshadweep Islands which need immediate attention. The published proceedings (Silas E. G. (Ed.) (1984) has brought out a wealth of information from Forest and Wildlife Departments, various organisations and individuals of the effort that has at present been mounted to help in the sea turtle conservation programmes. We are giving below some of the highlights and specific aspects which need consideration for declaring certain stretches and beaches which are nesting or feeding grounds of sea turtles which need surveys, evaluation and consideration as reserves. There is also a need for extending some of the wildlife sanctuaries to include also contiguous beaches within its ambit so as to offer protection for nesting turtles and the marsh crocodile and other endangered or vulnerable species.

The areas of special interest are :

1. Spawning grounds for commercially important fishes
2. Important feeding, breeding and nursery grounds such as Mangrove habitats.
3. Nesting, feeding and breeding grounds of Sea turtles.
4. Unique and threatened habitats.
5. Areas of geological, historical, cultural, aesthetic and recreational interest.

Nesting beaches, Feeding grounds and Mating areas of Sea Turtles

Wildlife sanctuary for turtles already exist along the Orissa Coast. Bhitarkanika Sanctuary at present does not include Wheeler and Shortts' islands in the north Orissa Coast. Also it was found that Hukitola island and False point (near Paradip Port) are very strategic southern points for ridley nesting. These should be included. In the Workshop on sea turtle conservation held at Madras in February, 1984 it has been recommended that the Bhitarkanika Sanctuary should be suitably extended on the seaward side so that the nesting beaches and the mating areas of the olive ridley could be adequately protected. It will be eventually necessary to develop a biosphere for the Bhitarkanika—Gahirmatha area where the mangrove ecosystem and the beaches are important for the protection of the sea turtle, crocodiles and other vulnerable species.

Another marine reserve at Kujang-Astrang along the Orissa Coast is felt essential since new olive ridley nesting grounds have been reported near Devi River mouth in Cuttack District. It will be very ideal if the proposed Konarok-Balukhand sanctuary in Puri District is extended to cover also a 48 km beach stretch as a reserve to protect turtle nesting grounds north of Keluni Muhana river mouth.

It was also suggested that the sandy beaches and islands of Sunderbans in West Bengal and Godavari and Krishna deltas of Andhra Pradesh be further studied for the location of turtle nesting sites and be adequately protected.

In Tamil Nadu coast, Point Calimere area is already declared a wildlife sanctuary for the black buck and migratory birds. The importance of the contiguous seaward beaches as sea turtle nesting grounds is important and it is all the more expedient to extend the limits of the Sanctuary further seawards to afford protection to the turtle nesting beach sites in the area. The best nesting places on the West coast of India exist in Gujarat-Bhaidar island in the Gulf of Kutch. This has already been declared a Marine Park area. The beaches south of Dwaraka and the coasts of Diu islands are critical areas for green turtle nesting and should be excluded from sand mining for the cement industry.

As feeding grounds for sea turtles, Andaman and Nicobar islands are very important areas. Most of these islands are now within reach of poachers and this poses problems. The beaches of Kwangtung, North reef island, Latouche, North cinque, South cinque, Interview island and Twin islands are places for nesting of turtles. These should be declared as Reserves.

Great Nicobar is the most important nesting island. Considering the growing importance of developmental activities particularly in the Middle Andamans, Car Nicobar, Comorta and Great Nicobar islands it is highly essential to declare the sandy beach and the tidal inlets leading to swampy interior in these islands as reserves for protecting the turtle nesting grounds as well as for the marsh crocodile. The areas to be declared as reserves could be properly delineated after a timebound baseline survey is carried out in these areas.

In Lakshadweep Green turtle nesting has been reported from Suheli Veliyakaran, Bangaram, Thinnakara and Parali islands. The entire beaches around these islands should be declared as reserves since the islanders exploit the turtle for flesh and oil. The Hawksbill turtle has been reported nesting on the Minicoy Island and the favourable sites of the beach need protection. The sub tidal and slightly deeper zones abound in luxuriant growth of seagrass which area the green turtle frequents on their feeding sojourns. Hence, it is also necessary to include parts of the Minicoy shore region and the seagrass beds as protected areas. Delineation and marking of boundaries of the reserves can be taken up after baseline studies are completed. Development of a National Seashore system and an integrated system of coastal zone management including social forestry scheme is suggested. Exclusive reservation of certain segments of beach for turtle nesting at specified distance at least 1000 m from high water mark to allow high beach platform for facilitating nesting of turtles and to act as a screen to shield beaches from artificial light at night which will keep turtles away from nesting is a must.

Mangrove Ecosystem

Destruction of mangrove vegetated shore line zones for industrial activities and coast line development is one of the most insiduous and damaging activities of man. This coast line challenge should be curtailed to minimise the set backs that can happen to the mangrove associated ecosystem and to the configuration of the coastal relief.

As such we have scanty scattered data regarding the extent of important mangrove lined beaches. But with the available data and information it appears necessary to take immediate steps to protect the following :

1. Mathupet swamp and the Pitchavaram backwaters along the Tamil Nadu coast where the mangrove vegetation stands the danger of pollution by recreational users as well as chopping down of trees for pathways for the tourists.
2. Already the entire islands in the Gulf of Kutch have been brought under a National Marine Park which affords guarantees on the principles of conservation.
3. The total inlets and the swampy delatic regions of all the major rivers in the east coast upto a distance of 5 km south and north of the coastline and interior should be declared as reserves.
4. After sufficient data collection similar measures can be taken in Andaman and Nicobar islands and Lakshadweep.

Breeding Reserves

Although no precise data are available about the inshore breeding grounds of commercially important and rare marine species, it is still a necessity that with whatever information available breeding reserves are established. A few examples are cited below.

1. In the Palk Bay zone (lat. 9° 15′-9° 30′ N and long 79° 30′E) seasonal occurrence of shoals of large sized *Chanos* spawners occur and this inshore movement for spawning is significant. This is also evidenced by the appearance in enormous numbers of *Chanos* fry ascending the tidal creeks and inlets during February to April and September to October of each year in the east coast tidal creeks and

inlets. The fishermen catch these spawners when they occur in the shoreward area by operating gill-nets and drift-nets during this season. This, if permitted, will ultimately spell disaster to the natural milkfish fry and fingerlings resources of the country. We are concerned with this problem in as much as the fish is extensively used in coastal aquaculture operations. Therefore, it is suggested that effective regulatory measures such as observing closed season for fishing of *Chanos* from Rameswaram upto Point Calimere within the Bay area may be observed after a careful study.

2. The Palk Bay squid is a rare species occurring in large quantities in and around Ramèswaram island and the habit of the squid and other cuttle fishes to lay the eggs during breeding season on floating objects and submerged weeds is a regular feature during May to July of each year. An area of 50 sq. km off Rameswaram east coast should be declared as a reserve and any attempt to operate seine-nets or stake-nets should be restricted and keenly watched to rescue the egg clusters that will become enmeshed and destroyed by fishing operations.

3. The flying-fish fishery of the east coast from Madras to Point Calimere is another example of how the fish needs protection during its spawning time when it moves shorewards to lay its eggs on submerged bushes intentionally anchored by fishermen to attract and aggregate the fish for laying eggs. This fishery which is unique off the coast of Tranquebar and Nagapatnam in Tamil Nadu coast has dwindled in recent years due to heavy fishing pressures. Therefore, a part of this fishing zone may be declared as a reserved zone imposing restrictions on the season of fishing (viz. May-June).

4. Imposing size restrictions and mesh regulations has in the past given positive result in increasing the chances of the animals breeding at least once before being fished. This is possible only when the life history of some animals of importance is fully worked out to find out the minimum size at spawning. The Tamil Nadu Government's restriction on fishing of chanks, by diving which are less than 55 mm diameter have given good results. But this needs further strengthening in order to improve the chances of survival. Diminishing size range in commercial catches indicates the lacuna which might exist in the criteria adopted for better yield. Therefore, it is suggested that instead of allowing exploitation of chanks extensively in the Gulf of Mannar and Palk Bay a few protected areas may be demarcated to serve as perennial breeding reserves. The possibility of declaring an extent of 100 sq. km of the sandy seabed lying between 16 m to 30 m in the Gulf of Mannar off Tuticorin and an identical extent between 8 m to 15 m depth off Tondi in Palk Bay should be explored.

5. Extensive and indiscriminate fishing by diving for *Trochus niloticus* and *Turbo* sp. is being done around the Andaman and Nicobar islands. The areas around the little Nicobars and Katchal and Camorta islands should be declared as prohibited zones for fishing these upto a distance of 500 m from shore line all around. Leasing out operations for commercial exploitation should be terminated and not renewed in future.

6. Commercial leasing out of estuarine zones of river beds by all State Government authorities should be controlled by seeking advise from the National Committee on Marine Parks. The classic example of mining the river beds in the vicinity of the sea for dead clam shells and oyster shells has adversely affected the traditional occupation of the fishermen who depend on the live clam resources in these areas for their livelihood. The disturbance to the river bed in all such areas leased out has markedly affected the ideal habitat needed for the growth and survival

of the valuable clams such as *Paphia* sp. and *Meretrix casta*. Recent survey conducted in the Kali river estuary of Karnataka has proved this point. Identical situation may exist in the other estuaries in the Dakshina Karnataka. To start with, it is necessary to declare some of the estuarine areas protected from dredging clams for the lime industry, but permitting traditional subsistence fishing.

7. The development of artificial reefs, especially in the Gulf of Mannar and Palk Bay and other selected stretches of the coast for marine habitat improvement should be encouraged.

CULTURAL AND ARCHAEOLOGICAL

Several submerged areas along the east coast particularly off Tamil Nadu are known for the lost cities which are lying submerged or destroyed by the sea engulfing the settlement in the past. Such archaeological sites are very important from the point of view of our cultural heritage. Good examples are the cities of Poompuhar off Tanjore coast and Mahabalipuram off Madras coast. Proper demarcation of such areas landward as well as in the littoral zone for declaring them as heritage reserves will be necessary.

It is but an example of an immensely rich cultural heritage of our country's coastal areas of the different maritime states. Several historically famous shrines, past cities and cultural centres may remain submerged or lost by sea erosion during the course of several bygone centuries. Inventories of such instances should be prepared and such coastal zones should come under Underwater Archaeological reserves. The Tamil Nadu Government's initiative in encouraging the Tamil University, Tanjore to embark on a Project Centre at Mandapam for underwater archaeological studies is commendable and should be emulated by other states to unraval the mysteries of the submerged ancient centres of culture.

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THE ROLE OF ZOOS AND OCEANARIUMS IN THE CONSERVATION OF MARINE MAMMALS

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ABSTRACT

Passage of the Marine Mammal Protection Act of 1972 in the United States reflected a recognition of the detrimental effect humans were having on marine mammals. It set the stage for increased research, conservation programs and improved care of captive animals. While zoos have been successful in propagating certain terrestrial species for reintroduction to the wild, it is not economically feasible to do this with marine mammals. Zoos can, however, help preserve marine mammals by participating in rehabilitation programs, supporting research and educating the public. These efforts require exhibits, husbandry practices and management of animals that will allow natural behaviour. The net result of this should be an enhanced public awareness of marine mammals which will help ensure their conservation.

INTRODUCTION

IN THIS paper I am going to draw attention to the need for marine mammal conservation, suggest how zoos can contribute to this effort and briefly discuss important aspects of captive husbandry and exhibit design.

I would like to thank Dr. John Seidensticker for encouraging me to write this paper. Lisa Dabek spent many hours helping prepare the manuscript. I am grateful to the following people for discussions on the subject and for comments on the manuscript: John Seidensticker, Edwin Gould, Christen Wemmer, Leslie Boness and Lisa Dabek.

In 1972, the United States Congress enacted the Marine Mammal Protection Act because '.... certain species and population stocks.... are or may be in danger of extinction or depletion as a result of man's activities.' (Public Law 92-522, 1972). This act resulted from the increasing number of marine mammals which were becoming endangered. Indeed, two species have gone extinct in the past 200 years, the Steller's sea cow, *Hydrodamalis gigas*, in about 1768 and the Caribbean monk seal-*Monachus monachus*, not seen since 1952. Five other species have come close to extinction over the last century (Table 1). Only one of these, the northern elephant seal (*Mirounga angustirostris*), has made a substantial comeback. A cetacean species endemic to India has also reached a critically low level, the Ganges river dolphin, *Platanista gangetica* (McClung, 1978).

Some marine mammals live in international waters or migrate from one country to another. Others inhabit coastal waters. Protection of these species therefore requires both strong national laws and international agreements. Table 2 lists some of the agencies and laws or agreements involved in the protection of marine mammals in the U.S. and internationally. In the U.S. the Marine Mammal Protection Act is the most comprehensive protective legislation for a particular group of animals. The USDA Marine Mammal Animal Welfare legis,

TABLE 1. *Pinniped species that reached critically low population levels during the past century.*

Species	Estimated Lowest Population	Present Status	Source
Juan Fernandez fur seal	Believed extinct 1880-1956	500-1000 ; increasing	Norris & Atkins 1971
Guadalupe fur seal	Believed extinct 1897-1926	1000-2000 ; increasing	Pierson 1978
Atlantic walrus	?	ca. 10,000 ; declining	Reeves 1978
Carribean monk seal	0	Not sighted since 1952	Kenyon 1977
Mediterranean monk seal	Present level	500-1000 ; declining	Sergeant et al. 1978
Northern elephant seal	$\lessdot$100 by 1982	48,000 ; increasing	Le Boeuf 1977

TABLE 2. *List of regulatory agencies and legislation involved with marine mammal care in captivity and protection in the wild*

Regulatory Agencies

National Marine Fisheries Service (NMFS) Department of Commerce

Fish and Wildlife Service (FWS) Department of Interior

Animal And Plant Health Inspection Service (APHIS) Department of Agriculture

State Fish And Game Commissions

Legislation

Marine Mammal Protection Act

Endangered And Threatened Wildlife And Plants Act

Convention On International Trade in Endangered Species

Marine Mammal Animal Welfare Act

lation is unique in establishing regulations for housing and care of captive marine mammals. A further indication of the need to preserve marine mammals is the number and percentage of species listed on the USFWS Endangered Species List and on the CITES (Table 3). Similar legislation in other countries also include a high proportion of marine mammals.

TABLE 3. *Number and per cent of marine mammal species listed on the U.S. Fish and Wildlife Service (USFWS) Endangered Species List and on the Convention for International Trade of Endangered Species (CITES)*

	Number (%) Listed	
	USFWS	CITES
Sirenians (4 species) ..	4 (100)	3 (75)
Cetaceans (75 species) ..	8 (11)	23 (31)
Pinnipeds (34 species) ..	3 (9)	4 (12)

Depletion of stocks in most marine mammals has not been due to loss of or deterioration in habitat, as is so often the case with terrestrial species. Instead, depletion has been the result of overhunting. For example, by mid-1880, 1000 fin whales (*Balaenoptera physalus*) were being taken per year, and by 1958-1968 more than 60,000 whales were being killed annually.

Between 1810 and 1834, when Guadalupe fur seals, *Arctocephalus townsendi*, almost became extinct from hunting, 200,000 seals were being taken per year (McClung, 1978).

In recent times, however, since most marine mammals live in coastal waters and a few live within confined bodies of water, increased levels of pollutants or other human activities have begun to affect some species substantially. Grey seals, *Halichoerus grypus*, (National Swedish Environment Protection Board, 1982) and ringed seals, *Phoca hispida*, (Helle *et al.*, 1976) in the Baltic Sea and harbour seals, *Phoca vitulina*, in the North Sea (Reinjders, 1979) are failing to reproduce because of high PCB levels in the fish they eat. PCBs appear to produce sterility in females.

In the West Indian manatee, *Trichecus manatus*, most present-day mortalities are due to boat collisions, flood control structures or fishing gear (Odell and Reynolds, 1979). These problems are clearly the result of expansion of human habitation and activities in areas that were once remote.

Role of Zoos in Conservation

It is clear from the above discussion that for many marine mammals a multifaceted conservation effort is needed. One might ask how can zoos, oceanariums and aquariums contribute to such an effort? Zoos have played a role in preserving and propagating several terrestrial species with the direct aim of reintroducing them to the wild. Some examples of such programs include golden lion tamarin, wisent and arabian oryx. Tamarins are currently being introduced to a preserve in Brazil by the National Zoological Park, wisent were reintroduced into nature reserves in Poland by a number of European zoos and the arabian oryx, bred at the San Diego Zoo and Phoenix Zoo, was sent to a reserve in Jordan.

As Campbell (1980) points out, nonetheless, these small successes '. . . should not blind anyone to the numerous problems entailed in the captive breeding of animals for reintroduction into wild habitats.' (p. 263). The cost of such programs are high. Between 1970 and 1980, the cost of setting up a reintroduction program with peregrine falcons was over a million dollars, and the program is still only in its early stages. Space to hold and breed animals is essential for any program with reintroduction in mind. William Conway of the New York Zoological Society (1980) believes that zoos will only have sufficient economic and space resources to preserve 100-150 species. The size and cost of maintaining most marine mammals makes it unrealistic to view zoos as a last hope for preventing them from extinction by captive propagation and reintroduction.

In species where population levels are extremely low, zoos can play a role in holding and rehabilitating sick or stranded animals. This requires some facilities and short-term commitments to individuals but is far less costly than long-term breeding for reintroduction. A rehabilitation program on this scale is not likely to prevent extinction of a species but might help delay it. Successful rehabilitation programs usually involve the cooperation of government agencies and zoos. Examples of successful marine mammal rehabilitation programs in the U.S. are those involving manatees, seals and dolphins. In the case of manatees, the USFWS supports and coordinates the program and institutions such as the Miami Seaquarium and Marine land of Florida provide the holding space and care of the animals. For seals and dolphins, the National Marine Fisheries Service, part of the U.S. Department of Commerce, provides the support and coordination and there are many facilities on both the east and west coasts which participate in the housing and care of the animals.

The two most important conservation roles that zoos can play are to support research on marine mammals and to raise the public awareness of them. The success of conservation programs like that for golden lion tamarins is only possible after many years of basic research (see Kleiman, 1980).

For marine mammals, studies of animals in the wild have been limited because of logistics. Most of what we know about pinnipeds is from their terrestrial behaviour which includes breeding, molting and resting (Ridgway and Harrison, 1981). For cetaceans, studies are mostly restricted to surface behaviour, acoustical analyses (see Herman, 1980), and information obtained from stranded animals (Geraci and St. Aubin, 1979) although telemetric studies are beginning to broaden our view (Jennings and Gandy, 1980; Butler and Jennings, 1980). Projects with animals in captivity should be encouraged despite the artificial environments because we can study facets of the animals which are not readily available in the wild.

Public support of conservation programs, which sometimes conflict with people's livelihoods, can only be achieved when there is public awareness of the animals and the problems. One must keep in mind that the public generally does not have access to marine mammals in the wild. Their exposure is therefore limited to images in books and films. Zoos provide an opportunity for people to see and appreciate the beauty and gracefulness of these creatures which is bound to have a far greater impact than any book or film. Marine mammals in an exhibit at the National Zoo are viewed by approximately one million people each year, far more than could ever view them in their natural habitats.

Beyond providing a passive availability of animals, zoos can further provide active programs to educate the public about the biology of marine mammals, their status in the wild and their interactions with humans.

ANIMAL REQUIREMENTS AND EXHIBIT DESIGN

The first step to accomplishing an increased public awareness of marine mammals is to keep them successfully in captivity. Keeping marine mammals is an expensive and complex task. Exhibit requirements are much greater than for many terrestrial species. In the remaining part of the paper, I will briefly review animal requirements and exhibit design, husbandry practices, the costs of maintaining certain species, and ways in which the public can be educated.

Some aspects of animal requirements and exhibit design are similar regardless of the taxonomic group of marine mammals being exhibited while others vary from one type to another. I will first discuss those aspects common to all groups and then briefly discuss aspects specific to each of the following groups: sirenians, pinnipeds and ceteceans. Confining a marine mammal to a pool can have a great impact on the animal's health because bacteria and fungi are able to concentrate at much higher levels in these areas than they do in open water. This, in conjunction with the likely higher stress level produced by captivity, may cause some agents which are not usually pathogenic to become pathogens (Montali *et al.*, 1981). It is therefore extremely important to maintain good water quality.

Water systems

There are three main types of aquatic systems for captive marine mammals (see Fig. 1): a complete flow-thru system in which water is pumped directly in and out of the primary holding pool without any treatment; a partial flow-thru system, where the water is treated before going into the primary pool (some water may be recirculated as well but there is still a continuous flow of water in and out of the pool); and a closed loop system, where the primary pool is filled with water which is then

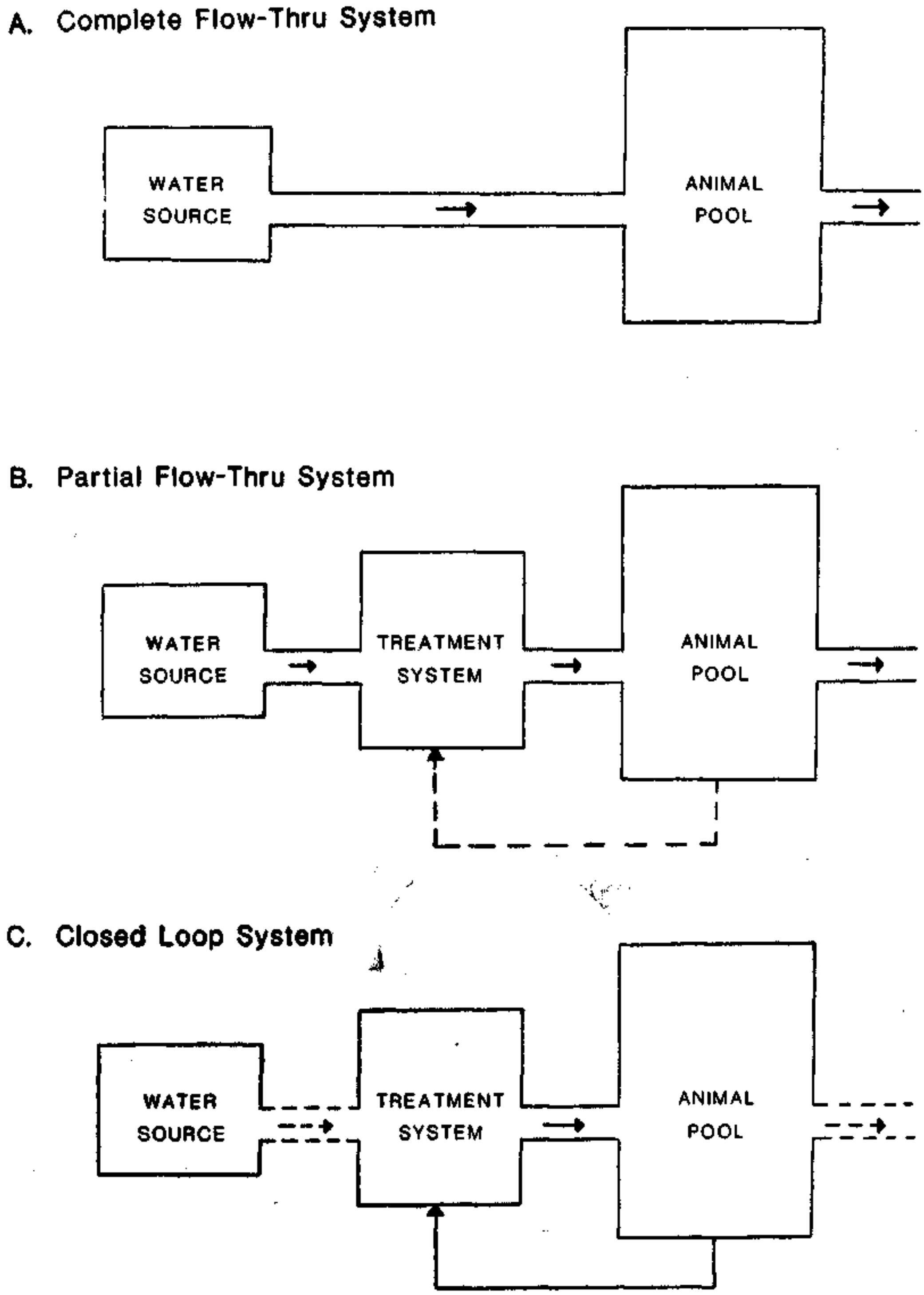

FIG. 1. Diagrams of three types of water treatment systems for marine mammal pools. Solid lines and arrows indicate continuous water flow and dotted lines and arrows represent periodic or optional water flow.

recirculated through the treatment process for a given period before being discarded. The type of system designed will depend to a large extent on the water source and how clean it is. The ideal system is a complete flow-thru system but, usually this is only cost effective if one is set up along a coast which has no coastal pollution. More realistically partial flow-thru systems are used at oceanariums or aquariums along the coast. Inland facilities almost always use closed loop systems because water sources are usually the same as those used for human consumption and thus expensive and limited.

There are two basic needs in water treatment for marine mammal exhibits : one is to remove particulate matter so there is good visual clarity for visitors and the other is to remove biological and chemical matter that is potentially harmful to animals. Removal of particulate matter is traditionally accomplished by mechanical filtration, using filters filled with sand, diatomaceous earth, anthracite or some combination of filters (Plate 1). Mechanical filtration alone may not be sufficient to control algae so sometimes algecydes (e.g., copper sulfate or chlorine) are used as well.

Control of bacteria and fungi is usually accomplished with some kind of disinfectant or oxidizing agent. Chlorine is by far the most widely used substance today even though long term exposure to it or its by-products may be harmful. One often sees skin and eye problems that may, directly or indirectly, be attributed to constant exposure to chlorine. It is difficult to test experimentally these hypotheses in a zoo setting but the circumstantial evidence is sufficient to warrant investigating alternatives to chlorine.

There has been only minimal effort made in testing alternative means of disinfecting pools. Spotte and Adams, having tested a variety of treatments (ultraviolet radiation, polymeric resins, ozonation and chlorination) on marine mammal systems, came to the conclusion that none of the methods alone, except chlorination, were viable techniques to control biological matter under closed loop conditions (Adams and Spotte, 1980 ; Spotte and Adams, 1981 ; Adams and Spotte, 1982). If this conclusion holds following further experimentation, then in the future we should develop systems in which the chlorine treatment is done in a storage tank, not the primary animal holding pool. Water could be dechlorinated as it is transferred to the animal pool. Such a system would obviously be more expensive to construct and operate, but would reduce animal health problems.

Sirenians

Space requirements are critical for the well being of captive animals. This is felt to be sufficiently important for marine mammals that the U.S. Government has passed legislation which establishes minimum dimensions for pools (Federal Register, 1984). According to these regulations, a pool for manatees or dugongs should be large enough such that a circle with a diameter of twice the mean length of an adult animal will fit on the surface. The minimum depth of the pool should be one-half the mean adult length. There is still some controversy over the importance of depth, however. It has been argued that breeding might be facilitated by animals being able to float vertically in the pool (Valentry, 1973). Others have argued that this is not necessary (Bertram and Bertram, 1973). At present there has not been enough effort to breed sirenians in captivity to resolve this controversy.

Water temperature appears to be critical for sirenians. Below about 16° C manatees stop eating (Jenkins, 1978). Comparable observations are not available for dugongs, but one might expect them to respond similarly. The recommended temperature range for sirenia

PLATE I. Rapid sand filters for a mechanical filtration system at Marineland in Los Angeles, California.

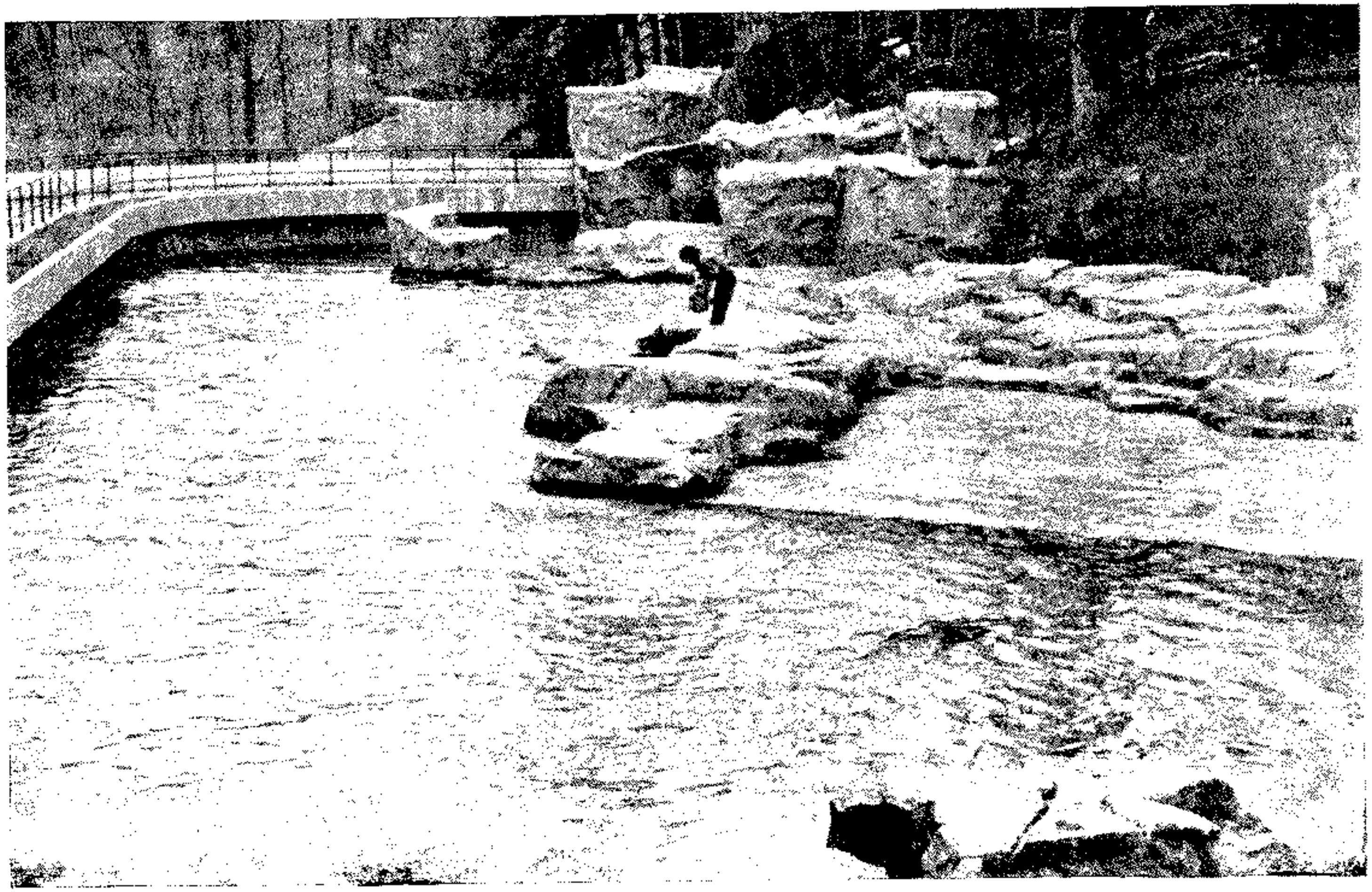

PLATE II. The California sea lion exhibit at the National Zoological Park in Washington, D.C.: an ideal design with rock islands, a large pbeach, a shallow ool for pups and an oblong shape for maximum facilitation of natural behaviours.

is about 20-30° C (Allen *et al.*, 1976 ; Zeiller 1978). With the exception of the Amazonian manatee, it is felt that sirenian exhibits should have the capability of holding fresh or saltwater. There is reasonable evidence to show that algae parasite and bacterial problems can be reduced by periodic changes between fresh and saltwater (Bartman, 1974 ; Brownell *et al.*, 1978).

Sirenian anatomy and behaviour (Marsh *et al.*, 1978 ; Domning, 1980) indicate that they are bottom feeders although most species will take food from the surface. Allen *et al.* (1978) suggest that dugongs might not take food from the surface and they provide a diagram of a simple device used at the Jaya Ancol Oceanarium in Indonesia for feeding dugong under water.

Pinnipeds

The U.S. regulations governing marine mammal facilities require that pinniped pools must have a surface area large enough to fit a circle with a diameter one and one-half times the mean adult length of the largest species to be housed in the pool. Its depth must be at least 0.9 m or one-half the average adult length, whichever is greater. In addition to these requirements, pinnipeds must have dry surface areas upon which to give birth, to care for their young and to rest. The regulations set forth a formula for calculating this but its complexity would require too much space to present it here (see p. 26685 of the Federal Register, 1984, vol. 49). Recent work by Bigg (1984), however, provides data which suggests that this requirement might actually be detrimental to reproduction in some species. He argues that the high incidence of still births in captive northern fur seals, *Callorhinus ursinus*, may be the result of year round exposure to a haul out area. In the wild these animals are pelagic most of the year and give birth shortly after arriving on land.

A desirable feature, but not a necessary one, is an oblong shaped pool (Plate II). This allows animals to make fast, long swimming bursts and, it affords an opportunity to perform in those species which breach water when travelling.

Critical water temperatures have not been determined for pinnipeds. Geraci (1978) indicates that healthy temperate and subarctic phocids can tolerate freezing water temperatures. Montali *et al.* (1981) provide some evidence indicating that high water tempera tures (27-32°C) for grey seals may have contributed to fungal lesions. In the absence of good information on threshold water temperatures it is safest to maintain levels that closely approximate those in the wild. This might require the use of heat exchangers to cool the pools.

Cetaceans

The U.S. regulations have divided cetaceans into two groups for the purpose of establishing space requirements. The first group (Group I), which includes the river dolphins, are animals that usually inhabit waters near land and for which considerable information has been developed concerning space requirements. The other group (Group II) comprises animals that live near the surface of the ocean far from land and for which we know very little about space requirements. The minimum surface dimension for Group I species should be large enough to fit a circle of at least 7.3 m or two times the mean adult length in diameter, whichever is largest. That for Group II species should be 7.3 m or four times the average adult length. The minimum depth should be one-half the average adult length regardless of the species.

As for pinnipeds, an oblong pool is desirable for these species to be able to achieve their full breadth of swimming and jumping. For some species, breaching may require greater depths than the minimum requirements.

Cetaceans are not able to locomote on land so any facility housing them must be connected by water to holding pools. The design of this connection is crucial so that the holding pool can serve as a quarantine facility when new animals arrive or there are sick animals in the group. Water should not be able to flow from the holding pool to the primary pool and the holding pool should have its own filtration system.

The water temperature range in which cetaceans can be maintained is reasonably large. Asper (1982) presents acceptable ranges for about 20 species. *Platanista* should be kept in the range of 20-30° C (Geraci, 1978).

Husbandry

Diet

Probably the most critical aspect of marine mammal husbandry is diet. All sirenians are vegetarians with hind-gut fermentation like horses (Marsh *et al.*, 1978) and are especially adapted for digestion of sea grasses. Studies of feeding ecology, not surprisingly, support the anatomical observations (*e.g.* Campbell and Irvine, 1977). In captivity, it is often more feasible to feed substitute food items in lieu of natural foods because of the high cost of obtaining the natural diet. Among the foods fed to captive sirenians are eel grass, mustard greens, long beans, swamp cabbage, lettuce, pasture grasses and water hyacinths (Hartman, 1971 ; Allen *et al.*, 1976 ; Asper and Searles, 1978). Allen *et al.*, (1976) provide proximate analyses of many of these items. Adult manatees eat between 25 and 35 kg of vegetation per day and dugongs appear to eat 50-75 kg per day. One report of the cost of feeding manatees in North America was about $ 1,700 per month (Brownell *et al.*, 1978).

In the wild, seals and whales are catholic in their feeding habits, eating a large variety of fish species, molluscs and crusteceans. In captivity, the predominant diet is frozen fish. Frozen fish is generally much less expensive than fresh fish and can be stored for longer periods of time. Fish quality is extremely important because if fish is not properly handled, it loses its nutritional value and deteriorates rapidly, producing a potential disease hazard (*e.g.* Geraci and Gerstmann, 1966). Frozen fish, especially, should be evaluated before being fed (Oftedal and Boness, 1984). The National Marine Fisheries Service has established a set of standards for judging human consumption quality fish (Title 50, Code of Federal Regulations, Part 260-261). These standards should be applied to fish fed to marine mammals as well. To be acceptable, fish must conform to the standards presented in Table 4.

TABLE 4. *Criteria used to judge the quality of frozen fish*

1. Mild odor—no strong, rotten or 'iodine' smell
2. Flesh intact and firm—not soft, spongy or with a tendency to separate
3. Natural skin color and appearance —no discoloration, dehydration or wrinkling of skin
4. Fish intact—no breaks in skin, bloating or protrusion of viscera

Many fish species very seasonally in their nutritional value. Ideally, one should perform gross composition analysis on fish lots received. For example, mackeral analyzed for fat content varied from 3 to 21% and butterfish from 5-18% at different times of the year (Oftedal and Boness, 1984). Simply feeding an amount of fish in terms of per cent body weight of an animal, as recommended in the past (Geraci, 1978), can produce quite different energy intakes at different times of the year.

Vitamin supplements are recommended for pinnipeds and cetaceans. Two vitamins in particular should be given, thiamin and vitamin E. Frozen fish contain enzymes (thiaminases) that breakdown thiamin (Geraci, 1981). In the absence of supplementation, thiamin deficiency, which may result in death, is likely to occur (Geraci, 1972). The recommended dosage of thiamin is 25-35 mg/kg of fish per day. Fish have a high level of polyunsaturated fat (Keyes, 1968) which increases an animals vitamin E requirement (Maynard and Loosli, 1962). Following the death of a yearling sea lion from an apparent vitamin E deficiency (see Oftedal and Boness for a discussion of this case), the National Zoo increased its vitamin E supplements from 200 IU/day to 400 IU/day.

In the U.S., fish of a quality fit for human consumption is expensive. From 1979 to 1983, the National Zoo spent between $ 20,000 and $ 36,000 per year to feed 11-13 seals and sea lions.

Management

Marine mammals because of their size and the fact that much, if not all, of their time is spent in water are difficult to manage in captivity. If there is a need to move them from one place to another or contain them for taking blood, they cannot easily be netted or pushed around like many terrestrial mammals. Further more, the stress associated with such practices may be substantial enough to outweigh any good being done by the treatment. For this reason, many zoos have a policy of waiting until a situation reaches a matter of life or death before they will intervene. An alternative approach to managing animals in this way is to train them using operant conditioning techniques. This requires a greater commitment of staff but in the long term seems to pay off in that animals appear to be healthier although I know of no studies which have quantified this. At the National Zoo, seals have been trained to haul out on cue and follow a keeper to a holding pen, to crawl into a squeeze cage, to sit unrestrained while a blood sample is taken and to hold still while a gross external examination is done. An additional benefit to having trained animals is that they can be used as vehicles for education and increasing public awareness of marine mammals.

Education and Public Awareness

Efforts to educate public can occur at several levels and be relatively passive or active. The use of signs to convey information is passive and unless kept short and simple will not be very successful. Lectures,symposia and courses are good because detailed information can be given, but these can only be presented periodically. Generally people who attend lectures are already relatively informed and interested. Thus reaching them with conservation information does not have the impact of reaching those who are less informed. I suggest that public demonstrations using trained animals is an ideal means of actively gaining the attention of large numbers of people who might not be self-motivated enough to become more informed. One approach followed by many large oceanariums is to use a story line which anthropomorhizes the animal. These shows capture the visitor's attention but do not maximize the opportunity to educate the public. An alternative approach is to give informal talks at the exhibit using the trained animals to illustrate aspects of the talk and to keep the publics attention. The interaction between the animal and trainer literally draws an audience who listen intensively for 15-20 minutes. That time then becomes an open forum in which to convey a message. Conservation issues and the biology of marine mammals should be high on that list.

In summary, many marine mammals, like many terrestrial mammals, are in need of conservation efforts. Human activity over the last two centuries has depleted numerous stocks. Zoos can contribute to these efforts mainly through support of research and raising public awareness. A necessary preliminary to making such a contribution is keeping representative marine mammal species in captive environments that allow the animals to exhibit their natural behaviors. With this as a starting point, zoos can further conservation efforts with active education programs and the encouragement and support of research.

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A STRATEGY FOR THE RATIONAL MANAGEMENT OF CORAL REEFS

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Abstract

There is a felt need in many developing countries of the Indo-Pacific to convince policy makers and administrators of the need to rationally manage their coral reef ecosystems for long term benefits. Although scientists have painstakingly worked out guidelines for rationally managing coral reefs, there is very little concrete evidence based on socio-economic considerations to convince governments of the short-sightedness of allowing the destruction of their coral reefs for short term gain. It is suggested, that scientists look for evidence to convince policy makers, administrators as well as users and abusers of coral reefs of the socio-economic value of this ecosystem, in addition to its scientific value. To be viable, management plans for coral reefs should not only be scientifically sound but politically acceptable as well.

Introduction

Coral reefs have received considerable attention of the scientific community over the past one and a half decades. This is evidenced by the tremendous response shown at international conferences, congresses, symposia and seminars on coral reefs held since the First International Coral Reef Symposium organized by the Marine Biological Association of India in 1969. Although at many of these international gatherings, the need for the rational management of coral reefs have been stressed, the coral reef management and conservation programmes of many developing countries of the Indo-Pacific region have yet to receive the enthusiastic support of their governments. The Coral Reef Newsletter No. 4 (1982) of the International Union for Conservation of Nature and Natural Resources lists only Sri Lanka and Thailand among the countries in the geographical region from India to Korea (Philippines and Indonesia have not been considered under this geographical region) as having established Marine Parks, Marine Sanctuaries or Marine Reserves. Untawale (1983) has stated that the concept of developing Marine Parks in India has received attention recently and that several localities have been found suitable to be considered for establishing Marine Parks. It is heartening to note that India has already taken steps to protect some of her coral reef resources by declaring the Piroton Islands in the Gulf of Kutch as a National Marine Park and proposing Palk Bay at the southern-most tip of India to be made into one (Untawale, pers. comm.). Several governments of the South Asian and the South-east Asian countries such as Philippines, Malaysia, Thailand, Indonesia and Sri Lanka have aken steps to declare protected marine areas to safeguard their coral reef resources. Even they have faced considerable problems of effectively enforcing the regulations designed to safeguard the status of their protected marine areas (De Silva, 1983 ; Gomez and Banzon, 1983 ; Davidson, 1982 ; White, 1982 and Gomez 1980). The low priority rating given by the governments of many developing countries for the rational management of their coral reef ecosystems could largely be attributed to a failure of these governments to fully appreciate the following :

(a) the proper value of coral reefs,

(b) that some extractive activities carried out within a coral reef ecosystem could destroy the very basis of the resource that is being exploited,

(c) the fact that many of the non-extractive and extractive functions of a coral reef ecosystem could be carried out within defined limits, and on a more sustained basis for the benefit of coastal populations that are traditionally or otherwise dependant on it,

(d) the fact that several human related activities carried out vast distances away from coral reefs could cause more damage to them than even some activities carried out within the confines of the reefs themselves. Such activities would include defores ation, land development practices without proper erosin control measures and the discharge of pollutants from agricultural as well as industrial sources.

(e) that constant monitoring of reefs is necessary to prevent infestations of predators of corals such as the 'Crown of Thorns' starfish (*Acanthaster planci*) which could destroy large extents of good coral within a short period on time.

A clear understanding and appreciation of the value of coral reefs, their vulnerability to human related activities and natural enemies such as *A. planci* by policy makers and implementers of policy as well as users and abusers of coral reefs is necessary. This would be a prerequisite for the success of any programme aimed at rationally managing coral reefs. Therefore, a strategy is required to attract the attention of the governments of developing countries—which are over burdened with everyday problems of providing basic necessities of life for their populations to the problems of coral reefs. This would necessitate the coral reef scientists to provide clear evidence of the importance of coral reefs and the need for their rational management.

THE VALUE OF CORAL REEFS

The impor ance of coral reefs for their scientific and educational value, extractive and non-extractive uses as well as because they represent our heritage have been pointed out by De Silva (1979, 1981, 1982 and 1983), Soule' and Wilcox (1980), Salm (1984) Radford *et al.*, (1981) and Salm and Kenchington (1984) among many others. However, in order to get the attention of the governments of developing countries that have not shown much interest in managing their coral reefs, there is a need to provide real evidence of the value of coral reefs which would appeal to the politicians, policy makers and administrators rather than to scientists or to conservationists. It would also be necessary to clearly illustrate that the long term benefits of rational management would surpass the short term gains of activities detrimental to coral reefs.

Productivity

Scientists (Odum & Odum, 1955 ; Lewis, 1977 and Birkeland, 1983) consider coral reefs to be among the most productive of natural ecosystems, both aquatic and terrestrial. It has been shown that tropical seagrass beds, coral reefs and algal communities have primary productive rates far in exess to those of coniferous woodlands, deciduous woodlands, field grasses or the open ocean near coral reefs (Table 1).

TABLE 1. *Primary productivity rate of coral reefs as compared with several other aquatic and terrestrial ecosystems*

(After Crisp, 1975 and Lewis, 1977)*

Ecosystem		Primary productivity ($g\ C\ m^{-2} yr^{-1}$)
Tropical seagrass beds	..	4650
Coral reefs	..	4200
Tropical algal communities	..	3836
Kelp beds	..	1750
Temperate algal communities	..	920
Coniferous woodlands	..	800
Deciduous woodlands	..	785
Field grasses	..	500
Open ocean near coral reefs	..	
Barbados	..	50
Rongelap	..	28
Hawaii	..	21-37

This means that in spite of the low nutrient levels that characterise tropical seas, coral reefs have a very high rate of primary production that make them comparable to oases in deserts. The total productivity of a coral reef i.e. at primary and consumer levels is maintained by a large and varied group of organisms ranging from algae at the primary production level to invertebrates and vertebrates at the consumer level (De Silva, 1983).

Fisheries

An obvious outcome of a coral reef's high productivity is its ample fish life. Smith (1978) estimated that the world's reef fishery potential to be approximately about 9 per cent of the total oceanic fish landings. Although, coral reefs are recognised as being important to the fisheries industries of countries that possess them, there is very little evidence to support this statement for many countries of the Indo-Pacific. In the Philippines, for the coral reefs around Apo island Alcala and Luchavez (1981) have given fish yield figures of 8-14.23 (mean 11.4) mt/km²/yr, while for the Sumilon island Alcala (1981) has given figures ranging from 9.7-23.7 (mean 16.5) mt/km²/yr. The fact that these figures exceeded the earlier predicted estimates of 4-5 mt/km²/yr of several scientists including Stevenson and Marshall (1974) by 2 to 3 times, indicate that individual reefs might have higher fish yields than previously credited. Marshall (1981) suggested that such differences in fish yields might be attributed to differences in edapho-morphic indecies of different reef systems. Chua and Lai (1975) have shown that reef fish form about 25 per cent of the total market landings in Kota Kinabalu, East Malaysia, and that during certain months of the year the reef fish composition could be as high as 56 per cent or more. De Silva (1979) has also made the observation that reef fish could be an important component of the fish landed in several states of the east coast of Peninsular Malaysia during some months of the year. Such evidence tend to indicate the importance of coral reefs to the fisheries industries of Philippines and Malaysia and help substantiate the importance of coral reefs. Munro (1983a) referring to the Caribbean coral reef fishery has stated that 'On the present evidence, admittedly scanty, it appears reasonable to believe that standing crops of unexploited fishes will commonly be found to exceed 2,000 kg/ha of shelf, provided that the amount of reef cover is not a limiting factor'. Although a fair amount of research has been conducted on coral reef fisheries (Munro, 1983b) this field of study is still in its infancy, especially in many of the Asian countries. A concerted effort in this direction by the scientists of Asian countries is necessary, to positively prove to their governments the value of coral reefs to the fisheries industry.

Breeding and nursery grounds

Coral reefs are regarded as important breeding and nursery grounds of many marine organisms including fishes, lobsters, cephalopods and a variety of molluscs (De Silva, 1983). The security offered by the many crevices and recesses as well as the diversity of organisms of a coral reef probably play crucial roles in a reef being important as a breeding and nursery ground. There is evidence to indicate that some reefs are the breeding and nursery grounds of fish and other marine organisms (Gaut and Munro, 1983 ; Munro, 1983c ; and De Silva and Ridzwan, 1983). Here again conclusive evidence would be necessary for many countries to prove the value of their coral reefs as breeding and nursery grounds.

Buffer against the sea

In many places coral reefs act as buffers by taking the full impact of the waves and dissipating energy and blocking currents that could otherwise lead to sea erosion. In this way, coral reefs protect coastlines and valuable coastal land from being eroded away. Salm (1982) has stated that ' In the Indian Ocean, for example, 77% of the isolated islands and island archipelagoes are built exclusively of reef deposits, and 18% have coral islands in addition to the principal island type.' He has further stated that ' Following destruction of reefs and removal of the coast's protecting barrier, the beaches erode away, trees and palms fall into the sea, and unconsolidated sand is washed away . . . .' The several coastal areas in southwest Sri Lanka which have undergone heavy sea erosion over the past few decades due to increased removal of coral for the purpose of making lime (De Silva, 1983) clearly illustrate the truth of Salm's latter statement.

Lagoons formed by coral reefs—which serve as buffers against heavy seas—have traditionally been used as safe natural harbours for fishing and other boats. The presence of such protective reefs in many places have created calm lagoons which have also been used for recereational purposes. Destruction of the protective reefs could have disastrous consequences on the use of some lagoons as harbours and recreational areas.

Storehouse of medicinally important compounds

It is increasingly being recognised that several coral reef dwelling organisms such as sea-fans, anemones and other invertebrates can produce highly bio-active chemicals which possess antibiotic, anticoagulant and anti-leukemic properties (Ruggieri, 1976 ; Angeles, 1981). The science of marine pharmacology is still in its infancy, and coral reef organisms might prove to be a valuable sources of medicinally important compounds which are yet to be discovered.

Tourism

Coral reefs have been recognised as one of the most aesthetically pleasing underwater communities known. The fascinatingly multicoloured organisms as well as calm lagoons and clean beaches associated with coral reef are factors responsible for attracting many people to these areas. Several coastal resorts in Philippines, Indonesia, Thailand, Sri Lanka and the Maldives are already exploiting their coral reefs to promote tourism.

THE EFFECTS OF EXTRACTIVE AND NON-EXTRACTIVE USES OF CORAL REEFS

The possible undesirable effects of extractive and non-extractive uses on the coral reefs of the Asian region such as certain fishing activities, collecting of reef organisms, mining of coral and recreational activities have been highlighted recently by Yap and Gomez (1983), Salm (1982), De Silva (1981) and Tsuda (1981) for the East Asian Seas Region and by De Silva (1983) and Salm (1981) for the South Asian Seas Region. However, there appears to be a real need to obtain quantitative estimates of the undesirable effects, if any, to coral reefs due to such extractive and non-extractive activities. It is only then that the sustainable yields of exploitable products and the limits of non-extractive activities in a coral reef ecosystem could be determined and a plan for its rational management formulated.

The effects of pollutants on Coral Reefs

Pollutants that pose a potential threat to coral reefs have been listed in the Coral Reef *Newsletter* No. 2 (1979) of the International Union for Conservation of Nature and Natural Resources. The effects of pollutants such as hydrocarbons, silt and sedimentation as well as industrial, agricultural and domestic waste on the coral reef ecosystem is dealt at length by Johannes (1972 and 1975), Loya (1975), Rinkervich and Loya (1979) and Marszaekl (1981).

Historically the exposure to brackish, silt-laden freshwater run-off is credited to be probably the greatest single cause of coral destruction (Johannes, 1972). Although floods leading to freshwater run-off occur naturally, its increased occurrence in many instances can be traced to man's poor management of land. It would thus be necessary to highlight the effects on coral reefs, of activities such as deforestation and land clearing programmes carried out without proper erosion control methods. Although there is no conclusive evidence to prove that floating oil could have adverse effects (De Silva *et al.*, 1980), evidence indicate that chronic oil pollution could have undesirable affects on corals (Loya and Rinkevich, 1979 and 1980). The careless introduction of oil into lagoon reefs by mechanised fishing and pleasure boats anchored in such areas could have adverse effect on the corals in the vicinity. A clear understanding of the local situation with respect to the possible effects of pollutants would also be a prerequisite to any attempt to manage a coral reef ecosystem.

Acanthaster problems

There is controversy as to the cause of sporadic population explosions of the 'Crown of Thorns' starfish (*Acanthaster planci*) a notorious predator of coral. Some biologists attribute population explosions of this animal to human interference with coral communities, while others maintain that such increase in number is due to natural fluctuations in populations (Endean, 1973 and 1977; Walsh *et al.*, 1971; Ormond and Cambell, 1974). Whatever the cause, these animals are capable of rapidly destroying large extents of coral within a short period of time. Predation by *A. planci* has been given by De Silva (1982) as a major cause of coral reef destruction in Peninsular Malaysia. Extensive damage to large extents of coral reefs in Sri Lanka by the same animal was reported by De Bruin (1972). As pointed out by Cameron and Endean (1981), 'the *A. planci* outbreak phenomenon now represents the most pressing management problem, not only in the GBR, but also on many other reefs of the Indo-Pacific region.' In Peninsular Malaysia, the author and his colleagues have been able to keep *A. planci* in check, on selected reef areas, through regular monitoring and removal.

Problems of Coral Reef Management

The actual scientific concepts of managing coral reefs are well established (Kenchington and Hudson, 1984; Bakus, 1983; Baker, 1983; White, 1982; De Silva and Ridzwan, 1982; Salm, 1982). However, some of the problems of managing coral reefs of developing Asian countries are :

(*a*) Lack of sufficient funds, scientists and expertise to manage coral reefs.

(*b*) Lack of proper understanding by policy makers, users and abusers of the value and vulnerability of coral reefs.

(*c*) Difficulties of attracting attention of policy makers and administrators to the plight of coral reefs.

Even in countries where coral reefs have been afforded protection through legislation, lack of enforcement has made these legislation redundant. Attempts by the Sri Lankan government to activate legislation to ban the mining of coral in the south western coast failed in the late 1970's due to political pressure. It was claimed that such a ban would leave some 20,000 people involved in the industry unemployed. Whether such a large number of people were actually involved was never openly contested. A similar fate befell a proposal to ban the export of tropical aquarium fish primarily comprised of coral fish. Venkataramanujam *et al.*, (1981) have pointed out that in spite of a ban by the Tamil Nadu State Government of India, an estimated 30,000 cubic meters of massive coral stone were landed annually in Tuticorin area alone.

Conclusions and Recommendations

There is a need to convince the governments of many developing countries of the value and vulnerability of their coral reef ecosystems. There is also a need to develop expertise not only to manage coral reefs but also to obtain estimates of their value in quantitative terms. It is not sufficient for coral reef scientists to understand the problems of coral reefs alone. They need to understand the problems of the policy makers and administrators as well. This will necessitate close collaboration between scientists and policy makers to formulate plans which are both scientifically and politically acceptable for managing coral reefs. Education of the public as well as the users and abusers of coral reefs through mass communication media such as television, radio and newspapers as well as by mobile units and colourful posters should be given priority. So also, should the establishment of Zoned Marine Parks with local participation on the multiuse principle. Wherever possible, the local communities should be made receptive to the idea of a Marine Park prior to its establishment. Regional cooperation for the optimum utilization of expertise on coral reef management and for the achievement of common goals should be strengthened, particularly in South Asia. This can be done through UNEP's newly formed South Asian Seas Regional Programme, South Asian Cooperative Environment Programme (SACEP) and UNESCO.

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POINT CALIMERE MARINE PARK : CONSERVATION AND MANAGEMENT PRIORITIES

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ABSTRACT

A historical resume of Point Calimere Wild Life Sanctuary together with its biological, ecological, geographical, cultural and religious aspects is given. The unique qualities of the Park, in combining the following habitat niches (namely, Dry-evergreen forests, Grass lands Scrub jungle, Salt-swamps-marsh land, and Marine ecosystems), has been pointed out. Observations on the Prey-Predator relationship, among the minor carnivores such as Jackal and Wild boar and prey species such as Sea turtle eggs and turtle hatchling meat and fawns of antelope has been assessed critically in the light of conservation policies. It is pointed out that denying the Sea turtle egg and hatchling, a natural diet for Jackals and Wild boar shifts the predation pressure on antelope fawns, which in itself is an endangered species. It is suggested that conservation policies may include permissible uses and prohibited uses, by which it is meant that Sea turtle conservation policy may be relaxed or enforced rigidly depending on the ecological history of a given area and biological situation.

A study on the Socio-economic condition of the local villages had been considered central to the success of conserving both the endangered species of antelope and Sea turtle. Short term remedial measures have been suggested for the upliftment of the Socio-economic conditions of the Forest dwellers.

INTRODUCTION

IN INDIA there are 11 National Parks and 202 Wild Life Sanctuaries. These are spread over an area of 75,700 sq. km and constitute about ten per cent of the total forest area (UNI, 1980). However, att ibuting importance to Marine Parks is long due in India. Currently attention has been drawn towards the creation of Marine National Parks at the Rann of Kutch, Sunderbans, Mannar Bay and Point Calimere areas.

The Thanjavur District has a coastline around 140 km. Point Calimere in Vedaranyam Taluk, Thanjavur District, forms one of the major fish producing centres of the State (Subramanyam, 1980 c). It was classified as a Wild Life Sanctuary in the year 1967 (Spillette, 2969), and is the only coastal Sanctuary in Tamil Nadu (Forest Statistics, 1976). Otherwise the Thanjavur deltaic region is practically devoid of forest, Enhancing its status to the level of National Park is a right step towards effective Wild Life Preservation.

The study of Point Calimere Wild Life Sanctuary was initiated by the Department of Zoology, University of Madras, through a Junior Research Fellowship Programme instituted by the Government of Tamil Nadu to carry out Pioneering work. This study was started during the year 1978 and is being continued.

Point Calimere, covering about 25 sq. km (10' 18 N 79' 51 E) is a low promontary on the Coromondal Coast. Composed of mostly sandy loamy soil (Blasco and Legris 1973), the area is isolated from the mainland by swamp backwaters and inlets (Stracey, 1960). The only human settlement in the area is found in two villages, the Kodikkarai village which means in the native language (Tamil) the 'Edge Coast' or near the sea-shore and the Kodikkadu village meaning the 'Edge Forest'. Kodikkadu extends further inland from the edge of the forest. The distance between the two villages is about three kilometres (Daniel, 1968). A Lighthouse is found about three Kilometres North West of the Kodikkarai Village and is in operation since 1902 (Ali, 1980).

Point Calimere Wild Life Sanctuary is unique in every sense since it is a combination of many types of habitats. They include coastal zone, Salt-swamp area, Dry-evergreen forest, Grasslands, Scrub jungle, and village ecosystem. In this area there are many ecological dominant species such as the occurrence of migratory Flamingo (Salt-swamp ecosystem), Black buck antelope (grassland ecosystem), Spotted deer (dry-evergreen forest ecosystem), Jackal and Wild boar (Scrub-jungle ecosystem), besides the Adivasis and other local settlers in the area (Village ecosystem). In the case of marine ecosystem, Dugong and Dolphins have been sighted and dead Whales have been washed ashore. (FAC, 1981 b). All the ecosystems are closely inter-linked with each other.

Point Calimere and its environs has religious significance too, due to the reported visit of Sri Rama of the Epic Ramayana (Hemingway, 1906 ; Sebastine and Ellis, 1967 ; Sarma, 1976). It is reported that it was the seat of many religious discourses and served as a point of Brahmin immigration to South India (Sarma, 1976). It has also been considered as a holy ceremonial bathing Ghat (UNI, 1981 a). Further, it played an important role as a minor port for coastal trade and transport in ancient India (Hemingway, 1906). As a commercial trade centre it maintained a vital link with the then island of Serendip (Baliga, 1957). Historically it was the place of the famous Salt Satyagraha movement (Chockalingam in Tanjore temples).

Concern was expressed for the preservation of the most dense and the tallest type of 'Dry, Evergreen-Forests' and 'Thickets' (Champion-1936 ; Champion and Seth, 1964 ; Blasco and Legris, 1973), and for the protection of the large populations of the Indian antelope, Black buck (Stracey, 1960 ; Sebastine and Ellie, 1967 ; Daniel, 1968 ; Krishnan, 1971 ; Johnson, 1972, 1975 ; Nair, 1976 ; Johnsingh, 1976 ; Natarajan, 1977 ; Natarajan *et al.*, 1977 ; FAC, 1981 a ; and Anantharaman, 1981). Recently it attracted much attention due to the reported activities such as smuggling (The Indian Express, 1981 b) and poaching (Anantharaman, 1981). It is also used as a place of repatriation of victims of race riots (Subramanian, Pers. Comm.), which was a subject of debate in the legislature (UNI, 1981 b). It is also considered as a good pasture ground for cattle grazing. (The Hindu, 1977 a). It is not only important as a major staging and feeding refuge for thousands of wintering migrant bird species (Ali, 1963 ; Daniel, 1975 ; The Hindu, 1987 c, 1980, 1981 b ; Miller, 1981 ; Bana, 1981 ; Venugopal, 1981 ; and The Hindu, 1982 b, 1982 c), but also serves as a holiday resort Subramanyam, 1980 a). Presently a Field-Research Station by the Bombay Natural History Society for bird banding (Ali, 1980 Hussain, 1980 ; Ali, 1981) has been initiated. More recently, the Government of Tamil Nadu has started constructing a fishing harbour near the Kodikkarai village on the coast (The Hindu, 1981 a). There has been a proposal to establish a series of salt based industries and chemical extraction plants in and around the Point Calimere areas (Vijayan, 1977 ; UNI, 1979 ; Dinamani, 1979 ; The Indian Express, 1981 b). On an experimental basis a small portion of Point Calimere Swamp area was allowed to be exploited for setting up an 'Integrated Marine Chemical Complex' (Marathi consultant, 1976).

Such a sanction has been objected by the ecologist (PTI, 1981). Management of the Coastal ecosystem has attained much significance presently due to the drilling and testing operations for oil exploration which are currently in progress off the Point Calimere Coast (The Hindu, 1982 d).

Field studies

Authors have carried out field studies on various aspects such as, Geographical, Geological and Climatological description of the area ; Inventory of the fauna and flora ; Feeding ecology of the migratory Flamingo species, Jungle cat, Wild boar, Indian Jackal, Cheetal, and the Impact of the Socio Economic conditions of the village ecosystem on the Point Calimere Sanctuary Forests, with special reference to the Marine ecosystem, have been carried out.

Fauna and Flora

A total of 236 plant species were collected and they were found to belong to 69 families. About 38 species of mammals, 165 kinds of birds, 14 types of lizards, 28 species of snakes, 3 species of turtle, 9 amphibian species, 53 fish species, 3 prawn species, 7 mollusc species, and 23 butterfly species were identified (Details published elsewhere).

Objectives

It is the aim of the present paper to bring to focus the status, science and needs of the Point Calimere Wildlife Sanctuary from the view point of human economy. In this attempt some remedial measures are suggested for the preservation of the habitat keeping other key factors like the Socio-economics of the adjoining village populations, traditional aspects, local customs, attitudes and folk cultures of Adi Vasis in the background.

In taking an inventory of the species of Point Calimere Wildlife Sanctuary particular attention was paid to the problem of Prey-Predator interrelationship between the minor carnivores and the species which are listed as endangered. This relationship is viewed in the light of conservation policies. The present paper attempts to resolve some of the problems identified within it.

Prey-predator relationship

Olive Ridley sea turtle (*Lepidochelys olivacea*) (Egg—Hatchlings), — Indian Jackal (*Canis aureus* Linnaeus) and wild boar (*Sus scrofa* Linnaeus)—Black buck antelope (*Antilope cervicapra* Linnaeus).

From the conservation point of view systematic and organised collection of turtle eggs on a large scale has been done for hatching purposes. It is reported (The Hindu, 1984) that the Forest Department's Sea Turtle Conservation programme in the Vedaranyam range on the Thanjavur sea coast was a success. The report says that as against the target of 30,000 eggs, 30,700 were collected and kept in the hatcheries at Point Calimere, Vanamandhevi and Vizhundumavadi. Of these, 25,761 Sea turtle hatchlings were born and released into the open sea. The success rate, due to this conservation effort, is about 83 per cent. In nature it is very unlikely to expect such high hatching rate since there is predation of eggs by natural predators such as Jackals (*Canis aureus*) Wild boar (*Sus scrofa*) and Jungle cats (*Felis chaus*).

It was seen during the field studies at Point Calimere that the turtle eggs and hatchling were the other main source of food for the minor predators. The other major food items of these lesser carnivores in the forests are the fawns of the blackbuck antelope and Spotted deer. The breeding season of antelope blackbuck just preceedes the North-East monsoon season (Oct.-Nov.). It is interesting to note that the nesting period of the green turtle and olive ridley along the coasts of Tamil Nadu is from December to March. During this period large number of turtles emerge ashore to lay thousands of eggs. By computation it is seen that at a time of peak egg laying by turtles, the fawns are aged about 20 to 30 days.

In nature the extravaganza of egg production is compensated by predation besides the extreme environmental condition. Recent studies have shown that predation is a biological factor that ensures stability of ecosystems (Cornell and Orias, 1964; Paine, 1966, 1971, 1974, 1980, Pianka, 1967, 1974, Odum, 1969, Mengc and Sutherland, 1975; Glasser, 1979). Considering the ecosystem of the Point Calimere Wildlife Sanctuary, there are Jackals and wild boar which feed on the turtle eggs and perhaps contribute to the ecological balance within the community of marine biome. The conservation efforts of sea turtles by the Governmental agencies, have many serious implications on the prey-predator relationship within the ecosystem. For instance the Jackal and the wild boar are denied of their rightful share of turtle egg and meat-of-turtle-hatchlings as predatory diet. Under such circumstances one of the ecological rules is that the availability of the prey controls the selection preference shown by the predator (Griffiths and Seiderer, 1980). When the preferred prey is not available then the predator turns to the next available prey. In the Point Calimere forests the Jackal and the wild boar, in the absence of turtle eggs, turn their attention to the antelope population, whose fawning season, as mentioned earlier, overlaps the breeding season of turtles. The young ones of antelope commonly called fawns are just the right size that are vulnerable for attack by the predators and hence the predation pressure shifts from turtle egg-turtle hatchlings to the fawns of black buck. In studies on prey-predation relationship within a marine community it has been shown that the predator may be responsible for producing a bimodal distribution of individuals within a population structure. It is reasonable to apply such ecological principle to the prey-predator relationship existing between antelope and minor carnivores. Some of the observed perturbations in the antelope population may be due to the increased predation by the lesser carnivores.

Frazier (1984) has mentioned that 'all round the world dedicated and more intentioned programmes have done more harm than good.' It may be added that any conservation measures must take into consideration the enterity of marine organisms. It is not known what are the ecological imbalances, if any, produced due to over population of marine turtles in the marine ecosystem due to conservation efforts. But it is certain that the conservation programme diverts the predator pressure on to some other organism such as the antelope which in itself is a protected species.

This suggestion does not undermine the conservation effects on the turtle. It is the view of the authors that traditional practices as observed both in nature and as well as in human ecosystem must be taken into account. These practices involve leaving at least half of the turtle eggs collected for the benefit of Jackal and wild boar, as well as for human consumption which represents a source of valuable and inexpensive proteins at the subsistence level of utilization. In Nairobi and Kenyan National Parks the increasing elephant population are periodically culled to maintain the condition of the parkland ranges to prevent it from deterioration (Joubert and Mostert, 1974). As a result it is kept within its carrying capacity. Likewise the increasing antelope populations in the Texas ranches (USA) are allowed to be hunted down for a trophy (Mungall, 1978) in order to maintain the carrying capacity of the land.

It is the opinion of the authors that the total conservation policy must include permissible uses and prohibited uses, which may be flexible enough to allow relaxation of the policy depending upon the ecological history of a given situation. In permissible uses, activities like predation by wild animals and egg collection for human consumption with permits may be included. Prohibited uses may refer to total ban on any egg collection, for any purposes other than conservation. Wildlife conservation authority may permit egg collection by other Agencies/Organisations only for conservation purposes.

In the light of the above suggestion it is recommended that turtle conservationary measures must be totally implemented all along the coast of Madras where there are direct human interference. But it must be relaxed or implemented on a slow footing basis in the Wildlife Sanctuary of Point Calimere, where the pressure due to man is relatively very low.

Authors are convinced that for the security and permanency of effective biological conservation, efforts must be directed at developing programmes for sustainable rational yields for the benefit for other local wild life and as well as human beings.

In this work a brief account of the Socio-economic condition of the resident villagers including a neglected group of Adivasi is included. On the basis of a careful study which indicated that any uncontrolled encroachment of the forest by the local villagers is a serious threat to the life of two endangered species namely the Black buck antelope and olive ridley turtle which migrates to the Point Calimere coast regularly for spawning purposes.

Socio-economic study

It was pointed out that the cooperation of the rural people is required if Wildlife resources are to be conserved and utilised rationally (Tiger Paper, 1980). Such cooperation however will be forthcoming only when the rural people realise that wildlife resources are managed primarily for a common benefit (Daniel, 1968; Gadgil, 1978; Bose, 1982). It is also a known fact that a sizeable population of the rural areas are still greatly dependent on forests/seas for firewood and for their day to day needs (Express, 1980 d; Sachitanand, 1982).

To assess the impact of village ecosystem on the wildlife, a study of the Socio-economic conditions of Point Calimere inhabitants was carried out. For this purpose a questionnaire containing relevant questions, spread over three schedules namely 'the village schedule', 'the household schedule' and 'the family budget schedule' was prepared in consultation with the Agricultural Economics Research Centre of the University of Madras. As a final step in sample design, a survey of a total of 100 households revealed the extent of dependance of the village communities on the forest for their bare minimum sustenance. Simple random techniques were used to select the households. The method adopted for the data collection was by direct personal contact. The information derived from the questionnaire was analysed and the impact of the village ecosystem on the forest ecosystem was assessed and the possible remedial measures have been suggested.

Village Ecosystem

In the fishing season (Dec.-Mar.), there is a heavy influx of the labour population from the nearby villages, districts and from other states like Kerala. On an average, the floating population of the two Point Calimere villages doubles. There are both diurnal migrant labour and seasonally resident migrant work force. During the migratory period of the year, pressure on both the forest resources and Marine resources is at the highest.

Village Composition

The two villages, Kodikkarai and Kodikkadu, adjoining the Point Calimere Sanctuary have 163 households and 217 households respectively. There were 57 Adivasi households at the time of survey. The main occupation of the Kodikkarai population is fishing whereas the tobacco cultivation forms the predominant occupation of the Kodikkadu people.

Forest Dwellers

The tribals who live in the Point Calimere forests are known as 'Adivasis'/Forest Dwellers. In earlier days they were known by the name of 'Cheendi Valayargals', a name which is derived from a tuber known as 'Cheendi Kazhangu'. These tubers are consumed by them. During the rainy seasons, the forest in and around the Adivasi habitations is rich in fruits and other vegetable products (List of fruits and vegetables furnished elsewhere). During these months that is, between October to December, they go to the forest and get enough food materials for their daily subsistence. At other times/seasons their existence is extremely marginal. The main source of food for the Adivasi is by gathering. Their daily avocation centres round the gathering of food in the forests and swamps primarily. The utilization of forest produce varies from, fruits, greens, nuts, seeds, vagetables and others. Not all the products mentioned above are available the year round. A large majority of the fruits they pick in the forest are raw eaten. Some others are boiled, salted and eaten. While the majority of the materials are the sources of subsistenc, some of them are of medicinal value. The day to day work in the forest is also commercially oriented. They collect dry fire wood stealthily and sell them in the village. They also collect dry leaves litter from the forest which constitutes one of the best sources of manure for tobacco plantations. From the money obtained from these sources they buy rice of poor quality and prepare food. The sources of income from the fishing operations is only seasonal. They collect 'Pazhupavakkai' in the forest and these vegetables are in great demand in the village for table purposes. The collection of these vegetable has been the traditional right of the Adivasi community. Any form of cultivation and crop raising is unknown to them. Normally these people are not associated with any cultivation operations of the local villagers. Whether they are aware of agricultural techniques or not, the location of the Adivasi settlements on an old sand dune precludes the cultivation of any sort. The soil is unfit for any such operations. They also profess a reluctance to do such work.

These people reflect an unique Marsh-forest ecology adaptation. According to them they have been put up in the forest more than ten centuries ago by the kings of South India to serve the God 'Kulagar', by conducting festivals. In due course they became hunters and lived in the interior forest. They are reported to hide themselves when they see or meet the village people or forest officials. Even today at the sight of a forest Guard or a forest Watcher in the forest, they take to their heels immediately, for they are physically manhandled by the forest officials, when they get caught red-handed in the act of cutting or stealing firewood from forest. Occasionally they are taken to courts for breaking the forest law and suitable punishments are awarded to them. In spite of all these travails they tend to return to forest regularly and promptly and continue the same avocations of cutting and selling wood. Only recently they have come out of the forest, got themselves associated with the villagers who are mainly caste Hindus and have adopted the present-day habits and customs in tune with the local Hindu tradition and culture.

REMEDIAL MEASURES

Short term remedies are necessary in order to buy time and enable the recovery of productive potential of the forest land vegetation. These include the changes in the dietary habits of the tribals, to reduce their direct dependance on forest produce in order to relieve the pressure on natural vegetation. Since these people depend largely on forest for their livelihood, adequate avenues must be created by alloting waste lands and diverting their attention on cultivation and other allied activities.

If such a neglected group of tribe is rehabilitated by providing housing, education and medical facilities much can be achieved. Specific programmes can be formulated to benefit these people to create purchasing power and to provide employment opportunities on a regular basis.

The study fully acknowledges that the active involvement of the local people is essential for the protection of the forest and wild life. The impact of human migration is spelling disaster, due to increased demand for fuel and food resources which may lead the scanty vegetation to gradual denudation of the forest cover.

The foergoing socio-economic aspects of Adivasis and local villagers must be given a serious thought since the depletion of the forest cover by their myopic action will expose the endangered antelopes for easy predations, which is turn will shift the prey pressure on to on the sea turtles. As a result serious imbalance may be introduced in the populations of both the antelope and sea turtle. If these two wildlife species are to be preserved, the upliftment of the forest dwellers is very essential for the success of conservation programme.

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IMPORTANCE OF VEDARANYAM SWAMP AS A MAJOR ECOLOGICAL ENTITY IN THE SOUTHEAST COAST OF INDIA

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ABSTRACT

The Vedaranyam swamp in Thanjavur District, Tamil Nadu is an important wintering ground for the long distant migrant as well as resident birds. Over 200 species of birds have been recorded from this area. The Bombay Natural History Society has been conducting field studies in the swamp as well as the forests of the Point Calimere Sanctuary. The 24000 hectare swamp hosts variety of marine and estuarine organisms which attracts not only birds, but also commercial activities due to rich marine resource. The swamp is also used to take salt in large quantities. Commercial over exploitation of marine resources and drastic alterations to ground conditions will lead to degeneration of the swamp in the long run and ultimate depletion of resources. In the meantime very little baseline data on the ecosystem is available.

There is an urgent need to preserve the entire area to study and understand the working of the ecosystem and to control overexploitation and alteration to ground conditions. A multidisciplinary research programme to study the ecosystem of the swamp is recommended.

INTRODUCTION

THE Vedaranyam-Muthupet swamp belt in the district of Thanjavur in Tamil Nadu, is one of the major and important sanctuary for migratory as well as resident water birds in the Indian peninsula. Every winter (October-March) over 90 species of birds (both passerine and wading) congregate along the mudflats and seashore as well as in the forest tracts of the estuary. The estuary also hosts, at different times of the year, about 70 species of resident birds.

The importance of Vedaranyam swamp as a major congregating area for wintering birds was not well known until the Bombay Natural History Society, under grants from the World Health Organisation and Smithsonian Institution, U.S.A., started winter bird ringing camps at Vedaranyam in 1969. The camps were conducted upto 1972 and during the course of this study it was apparent that there is a regular and phenomenal waterfowl migration to and from this area (Unpublished reports of BNHS). Prior to this, some stray references were available on the occurrence of flamingos and casual notes on avifauna and animal life of the Point Calimere Sanctuary, situated on the western part of the estuary (Ali, 1963 ; Daniel, 1967 ; Melluish, 1969 ; Krishnan, 1971). Apart from the working plan of the sanctuary prepared by the forest department of Tamil Nadu there was initially no other ecological data available about the estuary. Some interesting, aspects of the birds occurring here have been reported in the later years (Abdulali and Hussain 1971 ; Raju and Shekar, 1971 ; Hussian, 1976; Ali and Hussain, 1980-82 ; Sugathan, 1982), while information on vegetation (Blasco and Legris, 1973 ; Sebastian and Ellis, 1977 and some baseline data on climate, vegetation, insects, estuarine organisms and birds are available (Ali and Hussain, 1982).

This paper is based on the studies carried out at Point Calimere Sanctuary and the adjacent mudflats by the Bombay Natural History Society as a part of its project ' Studies on the movements and population structure of Indian Avifauna ' under the guidance of Dr. Salim Ali funded by the US Fish and Wildlife Service PL-480 grant No. 8851-658-01, sponsored by the Department of Environment, Government of India. We are thankful to the Department of Industries and Department of Forest, Government of Tamil Nadu for various facilities received.

Overview

Though primarily aimed at the study of the movement (migration) and population structure of the avifauna, it was imperative that the study should also attempt to collect baseline data on the various components of the ecosystem as well as to monitor population fluctuation of the organisms, both aquatic and terrestrial. Therefore, a multidisciplinary approach was adopted so that all interlinked ecological components having an impact on avian communities of the area could be monitored.

Environment

The Vedaranyam swamp stretches westwards from the promontory of Point Calimere (10° 18'N · 79° 51'E). The western boundary comprises of mangrove vegetation, while the rest of the area is mostly open mudflat and lagoons. The 24000 hectare swamp is interspersed with numerous small islets. The entire swamp is screened off from the Palk Strait, which forms the southern boundary, by a long spit or sandbar breached at various places by inlets and outlets for water flow. Five freshwater channels empty into the swamp maintaining the freshwater content of the large lagoon in the centre of the swamp. The swamp is flanked in the north by an artificial bund, beyond which villages and cultivated area occur.

Point Calimere Sanctuary is a low promontory, comprised mostly of sandy loamy soil. The area was originally isolated from the mainland by backwaters and inlets. The xerophytic vegetation of the patch of low scrub forest is furrowed by shallow drainage channels giving it an appearance of strips of vegetation alternating with corridors of water.

Field Work

Trapping/netting and ringing of the birds, both resident and migrants, constitute the basic field work. Professional trappers were employed for catching waterbirds, while forest birds were netted with nylon mistnets operated by the project staff. Trapping and netting were done in a systematic manner by using constant methods applicable both in terms of time and space. Each bird was measured (wing, bill, tarsus and tail), weighed and examined for moult pattern, physical condition, age and sex and released with a numbered aluminium ring. The data were recorded on specially designed sheets and stored for analysis. Recapture and recovery of birds were recorded separately. A part from this, bird censuses were conducted in different parts of the forests as well as the estuary. A 1 km long census path is traversed periodically and all birds seen and heard were recorded. For aging and nesting, behaviour of the resident birds was also noted. Climatic data, phenology of plants, insect population counts and estuarine conditions were also conducted simultaneously. Standard methods for data collection were adapted and species of plants, insects and macrobenthos were also collected, identified and preserved.

PROFILES

Climate

Situated at the spur of the promontory, the area bears the brunt of periodic cyclonic storms that lash the Coromandal Coast. One of the severest cyclones to affect the area in recent years was in 1943 when giant tidal waves swept through the major portion of the sanctuary area. The rainy season commences around October with the onset of the North-East monsoon. The average annual rainfall between 1969-1979 was *ca* 127.3 cm, the months of October, November and December recording the highest precipitation. Soon after the commencement of the monsoon the entire estuary as well as the forest area is flooded with freshwater and the salinity declines. This almost freshwater-like regime continues throughout the winter, even in the estuary as the drainage canals keep bringing in freshwater.

The water regime once again changes as the monsoon recedes and summer advances. Rapid summer evaporation increases the salinity of the estuarine water. The estuarine water partially dries up and the freshwater area in to the forest fully dries up leaving behind hard packed mud. Most of the commercial salt manufacture is taken up during this period.

Plant Phenology

The vegetation of the estuary comes under the following three categories :

1. Tropical Dry Evergreen Forest (Point Calimere),
2. Mangrove Forest (estuary, lagoon, etc.) and
3. Sea shore Vegetation.

Temperature, salinity and prolonged dry periods show extensive variations in the phenophases of the vegetation of the area. Certain evergreen species, due to the above conditions seem to be very slow in regeneration. From the data collected for the past three years (1980-83), it is evident that the flowering and fruiting season varies among species, sometimes even in the same species. Seashore and estuarine vegetation is rather low in profile. Except for the mangrove *Avicennia officinalis* (predominant), *Rhizophora mucronata* (common), *Tamarix gallica* (sporadic), *Exoecaria agallocha* (common) and low bushes of *Salicornia brachiata* *Suaeda maritima* and *S. nudiflora* (scattered sporadically), the estuary is devoid of other emergent vegetation. Of the submerged vegetation very little is known.

Seashore vegetation comprises mostly of *Spinifax littoreus*, *Ipomoea pescarpae*, *Arthrocnemum indicum* and *Pandanus tactorius*. A great deal of information on vegetation is yet to be obtained. Analysis of phenophases of the vegetation of the area for the past four years and a comprehensive checklist of the plants is under preparation.

Entomology

Insects are an important source of food for a large number of both resident and migratory birds. The fluctuation in insect population is also linked with climate as well as phenological regimes. Both forest as well as swamp provides ideal regenerating grounds for a large number of insects. More than 575 species of insects belonging to 16 orders were recorded from Point Calimere area (Table 1). Population counts of these were also made on a regular basis with standard methods. An initial perusal of the population dynamics shows the increase in the bird population coincides with increase in insect population.

Estuarine benthos

The great Vedaranyam swamp (' Swamp is a misnomer. As per the classification of Cowardin *et al.* (1979) this area falls under ' estuarine' system, subsystem, ' subtidal ' and class ' unconsolidated bottom ') as it is known, is a conglomerate of mangrove swamps, coastal salt flats without submerged vegetation, coastal open brackishwater with patches of aquatic bed and an irregularly flooded forested wetland, having water chemistry ranging from hyper-haline to euhaline and mixohaline fresh. The entire area is transformed into a vast sheet of almost freshwater lagoon during the peak of the rainy season. In the lean period, especially in summer, salinity content shoots up as most of the mudflat dry up and get periodically flooded due to high tides or excessive wind action.

(a) Seashore

Actual seashore is confined to the eastern-most portion of the swamp. Here fine sand perpetually washed by wave action harbours a variety of shore crabs, molluscs, coelenterates, amphipods, holothurians, isopods, littoral poly-chaetes and several other intertidal epifauna. The moist sand, when the tide runs out, is an ideal settling place for a large number of insects. Dead fishes and seaweeds are periodically washed ashore. A large number of shore birds such as gulls, terns, sandpipers, stints, plovers

TABLE 1. *Orders and number of species of insects collected at Point Calimere*

Order		Beating Net	Bark Analysis	Litter Analysis	Sweeping	Light Trap	Total	Identified
Odonata	..	—	—	—	12	—	12	—
Orthoptera	..	4	3	2	23	6	38	16
Dermaptera	..	—	—	4	3	5	21	0
Blattaria	..	2	5	6	5	2	18	6
Mantedea	..	1	2	2	—	1	6	4
Phasmida	..	—	—	—	1	—	1	0
Isoptera	..	—	—	1	—	3	4	1
Hemiptera	..	15	7	2	30	17	71	29
Coleoptera	..	32	13	16	13	68	152	41
Hymenoptera	..	8	5	6	48	3	70	24
Neuroptera	..	—	—	1	4	—	5	3
Lepidoptera	..	1	—	—	25	102	128	21
Diptera	..	1	—	—	20	20	41	7
Thysanura	..	—	—	1	—	—	1	0
Pthiroptera	..	1	—	—	—	—	1	0
		65	35	41	192	227	560	152

The estuary is very rich in micro and macro organisms and these are spread out in numerous microhabitats. For the sake of convenience the entire area can be divided into four broad categories : (*a*) Seashore, (*b*) Mudflats, (*c*) Lagoon environs and (*d*) Man-made environs. Particular mention must also be made of brackishwater inlets and freshwater pools.

and even scavengers and birds of prey such as Brahminy kite and Whitebellied sea eagles exploit this zone.

The fine sandy seashore gives way to a more silty-loamy shoreline westwards where, due to the sheltered nature of Palk Strait decreases considerably. Mangrove swamps pre-dominate and mudskippers (*Periophthalmus*) sp.

and other burrowing organisms are abundant. Crab plovers, Curlews, Godwits and other longbilled wading birds congregate here as they are better adapted to probe deep silt and ooze.

(*b*) *Mudflats*

Mudflats which occur on the leeward side of the sea shore are subject to variations in water levels caused by periodic flooding during high tide, excessive wind action as well as by overflow from freshwater inlets. The soil is mostly clay-silt and the fauna is predominantly of burrowing types. Due to variations in water level and temperature the polychaete worms which occur at depths of 5-20 cm have irregular activity rhythms. Feeding activity of certain species of the smaller wading birds (stints, sandpipers, plovers) is closely linked with this. Feeding intensity increases as the worms become active above or just above the substrate and decreases as the worms burrow deeper. Apart from polychaetes this zone is rich in molluscs, gobids, certain species of eels and crabs. At the onset of the monsoon, breeding of shrimps takes place in the area and these along with other breeding fish, provide abundant food for piscivorous birds. A large number of both small and big waders exploit this zone under favourable condition namely flamingos, spoonbills, herons, egrets, avocets, crab plovers and other medium sized waders.

(*c*) *Lagoon Environs*

Landwards the character of the micro-habitat changes slightly from the mudflats where freshwater channels bring in fresh silt deposits resulting in a rich clay-silt-ooze formation. The habitat here is less vulnerable to water and temperature fluctuation and the conditions are more stable. Both marine and freshwater regimes influence this zone giving it a mixed character. Extensive deposits of ooze, in addition to harbouring burrowing organisms, gives a natural protection from oppressive temperature. This area, incidentally, also harbours a certain amount of submerged vegetation thus providing an additional feeding zone for birds.

Shrimps, amphipods, molluscs (*Donax, Solen,*) *Katelysia* and *Mya*) : Crabs (*Scylla, Neptunea*), and fish (*Stolephorus, Tachysurus, Mugil, Liza, Therapon* and *Hemiramphus*) occur in this area. The varied range of water depths (shallow to deep water) provides ideal niches for a variety of bird species to feed. In fact this zone receives the maximum concentrations of wintering as well as resident waterfowl. Flamingos, ducks, spoonbills, storks, egrets, medium-sized waders such as curlews, shanks, crab plovers, avocets, godwits and smaller waders, such as sandplovers, sandpipers, stints are the major beneficiaries.

(*d*) *Man-made Environments*

Alterations in ground conditions made by man for manufacture of salt near Vedaranyam, in the easternmost portion of the estuary has given rise to different types of zonation both for epifauna as well as predator species. These artificially created environments are based purely on commercial considerations and as such whatever benefit that is derived by birds from such a system is purely coincidental.

Three types of systems are operated here by salt companies. These are :

(*a*) Direct pumping of sea water into a series of reservoirs leading in from the seashore,

(*b*) Salt water drawn from the creeks into reservoirs far inland and

(*c*) Conducting sea water through long channels deep into the hinter land before running it into reservoirs.

Salt is manufactured in three stages. First, brine is evaporated in the reservoirs and then pumped into condensers before finally being run off into pans where salt crystalises due to excessive evaporation. In the first system, littoral forms from the sea are pumped directly into the reservoirs. Water depth remains more or less constant, depending on pumping frequency and the salinity increases in successive reservoirs. *Enteromorpha* algal mats shelter a variety of organisms, mainly amphipods, shrimps and prawns. Condensers, though very high in salinity in summer months, lose their salinity content during monsoon and as a consequence harbour large populations of insects, insect larvae, shrimps, amphipods, chironomids and fish (*Tilapia* sp.).

Again, this varied type of artificial environment caters to a variety of birds such as ducks, flamingos, storks, herons, egrets and the smaller waders. However, except during monsoons, the whole system is artificially controlled where ecological considerations are given least or no importance at all.

The second system which involves taking brine from the estuary directly into the condensers, is rather restrictive in as much as marine elements are totally lacking here during summer due to the high degrees of salinity. However, there is a short period in the monsoon when some of the marine organisms manage to reach this zone. This system could be extremely harmful to the ecology of the area in the long run because due to high salinity and concentration of the nutrient elements, there is bound to be profuse bloom in phytoplankton. This phenomenon commonly known as 'red tide', is caused by blooms of *Trichodesmium erythraeum* and species of *Gonyaulax* and *Peredinium*. The run off may be harmful to fish and other organisms.

The third system is the poorest in organisms. Except for insects and insect larvae and during monsoon chironomous larvae, the area lacks marine components.

The salt pans which are the terminal components of all these systems, by virtue of their shallow evened-out substrate, are exploited by smaller waders as well as flamingos. In summer large numbers of insects and their larvae and in monsoon chironomous larvae, provide abundant food for these birds.

AVIFAUNA

Species Composition

The Point Calimere sanctuary and the adjacent estuary hosts six distinct groups of avifauna (*a*) resident, (*b*) transient, (*c*) local migrants, (*d*) wintering migrants, (*e*) breeding migrants and (*f*) over-summering populations.

Over 230 species of birds have been recorded so far from the area. Of these almost 14% are permanent residents, 32% are local migrants, including three species, Little Grebe (*Podiceps ruficollis*), Stone Plover (*Esacus magnirostris*), Little ringed plover (*Charadrius dubius*), Kentish Plover (*C. alexanderinus*) and Little tern (*Sterna albifrons*) which are also breeding visitors. Long distance migrants from as far as Arctic Russia, comprise 33%. Other species comprise mostly transients, occasional visitors and stragglers.

Though fruiting occurs throughout the year, very few frugivorous are seen to exploit it fully. Fish-eating waders occur throughout the year. Their peak is reached during February/March when food is abundant. However, none of these stay back to breed.

Of the species recorded so far 38% feed on littoral/aquatic elements. Birds of prey constitute 8%, granivorous/frugivorous constitute less than 8%. Insectivorous, of which the majority are migrants, comprise 27% and the rest are omnivorous (Table 2). A perusal of the monthly ringing figures for 1981-82 will indicate the trend of movements of the birds in the swamp area (Tables 3, 4).

TABLE 2. *Stomach analysis of waders showing food preference*

Groups of food organisms	Stints & sandpipers	Turnstone and Sanderling	Plovers	Shanks	Terns	Ruff & Reeve
Small insects ..	+	+	—	—	—	+
Large insects ..	+	+	+	+	—	+
Insect larvae .	+	+	—	—	—	—
Polychaete worms ..	+	—	—	—	—	—
Amphipods ..	+	+	+	+	—	—
Shrimps ..	+	+	+	+	—	—
Prawns ..	—	—	+	+	—	+
Crabs ..	—	—	+	+	—	—
Molluscs ..	+	+	+	—	—	—
Fishes ..	—	—	—	+	+	—
Organic matter ..	+	+	+	—	—	—
Inorganic matter ..	+	+	+	—	—	+

TABLE 3. *Movements of migrant insectivorous passerines in Point Callmere Netting Figures*

Species	Aug.	Sep.	1981 Oct.	Nov.	Dec.	Jan.	Feb.	1982 Mar.	Apr.	Total
Muscicapa latirostris ..	—	1	6	—	—	—	—	—	—	7
Muscicapa muttui ..	—	3	13	2	—	—	—	—	—	18
Muscicapa parva ..	—	—	1	—	—	—	—	—	—	1
Muscicapa rubeculoides	—	—	35	31	1	1	—	1	—	69
Terpiphone paradisi ..	1	1	79	69	4	1	—	2	—	157
Phragamaticola aedon ..	—	—	—	2	5	4	5	6	3	25
Hippolais caligata ..	—	—	—	—	1	—	—	—	—	1
Acrocephalus dumetorum	—	—	3	82	31	23	29	25	4	197
Sylvia curruca ..	—	—	44	62	31	19	20	4	—	180
Phylloscopus magnirostris ..	—	1	59	25	—	—	—	—	—	85
Phylloscopus trochiloides ..	—	8	6	6	—	—	—	—	—	20
Erithacus brunneus ..	—	—	2	3	—	—	—	—	—	5

TABLE 4. *Movement of selected waders in Point Calimere Trapping Figures*

Species		1981 Aug.	Sep.	Oct.	Nov.	Dec.	1982 Jan.	Feb.	Mar.	Apr.	Total
Pluvialis squatarola	..	2	1	2	1	—	8	6	3	3	26
Pluvialis dominica	..	—	—	1	2	—	—	—	—	—	3
*Charadrius alexandrinus**	..	7	3	4	3	12	10	23	17	1	80
Charadrius mongolus	..	41	98	76	39	33	81	207	81	19	675
Charadrius leschenaultii	..	1	8	—	—	—	2	7	5	—	23
Charadrius dubius	..	—	—	1	4	—	—	—	20	—	25
Tringa totanus	..	6	28	34	12	2	36	74	83	4	279
Tringa stagnatilia	..	—	3	14	25	24	58	2	22	—	148
Tringa nebularis	..	4	2	14	—	3	8	6	7	—	44
Tringa terek	..	3	7	4	1	—	6	10	29	4	64
Calidris minutus	..	1066	250	450	1348	1842	755	338	279	24	6352
Calidris testaceus	..	77	279	299	231	96	33	43	96	10	1164
Limicola falcinellus	..	4	74	173	7	3	4	30	3	—	298
Philomachus pugnax	..	2	1	6	63	142	5	—	—	—	219

* also nesting.

ECOLOGICAL CONSIDERATIONS

The entire estuarine ecosystem of Vedaranyam swamp is exploited, apart from the birds, by the villages of Kodikkarai, Kodikkadu, Agasthyampalli and Vedaranyam in the east; Seerthalaikadu, Karapampulam, Voimedu, Tholasapatham in the north and villages along Muthupet, Adhirampattinam in the west. The human exploitation of the area consists of (*a*) sea fishing (including trawling), (*b*) estuarine fishing, (*c*) salt manufacture and (*d*) forest produce and cattle grazing.

It is generally accepted that wetlands and deep water habitats contribute a great deal to the propagation of a vast number of organisms and life forms dependent on them. Estuaries play a significant role in providing breeding, rearing and feeding grounds for many marine fauna including several commercially important species as well as other wildlife. A recent trend has been the commercial, industrial and oil resources exploitations and land reclamation in the estuaries which has caused great stress on the natural regeneration cycles of these estuaries. An aspect which has been neglected so far is the collection of baseline data for major estuarine systems.

Vedaranyam Estuary is one such major ecosystem in India which has received little attention from the scientific community. As mentioned earlier a great deal of exploitation is being carried out by various agencies. The two most detrimental developments in the area in the course of the last 20 years have been the phenomenal increase in commercial fishing, especially extensive trawling for prawns in the Palk Bay off Point Calimere and the resultant destruction of epifauna and expansion of salt manufacturing units which not only increases the salinity content of the area but also alters the natural drainage of the estuary. The magnitude of the former can be seen by the increase in fishing boats in the area. From the traditional catamarans with sail—not more than 30 or 40 belonging to local fishermen—the fishing fleet has increased to over 300 mechanised boats coming to the area from as far as Cuddalore and Mandapam in the winter months (Table 5). These boats operate

TABLE 5. *Commercial fish catches at Point Calimere*

Scientific Name	Winter season Oct.-Feb. (Trawling)	Off season March-May (shore fishing)	Summer Season May-Sept. (Local craft fishing)
(1)	(2)	(3)	(4)
Fishes			
Polynemus tetradactylus ..	+		+
Lates calcarifer ..	+		+
Arius jella ..	+		+
Otolithus ruber ..	+		
Leiognathus sp. ..	+		
Sillago sihama ..	+		+
Therapon jarbua ..	+		
Hemiramphus georgii	+		
Hilsa ilisha ..		+	
Sphyraena obtusata		+	
Trichiurus savala		+	
Rhynobatus granulatus		+	+
Carcharius sp. ..		+	+
Cybium sp. ..		+	
Upeneus sp. ..		+	
Cynoglossus macrostomus		+	
Serranus sp. ..		+	
Gerres abbreviatus		+	
Notopterus sp. ..		+	
Pellona sp. ..		+	
Sphyrna blochii ..		+	
Galeocerdo articus ..		+	
Stromateus sp. ..		+	
Liza macrolepis ..		+	
Rastrelliger kanagurta ..			+
Chanos chanos ..			+
Caranx sp. ..			+
Prawns			
Metapenaeus affinis ..	+		
Metapenaeus dobsoni	+		
Metapenaeus monoceros ..	+		
Metapenaeus lysianassa ..	+		
Metapenaeus brevicornis ..	+		
Penaeus semisulcatus	+		
Penaeus japonicus ..	+		
Penaeus indicus ..	+		
Penaeus merguiensis	+		
Parapenaeopsis stylifera ..	+		
Solenocera crassicornis ..	+		
Crabs			
Scylla serrata ..	+		
Portunus pelagicus	+		
Portunus hastatoides	+		

trawling nets, day and night, for 3-4 months at a stretch and in the process clean out the ocean floor of not only commercially valuable species, but also other organisms present in the area. A colossal waste of biomass and an alarming resource over exploitation.

The other great impact on the area has been the expansion of salt pans and the possibilities of establishing salt-based industries. Two privately owned Bromine extraction plants are already operating in the swamp. Bitterns released from the factory as well as effluents and gaseous discharges, in the long run, may cause some damage to the ecosystem. Increased land use and alteration of water flow has affected the ecosystem of the area.

CONSERVATION OUTLOOK

Point Calimere Sanctuary and the adjacent salt swamps are one of the major and important estuarine components in the east coast of India. The richness and diversity of the biomass available here attracts a vast number of migratory waterfowl in winter. A recent increase in fishing activity in the area also underscores its potential as a major biological entity. However, sadly, this area has been overlooked so far by biologists and others. The neglect is further emphasised by the fact that only a few published papers are available on the estuarine fauna or flora of the area.

It may be conceded that economic considerations and human population pressures will eventually lead to (*a*) over exploitation and consequently depletion of resources and (*b*) habitat alteration which will have detrimental effect on the regenerative cycle of the resources as well as destruction of the habitat. In the long run, this great swamp may loose its potential both as a dynamic system and as a major source of wintering ground for birds and livelihood for man. In the meantime, unless we act now, one of the largest living estuarine system in India will degenerate without being studied, understood and preserved.

On the advice of the BNHS, the Department of Industries of Tamil Nadu has shelved a proposal to set up a large scale salt extraction complex in the entire swamp. At our initiative the State Government has set up a Committee to monitor the developments that are taking place in the area. As an initial step the Committee has recommended that the entire swamp should be declared as a sanctuary, which would lead to better control of the area. As a consequence the Tamil Nadu Government is taking steps to regularise land acquisition and enact legislation to declare the area as a sanctuary.

The Bombay Natural History Society has made a beginning by setting up a small field station to study and monitor the working of the swamp with special reference to birds. A more comprehensive, collaborative and concentrated study of other disciplines especially marine science is now essential and overdue.

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GUJARAT'S GULF OF KUTCH—A MARINE PARADISE

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Abstract

With its rich diversity of flora and fauna, Gujarat's Gulf of Kutch is perhaps the finest marine ecosystem on India's west coast. Unforunately, there has been no general awareness of the ecological significance of such marine habitats in this country until very recently, with the result that their rich natural resources have been over-exploited, particularly by local industries, without any consideration for ecological principles and the resultant environmental degradation. The credit for first focusing attention on the deteriorating ecological status of the Gulf's marine habitat must go to the W.W.F., Western Region, which brought out in March, 1978, a Status Report on Pirotan Island in the Gulf of Kutch through the National Institute of Oceanography at Dona Paula, Goa. This report revealed for the first time the alarming situation created as a result of the various decimating factors operating in the area mainly through reckless exploitation of raw material by the local cement company by dredging for calcareous sand around the coral islands in the Gulf.

The author, in his capacity as Head of the State Wildlife Department from 1977 to 1982, spearheaded the movement started to save the Gulf's marine habitat from further destruction. In the teeth of strong opposition from powerful vested interests, he ultimately persuaded the State Government to issue a notification establishing a Marine Sanctuary/National Park in the area in 1980. Although, for obvious reasons, it was not practicable to put a complete stop to the industrial exploitation going on in the area, the new enactment did put an effective brake on their activities so as to minimise the damage.

This paper gives a fairly detailed description of the unique flora and fauna of the Gulf's marine ecosystem, with special emphasis on the characteristic mangrove-coral association which is its most vital component. It further deals with the various decimating factors operating in the area and their disruputing influence on the ecosystem. The concluding part of the paper gives an account of the various conservation measures adopted by the State and Central Governments to save this marine paradise for posterity.

General Description

Location

Situated between 22° 15′ and 23°N latitudes and 69° and 70° 35′E longitudes, Gujarat's Gulf of Kutch is the only part of its vast coastline where extensive live coral formations and natural forests of mangroves occur. Being well sheltered from the elements, the Gulf is eminently suited for navigation and invites a considerable volume of ship cargo traffic from across to Arabian Sea, including tankers bringing crude oil from the Middle East. The Gulf is rich in various forms of marine life and constitutes one of the finest marine habitats in the entire sub-continent, with tremendous potential for future development in a regulated manner.

Physical Features

The entire southern coast of the Gulf is ringed by a cluster of 34 coral islands, of which the most well known is Pirotan Island which lies about 16 km north-west of Bedi Port (near Jamnagar) and has an area of about 6 sq. km. A drive by mechanised launch from Bedi to Pirotan with the rising tide takes under 2 hours. Many of the islands are fringed by coral reefs and bear mangrove vegetation and are as yet unexplored. The different types of features are coral reefs, mangrove formations, sandy beaches and mudflats, each with its characteristic flora and fauna.

The Gulf is elongated in the east-west direction and has an average depth of 30 m. Its tides are mainly of the semi-diurnal type with a large diurnal inequality. The mean spring tide influx extends from the mouth to the closed end of the Gulf and has a range between 2.1 and 6.2 m. Its coastal configuration is very irregular, with a number of creeks and bays.

Climate

The constant sea breeze makes the climate generally moderate and equable, the maximum and minimum temperature being around 40°C during May-June and 10°C during Jan.-Feb. The annual rainfall of under 400 mm is erratic and arid conditions prevail. Although theoretically the rainy seasons lasts for three months from July to September, the actual rainy days are few and far between with long spells of dry weather. The area is constantly swept by strong westerly winds which are surcharged with salinity, particularly from June to August. This atmospheric salinity decreases with the arrival of moisture-laden monsoon winds around August-September. Occasional cyclonic winds during the last quarter of the year (October-December) are also not uncommon.

Biota

Flora

Mangrove constitute the most important component of the natural vegetation. The 3 common species of mangrove found in this area are Cher (*Avicennia marina* and *A. officinalis*), Karod (*Rhizophora mucronata*) and Kunri (*Ceriops candolleana*). Cher is the largest and most widespread of the three species, attaining a height of 6-7 m and a girth of about 1.5 m. Its seed structure is especially adapted for dispersal by sea water ; thereby helping it to successfully colonise the coast, particularly in the inter-tidal zone. The spongy covering of the apricot-like fruit makes it buoyant, which facilitates its dispersal by sea water. As is the case with all mangrove species, its seeds are viviparous, *i.e.* they start germinating while still on the parent tree ; but, more often than not, the seeds get detached before the radicle has actually split the outer covering. The buoyant outer cover splits and starts curling outwards on either side. As soon as it separates, the seed sinks to the bottom with the radicle pointing downwards. The emerging radicle produces a number of small side roots which, on penetrating the substratum, rapidly form a number of anchoring roots and later develop radially into the spreading subsurface roots, forming the pneumatophores (breathing roots) which enable mangroves to keep contact with the atmosphere in their swampy anaerobic environment. The unusual folding of one cotyledon over the other to form two 'V's enables the seed to get buried readily into the mud. As the ebbing tide flows out, the prow of the 'V' gets oriented against the tow so that the water flows past and the eddy caused fills up sand behind into the folds to provide effective resistance to the dislodging of the seed. This enables the radicle to put forth quickly the radial roots which anchor the seedling to the shifting sand.

The shape of Cher leaves, which are narrow and pointed, also makes the frond bend with the water current and permits the tide water to flow past easily so that, even with the strongest of tidal flows, the young plants are little affected. Cher seedlings can therefore colonies those mudflats where the new leaves get exposed to sunlight above the water level for as little as a couple of hours a day. At this initial stage, the main danger to the seedlings is from the strands of algae which are swept in and out with the tides since algal growth gets entangled around the seedlings and smothers them.

The other two mangrove species found in the Gulf in lesser abundance are Karod and Kunri. Karod grows into a medium-sized tree and its leaves are large, thick and glossy, somewhat resembling those of *Ficus bengalensis*. It puts out strong adventitious roots from the lower stem and branches and these perform a breathing function. The spreading subsurface roots of Cher are absent and this species cannot colonise very exposed locations as effectively as Cher does. However, once established, it seems to thrive exceptionally well even where the rise and fall of tidal level is considerable. The nature of Karod seed prevents it from being an effective pioneer species on distant islands and on more sandy substrates. In this case also, the seeds start germinating while the fruit is still attached to the parent tree. The clusters of bean-like structures are in fact the germinating radicles, presumably corresponding to the hypocotyl in conventional seeds. When it is ready to detach, a collar appears below the toothed remnants of the calyx. When this collar is complete, the slightest touch or jerk as by wind detaches the elongated seed which drops straight down with its tip getting embedded into the mud like a dart. On detachment, the plumule is exposed at the point of separation and later unfolds into the shoot. Roots develop from small knobs visible just behind the point of the radicle. Only those seeds which get deeply stuck in the mud grow into seedlings and get established. Those which get washed away will only grow if they get so enmeshed as to permit the roots to get a chance to find a hold on the substrate, which is normally not possible on exposed locations. Established trees of this mangrove provide favourite roosting and colonial nesting sites for aquatic birds such as egrets and herons. It is therefore very necessary to preserve the remaining good stands of this species and to raise new ones through artificial planting.

Kunri is the smallest of the three mangrove species. It grows up to chest height on the average and forms dense stands which are submerged only during spring tides. Like Karod, it also forms stilt roots when growing on heavy mud but these are not apparent when growing on sandy soil where better aeration is available. The seeds resemble those of Karod but are shorter and thinner. They too drop down like darts to get embedded in the mud. However, since many of the seeds develop too close to the ground because of the short stature of the species, they cannot get enough fall to provide the thrust necessary to get their tips embedded. Such seeds fall sidelong and generally fail to grow into seedlings.

The mangroves in association with corals support and nurture diverse forms of marine life and play a vital ecological role in sustaining the unique but fragile marine ecosystem. The benign influence of mangroves may briefly be summarised as under :

(*a*) Mangroves play a vital role in holding and binding the otherwise highly mobile coastal soil by breaking the disintegrating force of tides and storm waves.

(*b*) Their ramifying root systems act as effective silt traps causing the deposition of silt brought down from the mainland by surface run-off. This filtering action prevents the silt from getting deposited on the coral formations and smothering them.

(*c*) They intercept the prevailing strong salt-laden sea winds, thereby encouraging and promoting better and healthier tree and shrubby vegetation on their leeward side.

(*d*) They produce immense quantities of leaf litter which on decomposition forms a rich organic detritus sustaining a host of organisms which in turn provide sustenance to the larvae of marine organisms such as crabs, prawns and fish fry. The mangrove are thus of immense value in the growth and development of coastal and estuarine fisheries.

(*e*) Above the water, the mangrove offer excellent nesting sites for heronries which are tenanted by roosting and breeding colonies of a multitude of aquatic birds, such as herons, egrets, storks, pelicans, ibises, spoonbills, darters, cormorants, etc. Mangrove flowers also attract land insects like bees and wasps which in turn attract terrestrial birds, thus providing the latter with both food and shelter in an otherwise totally alien habitat.

(*f*) They help to improve the microclimate by increasing atmospheric humidity through transpiration, thereby encouraging dewfall, particularly during winter months. In such an arid tract, dew precipitation adds appreciably to the meagre annual rainfall and immensely benefits the growth of local vegetation.

(*g*) Last, though by no means the least, mangrove are a most valuable source of fuel and leaf fodder in this forest-deficient tract. Cher and Karod leaves and Cher fruits, which are believed to be as rich in nutritive value as cotton seeds, are locally in great demand as fodder and smaller branches and twigs of these species are constantly lopped and removed for this purpose. Being drought resistant, they provide excellent browse for camels and a dependable source of cattle fodder during lean years which are only too frequent. The bark of Karod and Kunri is used by local fishermen for tanning their fishing nets. Unfortunately, their unscientific overexploitation for these purposes over a long period has resulted in their disappearance from vast stretches of what were once luxuriant mangrove forests which are now badly in need of restocking by artificial planting.

Next to the mangrove, the other important component of the Gulf flora are the marine algae, many of which are edible or capable of yielding products of economic importance, such as protein, iodine, algin, agar agar and organic manure, on a commercial scale if harvested systematically. Among the species of algae found in this region may be mentioned *Ulva fasciata, U. reticulata, Sargassum ilicifolium, S. tennerimum, Caulerpa racemosa, C. peltata, Enteromorpha intestinalis, Hypnea musciformis, Gracillaria corticata, Padina tetrastomatica, Dictyota sp., Cystocera* sp., *Corallina* sp. and *Laurencia* sp.

The terrestrial flora constituting the natural vegetation growing on and around the islands consists of zerophytic and halophytic species, such as *Euphorbia neriifolia, E. caudicifolia, Aloe vera, Calotropis procera, Ipomoea pres-caprae, Sporobolan madraspatneus, Eragrostis unioloides, Fimbristylis* sp., etc. *Ephedra foliata* is a gymnospermous climber commonly found growing on *Euphorbia* sp. Sea grasses growing on mudflats are represented by *Halophila ovalis, H. beccerii, Zostera marina* and *Urochonolra setulosa.*

Fauna

The Gulf of Kutch can boast of a rich variety of marine fauna comprised of as many as 55 species of corals, edible and pearl oysters, sponges, worms, sea anemone, octopus, crabs, turtles, *Bonnelia*, dolphin, about 200 species of fishes and 8 types of sharks. Sea turtles migrate to this area from their far off native haunts thousands of miles away for nesting in October-November. The coral species include *Favia favus*, *F. melizerum*, *Symphyllia recta*, *S. radians*, *Montipora informis*, *Coscinarea monilae*, *Goniastrea pectinata*, *Turbinaria peltata*, *Porites* sp., *Goniospora* sp., *Sidetastera* sp., *Meandria* sp., *Asteria* sp., etc. Molluscs are abundantly represented by as many as 92 species of pelecypods, 55 species of gastropods, 3 species of cephalopods and 2 species of scaphopods and amphineura. The erstwhile princely State of Nawanagar had a well developed industry based on the exploitation of pearl oysters (*Pinctada* sp.) from this area which was subsequently lost due to heavy sedimentation caused by the continuous dredging operations of the local cement factory at Sikka on the Jamnagar coast. The sea bed in the Gulf consists for the greater part calcareous sand derived from the natural disintegration of corals and is consequently found to be eminently suitable for cement manufacture due to the high proportion of limestone it contains. Among terrestrial snakes, the saw-scaled viper is fairly common on Pirotan Island.

Being strategically located at the crossroad of the large scale annual bird migration route from temperate Eurasia to Africa and peninsular India, the Gulf of Kutch also attracts large flocks of migratory as well as resident aquatic and land birds. It has been known to ornithologists that a very extensive autumnal migration occurs annually down the fertile Indus plain, both of land and water birds. This concourse splits over the Kutch area to either fly south and south-east into India or west along the Makran coast and then down the Arabian coast to East Africa. A similar flyway is provided by the fertile plain of the Tigris and Euphrates rivers (Mesopotamia) and the Persian Gulf, with birds from Eastern Europe and the Mediterranean flying east along the Makran coast to enter our area. The head of the Gulf of Kutch is the take-off point westward flow and land fall for the eastward flow of migrants, with the western flow towards Africa comprised of Central Asian species and the eastern flow towards India of European species of land birds. From both sides we receive temperate and circumpolar shore birds.

The Gulf of Kutch has a very high tidal range producing extensive tidal mudflats which provide an ideal foraging ground for throngs of wintering shore birds, gulls and terns. The extensive areas of mangrove vegetation further enrich the habitat for birds and there are thriving nesting colonies of herons, egrets and storks which are resident in the Indian sub-continent. The tidal mud provides rich feeding for the Greater and Lesser Flamingoes, both of which breed colonially in the Great Rann of Kutch. In addition, huge concourses of the Lesser Flamingo arrive here in winter from their breeding locations on the East African lakes.

Thus the Gulf of Kutch is a veritable marine paradise offering a magnificant panorama of nature's beauties and marvels to gladden the heart of every lover of nature.

Environmental Problems

Industrial Exploitation of Natural Resources

With the setting up of a large cement factory on the Jamnagar coast dependent on calcareous sea sand from the Gulf area as a cheap and abundant raw material, a long term lease for the exploitation of this resource from the vicinity of some of the nearby islands including Pirotan was given to the company by the ex-Nawanagar State. This proved to be a major ecological disaster for the Gulf and its marine life. The company's dredging operations in the close proximity of the islands caused severe damage to the coral reefs and resulted in heavy mortality in corals and other marine organisms by the constant deposition of a thick layer of silt which ultimately suffocated them. The company's labourers camping on the islands also indiscriminately hacked the mangrove vegetation for clearing extraction paths and land for housing colonies and for their daily fuel supply. The bird life sheltering in the mangrove was also rudely disturbed and sacred away. With sand being extracted from the sea bed at the staggering rate of about one million tonnes per annum over a few decades, the extent of environmental damage caused to this fragile marine ecosystem can easily be imagined. To further aggravate matters, this damage was continued and compounded when the successor Government of Gujarat State decided to honour the company's lease agreement even after the merger of Nawanagar State in 1948. This ultimately resulted in the overall destruction of an estimated 50% of the original coral formations. It was only in the late seventies, when the company's lease agreement became due for renewal, that the Forest Department realised the gravity of the situation and strongly recommended that the lease agreement should be terminated to cry a halt to the process of environmental degradation. Unfortunately, at the insistance of the Industries Department, the State Government in their wisdom decided to renew the company's leases, though certain restrictions were imposed to regulate its working. This decimating factor continues to operate in the area even today, although its deleterious effects have been minimised to the extent possible.

The other major industry adversely affecting the Gulf's marine habitat is the large number of salt-manufacturing units operating all along the Jamnagar coast. They do harm to the marine flora and fauna by releasing into the sea highly concentrated brine by way of a waste product. Neither the various forms of marine fauna nor the mangrove vegetation can tolerate such a high degree of salinity in the water and soil. The only solution to this problem lies either in making the units recycle the brine for the extraction of bromide or making them dilute the brine to a safe level of toxicity before discharging it into the sea.

Exploitation of Mangrove Vegetation

In the absence of any natural forests worth the name in the arid mainland areas surrounding the Gulf, the mangroves have had to bear the brunt of meeting the fuel and fodder requirements of the local population, particularly during years of scarcity which are only too common in this drought-prone tract. Mangroves are much priced as a source of firewood of good calorific value and their leaves are used as fodder, particularly for camels. As effective patrolling of mangrove forests is difficult on account of poor communications, they have continuously suffered heavy damage from unauthorised hacking, lopping and camel browsing, with the result that the existing vegetation has become patchy, bushy and stunted in size. Stumps of tree-sized mangroves cut down in the past still bear mute testimony to the true growth potential of the local mangroves, if allowed to grow unmolested. The rehabilitation of these derelict mangrove forests through large scale artificial regeneration is now required to be taken up on a war footing for restoring the badly disturbed ecological balance.

Offshore Oil Terminal at Vadinar

Taking advantage of the good navigational facilities offered by the Gulf of Kutch, a large off-shore oil terminal was set up by the Government of India at Vadinar in 1976 for unloading crude oil brought from the Middle East by large tankers for onward transit to the refineries at Baroda and Mathura. The erection of this strategic facility does not appear to have taken into reckoning the serious hazard it poses to the marine ecosystem from the likelihood of oil pollution which could play terrible havoc with the precious marine life of the Gulf in the event of a mishap to one of the oil-laden tankers or to the terminal facility itself. However, since this is now a *fait accompli*, all that can be done now is to provide certain basic safeguards against the possibility of oil pollution which should be strictly enforced.

Target Bombing Exercise by the I.A.F.

Jet planes from the Indian Air Force air base at Jamnagar conduct regular bombing exercises within the prescribed target areas selected by them in the Gulf. This is a constant source of disturbance to all forms of life in the area through the noise and shock effects of the resulting explosions and the deafening roar of the jets. This is, however, unavoidable and therefore has to be tolerated.

Future Developmental Activities on the Mainland

Jamnagar District, which constitutes the mainland region south of the Gulf of Kutch, was hitherto a backward and poorly developed tract with only a sprinkling of major industries, such as the cement factories at Dwarka and Sikka, the soda ash plant at Mithapur and the numerous salt manufacturing units operating all along the Jamnagar coast. Even this limited industrial activity has taken a heavy toll of the natural environment through injudicious over exploitation of natural resources by way of raw material and by polluting the atmosphere, water and soil. The excessive cattle population so characteristic of this tract has also destroyed its natural vegetation and the capacity of the land for sustaining its human and cattle populations by traditional land use methods has long since been stretched beyond the safety limit. Whatever patchwork of thorny scrub remains owes its existence to the remoteness of the region and its hitherto relatively sparse population. However, this position is likely to deteriorate rapidly in the near future with the recent advent of a broad gauge railway line extending further westward along the northern boundary of Jamnagar District and the increasing volume of sea traffic into the Gulf on account of improved docking facilities for large cargo ships and oil tankers. These developments are bound to bring in their wake a rash of mushrooming industries and a large human influx into this region in the years to come. Even on the agricultural front, an increasing number of efficient pumping sets are finding their way into villages where supply of sweet subsoil water is available. It should therefore not be long before the malady of salinity ingress from the sea into the substratum due to excessive pumping of underground for irrigating lucrative cash crops, which has already rendered useless fertile irrigated farmlands in the coastal areas of Junagadh District farther south, starts afflicting this area also. This is therefore the right time to think in terms of eco-development planning of this region, giving due weightage to hitherto neglected ecological considerations.

CONSERVATION MEASURES

Establishment of Marine Sanctuary/National Parks

In order to put a curb on the indiscriminate exploitation of natural resources from the Gulf of Kutch and to give adequate protection to the marine habitat, the State Forest Department caused to be notified about 270 sq. km of the coral and mangrove area of the Gulf extending from Okha to Jodiya as a Marine Sanctuary with a core area of 110 sq. km which was notified as a Marine National Park in 1980 under the provisions of the Wildlife Protection Act, 1972. This enactment gave the Department the necessary legal powers to regulate the exploitation of corals and mangroves and the operations of the industries which were damaging the natural environment. Subsiquently, in 1982, the protected area was enlarged to over 400 sq. km so as to cover all the vulnerable areas. This was perhaps the first Marine National Park to be set up in the country.

Apart from affording much-needed protection to the marine habitat, the Marine National Park project also envisages an elaborate programme of research, education and public recreation and provides for the following items of development and infrastructural facilities in a phased manner :

> A Museum of marine resources and products ; Research laboratory ; Oceanarium ; Dolphinarium ; Aquarium ; Corallarium ; Serpentarium ; Auditorium with audio-visual equipment ; Glass-bottomed boat for viewing underwater life ; Scuba diving ; Underwater filming and photography ; Artificial regeneration of mangroves ; Enclosures for breeding fishes, prawns, edible and pearl oysters ; Boarding and lodging facilities and luxury coaches for tourists, and so on.

Thus this prestigious project, apart from protecting the marine habitat, will prove to be a great boon to students and researchers in marine biology and will also give a tremendous boost to wildlife tourism for which there is immense potential in this State.

Nature Education programme

A novel feature of the active conservation movement in Gujarat is a regular programme of organising nature education camps for creating the necessary awareness in the general public-particularly the younger generation. These outdoor camps are organised and subsidised by the State Wildlife Department (which provides the boarding and lodging facilities free of charge) in close collaboration with local branches of World Wildlife Fund which contribute camping equipment and volunteers to act as guides. Participants only pay for their transport to and from the place of camp. The programme content includes spending a couple of days and nights outdoors (usually in tents) in a friendly and informal atmosphere and exposing the participants to various aspects of nature and the need for its conservation, the basic principles of ecology and the judicious use of natural resources. The venues of these camps change according to the season. The winter camp is usually held on Pirotan Island which is very popular with children who are thrilled by the launch ride and love to walk along the coral reefs at low tide. Several thousands of children who have been exposed to this unique and unforgettable experience over the past 5 years or so will hopefully form the vanguard of our nature conservation movement in the yeats to come.

Other General Measures

Another recent welcome development is the setting up by the Department of Environment, Government of India, of a National Mangroves Committee under the MAB/UNDP programmes to co-ordinate research and training activities in mangrove ecosystems. A status report on Mangroves in India is being prepared by a team of experts in collaboration with the Botanical Survey of India. An All India Co-ordinated Project on Mangroves is also being formulated.

Earlier, in 1980, the Government of India had also set up a Coral Reefs Committee (of which the author was a member) under the auspices of the Department of Science and Technology. This committee, at its last meeting held at Jamnagar in June, 1980, had made a number of far-reaching recommendations aimed at saving the coral reefs from further damage, particularly through industrial exploitation. However, it is not known what action, if any, was taken on these recommendations, nor did the committee meet again thereafter.

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STATUS OF MANGROVE ECOSYSTEM IN GULF OF KACHCHH

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ABSTRACT

The status of the mangrove ecosystem in the Gulf of Kachchh is outlined and measures underway for their conservation and management are discussed. The advantages of the setting up of the National Marine Park in the Gulf of Mannar in protecting the mangrove ecosystem are stressed. Recommendations for further strengthening the conservation and management programmes are indicated.

INTRODUCTION

GULF of Kachchh with its shallow intertidal zone, has one of the richest marine habitat in this subcontinent. Gulf, covering an area of 7350 sq. km has a maximum depth of 60 m. The coastline is endowed with mangrove formations, extending from Okha to Navlakhi and Mandvi-Mundra to Jakhau. Mangroves the characteristic littoral plant formations of tropical sheltered coastline—also described as 'coastal woodland', 'tidal forest', or 'mangrove forest'—once very richly covered the coastal belt. The area between Okha to Navlakhi,—measuring 162 sq. km of Marine National Park and 450 sq. km as Marine Sanctuary contains about 30000 hectares of mangrove forest. The total mangrove forest in Gulf of Kachchh is about 57000 hectares.

Most of the coastal belt is having criss-crossing creeks, lined by mangrove. The intertidal zones are sandy and muddy or with sand-stones of vast expanse and subject to prolonged exposure.

For many years now mangroves have been providing valuable resource to the coastal population of Gulf of Kachchh, in the form of fuel, fodder, timber besides providing protection against frequent cyclones or storms on this coast. Mangroves, have also been instrumental in rich fish catch. They also provide shelter, food and roosting for large number of resident, as well as, migratory birds.

PAST HISTORY

Mangrove forests were much denser, trees were taller reaching over 14 m or so. Along the coast between Okha-Salaya, Vadinar-Sarmat-Sachana-Sui and from Mundra-Mandvi-Jakhau, mangrove vegetation was thick. Most of the islands between Okha to Sachana also had thick belt of tall mangrove trees. Pirotan, an island close to Jamnagar and Dera, Dhani off the coast of Salaya,had thick mangrove belts all around the islands. Because of its rich mangrove ecosystem, Pirotan was famous for its pearl oyster fishing during erstwhile Jamnagar State. (H. H. Shri Shatrushalya Sinhji of Jamnagar and Shri Kasam Haji Veri per. comm).

Pirotan and other islands on Jamnagar side and Jakhau on Kachchh side were represented by species of *Brugeria* along with *Avicennia*, *Rhizophora*, *Ceriops* and *Aegiceras*. *Avicennia* pure stands were of much taller trees than seen presently.

VEGETATION

Vegetation of Mangrove Ecosystem can be divided into the following broad classification : (i) Mangroves (ii) Salt marshes, (iii) Sandy strands, (iv) Inland scrub and (v) Grassland.

1. *Mangrove Vegetation*

Mangrove forests are extensive along the coastal belt of Jamnagar District. Dominant species in this vegetation being *Avicennia marina* var *acutissima* forming almost pure stands at places. In some places this is associated with *Avicennia officinalis*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza*, *Ceriops tagal*, *Aegiceras corniculatum* and *Sonneratia apetala*. Other associated mangrove flora includes species such as *Salicornia brachiata*, *Suaeda fruticosa* and *Atriplex stocksii*.

Bhaidar and Pirotan Islands have mixed stands of *Rhizophora* and *Ceriops*. *Bruguiera* and *Aegiceras* have become rare. Pure stands of mangroves in Dhasodiya near Jodia has become scrubby growth, due to heavy pressure from adjoining salt works, ship breaking yard and so on.

In the exposed areas bordering the Gulf *Atriplex stocksii*, and *Salicornia brachiata* are the dominant species.

Due to pressure of camel grazing *Avicennia* strands near Bedi, Navabundar, Singach, Salaya, etc. areas is of scrubby nature.

2. *Salt marshes*

The vegetation of this zone is prominently of *Aeluropes lagopoides* supported by *Sporobolus* spp. There is also presence of *Cressa cretica* on dried salt marshes and salt-pans. Presence of species such as *Cyperus pangorei*, *Bergia odorata* and *Oldenlandia umbellata* are probably the indicators of the retrogression due to the detrimental effect of salt works.

3. *Sandy stretches*

In the sandy patches between the rocky shore line, few species such as *Cyperus conglomeratus*, *Asparagus demosus* are to be found. Foreshore is mostly free from vegetation. On sandy beachridge, sometimes pure strands of *Ipomoea pes-caprae* and *Halopyrum mucronatum* are observed. Other interesting plants found are *Orobanchus* sp, or root-parasite. On some islands, (*e.g.*) Pirotan, *Urochonolra setulosa*, not reported from any other part of India, also grows.

4. *Inland scrub forest*

The scrub forests on sandy plains of some of the islands and few patches along the coast are composed of *Acacia senegal*, *A. leucophloea*, *A. nilotica* sub sp. *indica*, *Capparis decidua*, *C. grandis*, *Balanites aegyptica*, *Commiphora wightii*, *Euphorbia nivulia*, *Ephedra foliata*, *Cadaba fruticosa* and *Zizyphus numulasia*.

In saline tracts and adjoining sandy beaches of the islands and coastal region *Salvadora oleoides*, *S. persica*, *Tamarix* spp., *Calotropis* spp. are commonly observed.

Trees such as *Borassus flabellifera* and *Phoenix sylrostris* once abundant, are now rare and completely destroyed on the islands.

Grasslands

On some of the islands, destruction of land vegetation has led to formation of grassy patches of *Eragrostis* spp., *Eleusine* spp., *Aristida* sp. along with some cyperacean members.

Mangrove Fauna

The resident fauna of mangroves include *Littorina* on the trunk and the undersides of trees. *Balanus* sp. are found on the roots and pneumatophores. At higher level, among *Rhizophora* and *Ceriops*, *Uca* sp. is common. On mud flats the gastropods *Cerithidia flaviatilis* and *Cerithium* sp. were in abundance, often forming thick beds at certain places such as Pirotan island and Dholani. Large number of mudskippers, species of *Periophthalmus* and *Boleophthalmus* were found 'walking', or scuttling on the muddy bottoms of the intertidal portions, at low tides. Tube dwelling polychaete *Eunice tubifex* and large forms of echiuroid worms are plenty at places. Shallow waters near mangrove zone contain young ones of prawns and mullets.

Another important inhabitant of the mangrove vegetation is *Scylla serrata.*

Only twice a single jackal has been seen on Pirotan Island.

Mangrove fauna and adjoining fishery is closely dependant upon mangrove detritus (Heald and Odum, 1970). Large number of tiny crustaceans, bivalves and worms live in muddy mangrove marshes.

Molluscs found in the mangrove areas consist mostly species of *Littorina, Neritina, Cerethidium, Teredo, Terebella, Telescopium, Murex, Astrea, Thais* and *Trochus.*

Mangrove Avifauna and the Heronary

Mangrove based ecosystem in Gulf of Kachchh with its mangroves stands form an excellent sanctuary for large number of resident as well as migratory birds.

Large populations of many species of waders thrive on mangroves, sheltering under mangrove thickets from birds of prey.

Pure stands of tall *Avicennia* at Pirotan harbour large egrets, darters, cormorants, pointed stocks, ibeses and grey herons. *Rhizophora* and *Ceriops* strands contain wonderful heronary on Pirotan, Bhaidar, Chusna and other islands. Observations revealed that these mangrove had breeding colonies of grey heron, night heron, pond heron, egrets and little green heron.

Under the mangrove vegetation waders such as curlew, whimbrel, red and green shank, snipe and sandpipers are abundant, playing hide and seek with birds of prey like brahminy kite and marsh harrier. The crab plovers, occupy sandy beaches, running after the receding tide to catch food. Along the creeks, few remaining tall mangrove trees have nests of darters and egrets. Aerial survey revealed large breeding colonies of painted storks, crab plovers and large egrets on Khara-Mitha Chusna, Dhabdhaba and Balachadi.

Large colonies of godwits, gulls, painted storks, migratory sanderlings and Ternstone occupy mudflats in mangrove areas of the island. Winter migrants commonly visiting mangroves are flemingos and pelicans.

The Causes of Mangrove destruction

In recent years the rate and variety of human-induced influences had increased to the point where majority of mangrove vegetation was threatened with destruction. Survey of mangroves in Gulf of Kachchh has revealed that vast coastal stretches were being destroyed either intentionally or as a secondary result of policy decisions relating to economic development by both government and private sectors. Decisions were being made ignoring the value of mangrove forests *vis-a-vis* salinity increase.

Unlike natural calamities affecting the mangrove habitat, the effect of human influence can be instrumental in changing the intertidal environment to such an extent that the subsequent recolonisation and natural regeneration of mangrove is prevented.

Taking into account the survey of mangrove destruction in Gulf of Kachchh, we can divide it into two broad categories :

(*a*) Over exploitation and destruction by users.

(*b*) Destruction resulting from activities of Industries and so on.

(*a*) *Over-exploitation and destruction by users :*

(i) *Cutting for fuel and timber :* Cutting of mangroves for timber is discontinued, because of lack of any timber sized trees available. Forest department has stopped coupe working according to the working plans, since last year or so. However, cutting of bushy and shrubby growth of mangrove for fuel had continued unabetted by local fishermen, workers of Cement Company and Salt works.

(ii) *Camel grazing* : Because of its nutritious fodder value there has been heavy camel grazing as a privilege right from the State times. Till recently some camel grazing continued. This had resulted in degradation of mangrove stands to ' open bushy type mangroves '.

(iii) *Exploitation of shells, algae and oysters by Fisheries Department* : Fisheries Department was giving contracts for collection of shells, oysters and marine fauna from the coastal region and islands. Fishing community camped on these islands for over a week at a stretch and this led to cutting of mangroves.

(*b*) *Destruction resulting from the activities of Industries and Construction :*

(i) *Mining*—Mining by two cement companies from Okha upto Pirotan has taken heavy toal of mangroves. These industries, while dredging for calcarious sea sand and corals from the coastal sandy beaches and the islands, have cut and hacked away large chunks of coastal mangrove forests. Excessive sedimentation is also detrimental to mangroves.

(ii) *Salt ponds or Brine evaporation ponds* —A huge chemical-Salt industry has mushroomed in the north-western coastal zone of Gujarat State. This has adversely affected a considerable area of Mangrove Forests. Salt ponds or brine evaporation ponds are constructed on mud flats or commonly in mangrove areas. Salt ponds require complete clearing of all the trees and shrubs, levelling and diking of the terrain, construction of canal flooding system and intensive mechanical compaction of the soil surface. This operation is facilitated by solar heat input. Under operation, the salt-pans are subjected to an inundation regime, depending on local evaporation rates. This repeated inundation and drying of the saltpan soil surface increases the salt content, altering the very soil structure of the salt ponds. This results in total, irreversible clear-cutting of the mangroves, for clearing the area for the salt pans. Thus a major chunk of coastal mangroves has been clear felled and destroyed, by more than 30 salt works between Okha and Navlakhi. Already applications for more than 50 salt works is pending between Sachana and Hansthal creek.

(iii) *Coastal development*—There has been a great pressure on the coast of Sikka-Vadinar for a Fertilizer Project. This will increase the clear-cutting of mangroves in surrounding areas, by the camps of labourers.

(iv) *Oil and other chemical hazards* — Increasing oil transport of bulk liquids in sea, off Vadinar Port, is associated with an increasing frequency of oil spillage. This is detrimental to the growth of mangroves and harmful to the natural regeneration.

(v) *Creation of Harbours and Ship-breaking yard*—Creation of harbours, new ports, anchorages, loading-unloading facilities and ship breaking yard at Sachana has also made an impact on the mangrove environment. Thus due to New Port, and its extension of loading facilities at Vadinar, Salaya, Kandla and continuous dredging of silt at Kandla, New Port, Bedi Port has had its impact on mangrove environment. Dominant being change in the local hydrology, particularly with respect of Mean Water Level at these three places. Along with this mixing of freshwater and seawater in the new shore environment may have a great effect on the intertidal environment in these areas, resulting in chronic salinity stresses.

(vi) *Waste disposal by steamers*—Large commercial steamers coming to Kandla Port, often carry chemicals like Naptha, Acids, etc. On the way back, they clean their tanks in the Gulf of Kachchh. Similarly steamers coming to Pirotan Sea, clean their tanks and release lots of waste material. All these activities are harmful to the growth of mangroves, affecting its natural regeneration in areas near Kandla, Sachana, Bedi and Nava Port.

Consequences of Mangrove Destruction

Some of the consequences of mangrove destruction are mentioned below:

(i) Mining by Digvijay Cement Company of Sikka, in the areas of Dhani, Dera, Goose, Pirotan and Jindra, all of which are situated in the mangrove ecosystem in Gulf of Kachchh, has resulted in the deposition of silt and sand Excessive sedimentation caused by this mining activity is detrimental to mangroves through its blocking role in the exchanges of water, nutrients and gases within the substrate and over lying water. Death of mangroves occurs, when this exchange is totally blocked.

(ii) The turbidity and increased siltation caused by dredging activity of cement company has also resulted in destruction of local corals and sea-grass meadows in Dhami, Dera, Jindra and parts of Pirotan island.

(iii) With disruption of mangrove detrital based food-web, there is an overall reduction in fishery yield from areas of Jodia, Goose and Pirotan. There is significant reduction in the catch of lobsters from Jodia by more than 10% (Kasam Haji veri, per. comm.).

(iv) Partly due to exploitation of trees, by unauthorised cutting of mangroves for fuelwood and partly by grazing of camels, big openings are created. These have remained to be afforested, leading to creation of large mudflats and later subject to sedimentation.

(v) The drastically changed physical and chemical soil condition in the salt works will now allow recolonisation from adjacent mangroves forests. This has been observed in Bedi, Salaya, Vadinar, Sikka, Jodia areas. Thus the damage caused to the mangrove forests by all the salt works along Jamnagar sea-coast is very severe.

(vi) Construction activities on the ports along the Jamnagar coast, anchorages and loading-unloading facilities, dredging in the ports of Kandla, Nawabander, Bedi, Salaya, Vadinar have certain effects on the mangrove environment changes have been observed in the local hydrology particularly with respect to mean sea levels and the mixing of freshwater and sea water in the adjoining shore area environment. This has a great effect on intertidal environment, resulting in chronic salinity stresses. This has led to the disappearance of mangroves in some areas along Jamnagar coast.

(vii) Due to oil terminal at Vadinar loading-unloading activity on the Gulf of Kachchh has oil spillage hazards, causing damage to mangrove supported ecosystem in Gulf of Kachchh.

(viii) Human presence at Pirotan, has replaced some of the natural fauna with crows, dogs, rats and sea gulls, thus disturbing the mangrove based ecosystem on Pirotan island.

Species at Risk

Due to extensive exploitation and conservation of mangrove ecosystem for other uses in the Gulf of Kachchh, a number of species of plants and animals which are largely or exclusively dependent on them, are endangered. Table 1 provides an assessment of the conservation status of species, as per various categories.

Marine National Park and Present Status of Mangroves in the Gulf of Kachchh

Government of Gujarat has taken a dynamic step towards preserving the unique Mangrove Ecosystem, by declaring the area as a Marine National Park and Marine Sanctuary. All the mangrove forests along Jamnagar Coast are covered under this Marine Park which happens to be the first in India.

The decision and subsequent action in declaring the area as Marine Park, has been the turning point in this deteriorating mangrove ecosystem. Since the area has been declared as Merine Park, there has been constant patrolling and vigilance against unauthorised cutting of mangroves. Incidence of grazing by camel has been reduced, though not stopped altoteher.

There has been considerable improvement in the growth of *Avicennia* in pure stands. My observations of last 3 years have shown that at Piiotan, bushy growth of *Avicennia* has shot up to big trees about 25′ on an average, putting on height growth of about 12′-15′. Pirotan Swamp between Bedi, Nawabander, Chad, Sanada, has also put in good height and already birds have started nesting on it.

TABLE 1. *List of species with their present status*

Species	Common Name	Status
Aegiceras corniculatum	Mangrove	Endangered
Bruguiera gymnorhiza	Mangrove	Vulnerable
Sonneratia apetala	Mangrove	Vulnerable
Rhizophora mucronata	Mangrove	Vulnerable
Ceriops tagal	Mangrove	Vulnerable
Comminphora wightii		Endangered
Animals at Risk (*Mullusca*)		
Strombus gigas	Strombus conch	Endangered
xuncus pyrum	Sacred conch	Vulnerable
Lambis spp.	Spider conch	Endangered
Murex spp.	Murex oyster	Vulnerable
Pinctada fucata	Pearl oyster	Vulnerable
Other Marine Animals		
Acropora spp.	Branch corals	Extinct
Porites spp.	Corals	Vulnerable
Ikedella spp.	Bonnelia	Vulnerable
Reptiles		
Dermochelys coriacea	Leatherback Turtle	Endangered
Chelonia mydas	Green Turtle	Vulnerable
Lepidochelys olivacea	Olive-Ridley	Vulnerable
Birds		
Butorides striatus	Little green Heron	Endangered
Tringa erythropus	Spotted red Shank	Vulnerable
T. nebularia	Green shank	Vulnerable
Phalaerocorax fuseicollis	Indian Shag	Vulnerable
Anhinga rufa melanogaster	Darter	Vulnerable

Reduced human activity on Pirotan, Dhani, and other islands has resulted in heavy seeding and excellent natural regeneration. *Avicennia* has started colonising in patches on the eastern, southern and northern portions of Pirotan island. On mud flats along the mangrove lined creeks *Suaeda*, *Salicornia* seem to be colonising.

However, mushrooming large number of salt works along the sea coast has taken a heavy toll of mangroves, destroying it from around the salt works in Jodia, Bedi, Vadinar, Singach, Chudeshwar, Okha areas. Mangroves around Kandla Port are almost disappeared and other areas of Kachchh Coast are in dilapidated condition, Jakhau has some good mangrove stands.

Mangrove Management

Most of the mangrove forest of Gulf of Kachchh are poorly surveyed and studied. Most of the decisions on coastal beach areas, which formed mangrove habitat along Jamnagar-Kachchh coast, came without much consideration for preserving this unique habitat. Wherever possible, Forest department tried covering the area under mangrove planting. But, where the area fell out-side reserve forest there was little hesitation in handing it over to salt or cement industry. All these decisions for salt works complex in past, have lead to unanticipated result in severe destruction of mangroves, for preparing salt ponds in salt work areas. Loss has been irreversible. For fishing, fisherman now go to much deeper areas in the Gulf. Even the Fisheries department has been ineffective in stopping the fast growing salt industry along Jamnagar Coast. Results, unknown while taking the policy decision, are apparent now. The Coast of Jamnagar District, stretching between Okha to Navlakhi, area has become saline ; with ingress of salinity drinking water wells and lakes have turned brackish. Fortunately Gujarat Government has realised the importance of protecting and conserving this complex mangrove supported ecosystem. Area between Okha to Sachana, Sui has been declared as Marine National Park and Sanctuary. Over and above this Government has taken a decision not to permit any new industry which would pollute the Coastal Sea belt and mangrove areas. Thus there is to be no addition permitted in Salt Works, Cement Factories and so on. The creation of the Marine Park has succeeded in releasing three sea leases of Digvijay Cement Factory, Sikka as under :

(1) Dhani 741.30 acres ; Kalwan 49.40 acres ; Jindra 568.30 acres.

Remaining two leases of Dera and Goose measuring 69.26 acres and 148,26 acres respectively, will be taken over from the Company by early 1985, as per Government decision. From the 3 areas taken back in 1983 already natural regeneration of *Avicennia* is seen in places.

Afforestation

In two and a half years, the Marine Park has developed the technique for Mangrove Nursery, where in *Avicennia, Rhizophora* and *Ceriops* seedlings are successfully raised. They are then planted in tidal sea areas, where mangrove once existed. Results of past two years are encouraging. In Pirotan island, where mangrove afforestation has been taken up, results are showing up ; seedlings have put in height growth and also pneumatophores. But the best result is in the fact that mangrove based fauna has already started colonising these seedlings. Thus *Trochus* and Barnacles, are already colonising these established mangrove patches.

Protection

On the other side, strict protection and vigilance over mangrove cutting have shown dividend by putting excellent height growth at Pirotan, Dhani, Sarmat and along the creeks. More bird nesting is observed as a result of this.

Work has been taken on hand for formulating a proper management plan for the Marine Park in Gulf of Kachchh, so as to conserve and develop the mangrove and marine resources. Another dynamic step taken by the State Government, is to form an expert committee for the development of Marine Park.

In the Management Plan of Gulf of Kachchh it is proposed to :

(1) Identify the total mangrove resources through surveys,

(2) Through Community Forestry Project find alternative sources for fuel to satisfy the needs of local population.

(3) With the help of World Wildlife Fund, IUCN Research Teams, assess the natural as well as international significance of these mangrove forests and marine ecosystems in relation to

(i) Water-fowl migration

(ii) Turtle breeding & migration

(4) Enumerate necessary strategies for efficient management of existing mangrove stands and massive afforestation of mangrove in vacant areas to improve the marine environment.

(5) Under Indian Forest Act and Wildlife Protection (Act) 1972, necessary legislation is provided to preserve these mangrove resources.

Recommendations

Mangrove ecosystem in Gulf of Kachchh, which plays an important role in fishery production, coastal stabilisation and maintaining critical habitats of corals and other threatened, endangered species *i.e.*, marine turtles. These need to be studied and managed properly. Realising this the following recommendations are made :

(i) Proper survey and comprehensive data base, including quantitative information, on biological, physical and socio-economic aspects of the mangrove ecosystem in Gulf of Kachchh.

(ii) Alongwith preparation of Management Plan for the Marine Park, also develop the Mangrove Plan and link it with National Mangrove Plan.

(iii) Creating awareness of the value of mangrove resource. This has been already taken on hand in the Marine Park area, through Marine Nature Education Camps in which school and college students do the planting of mangrove seedlings after studying its ecosystem. Local fisherman, too have been covered in the education programme and results are very encouraging. Preparation of literature has been taken up for such educational purposes.

(iv) It is essential to promote research in the field.

(Presently we are collaborating with Saurashtra University, Department of Biosciences and Fisheries Department in taking up various research projects in the Gulf of Kachchh which would help in Conserving Mangrove and Mangrove based ecosystem.)

(v) After study and survey it would be necessary to manage the mangrove resources for sustained management, without concommitant loss of their values and services.

(vi) With rapid degradation and retrogression in mangrove ecosystem with Salt Works and Cement Companies, steps should be taken to strictly preserve these mangrove resources.

(vii) Afforestation of mangrove in its original habitat presently degraded, and in blanks or vacant areas is of utmost importance in recovering the lost balance in the mangrove ecosystem.

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CALCAREOUS SAND MINING FROM BEACHES AND LITTORAL AREAS IN THE GULF OF KUTCH, GUJARAT AND THEIR POSSIBLE DELETERIOUS EFFECTS ON MARINE LIFE

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ABSTRACT

An account of calcareous sand mining from beaches and littoral areas in the Gulf of Kutch, Gujarat is given highlighting the possible adverse effects on marine life in the area.

INTRODUCTION

M/s DIGVIJAY Cement Co., Sikka is manufacturing cement by using calcarious sea sand as their raw material. They are excavating sea sand from different islands, leased to them by the Government of Gujarat. This is continued since the setting up of this factory. Upto now no attempt has been made to analyse the calcareous sea sand and the adverse effects of their removal on the environment. The author has made an attempt to analyse this for the different lease areas and reports along with their possible deleterious effects on marine plants and animals.

The author expresses his sincere thanks to Shri Vijay Ranchan, Former Commissioner of Fisheries and Shri A. K. Luke, Commissioner of Fisheries of Gujarat State for being kind enough to permit him to attend the symposium and to present this paper. He is grateful to Prof. N. D. Chhaya, Dy. Commissioner of Fisheries, Okha for valuable guidance and Shri H. A. Rawal, Laboratory Assistant, Sikka for the secretarial help.

MATERIAL AND METHODS

The author has visited the lease areas of M/s. Digvijay Cement Co., Sikka for redemarcation and assisting the Joint Commissioner of Fisheries on a number of occasions. During these visits, sand samples were collected from each area and analysed and the data is presented here briefly.

RESULTS AND DISCUSSIONS

(*a*) Government of Gujarat has freshly leased some areas and the lease has been extended for some areas to M/s. Digvijay Cement Co., Sikka as shown below :

Name of the area	*Lease area*	*Details*
Kalvan	0.8 × 0.25 Km	Opp. Bedi Bandar
Jindra island	2.3 × 1.0 Km	Opp. Bedi Bandar
Dhani island	0.29 × 0.99 Km	Opp. Chudeshwar
Dera island	0.1041 × 0.35 Km	Opp. Sarmat
Goose island	0.75 × 0.8 Km	Opp. Sikka

(*b*) Besides Government has discontinued the lease of the two areas *viz.*, (1) Pirotan island and (2) Narara reef.

Of all the above areas described in (*a*), Kalvan point remains always submerged, while Goose, Dera, Dhani and Jindra are in the form of islands. The islands Jindra, Dera and Dhani are supported with thick shrubby growth of mangrove whereas Goose area is devoid of any mangrove.

Sand analysis of Kalvan point

It consists of dead fragments of corals, molluscan shells, foraminiferan shells, silica particles and clay particles. The dominancy in this sample is of coral and molluscan shell fragments. The sample is coarse.

Sand analysis of Jindra, Dera, Dhani and Goose areas

They consist mainly of silica particles and molluscan shell fragments of almost uniform size and hence the samples are not coarse as at Kalvan area. They are distinguished by the absence of clay particles. The samples of sand from these areas are loose just like river sand.

For crosschecking, collections have been made of a number of samples at different times from barges returning from various lease areas to unload at Sikka Sand Jetty. These samples also resemble that from Kalvan point. However, Kalvan point is a very small area and cannot result in such large quantities of sand brought to this sand jetty. The Company apparently resorts to bringing calcareous sand from other places in the Gulf of Kutch which are not leased to them. Case for illegal activity has been registered against the Company. The Fisheries Cooperative Societies and fishermen have complained a number of times regarding illegal mining activities of the Company from areas not leased to them.

A letter received on 16th August 1977 from the Company shows that they require on an average app. 1675 tonnes of sea sand for the production of 1531 tonnes Cement per day. This is being carried on since the setting up of the factory in 1946-47. This would give a rough idea of the immense quantity of calcareous sand they have extracted till now from the different lease areas of Gulf of Kutch. However, no account is maintained by the concerned Department of landings at the Sand Jetty as to how much sand is extracted from different lease areas and fed to the factory. This should be a primary requisite and the authorities should see that such a record is maintained even if it involves posting additional personnel for this.

Deleterious effects on Marine Biota

1. *Kalvan point*

The lease point is situated in the mouth of Bedi creek and remains always submerged. Because of extraction of sea sand from this point by operating their dredgers for a small period, they have increased sedimentation which has altered the topography of the point as well as the surrounding areas. Along with their operations they have exploited live chanks *Xancus pyrum*, giant size *Murex* sp. etc. The adverse effects is not understood from the area which is submerged and needs to be investigated.

2. *Jindra island*

This is a lease point whose right side and north side is covered by reef flats. Some portion of lease on the west side and south side is totally covered with a dense growth of dwarf mangrove. The Company has introduced motor trucks for the easy transportation of sand on the island. For this, they have made roads by laying mangrove twigs on loose sand. Thus, they have destroyed a considerable part of the live mangrove.

To have mangrove twigs of appropriate sizes, they have even penetrated to mangroves growth in muddy areas. In doing so, they have upset and destroyed the mangrove fauna as well (*e.g. Littorina* sp., *Uca* sp., *Telescopium telescopium, Scylla serrata, Cerithidea fluviatilis, Cerithium* sp., *Periophthalmus* sp., *Boleophthalmus* sp., *Balanus* sp., *Saccostrea cuculata* and a number of marine bivalves).

Labour hutments were created by the Company on the island. They have cut mangrove for firewood further adding to this depletion. They have uprooted horizontal roots of mangroves and breathing roots also. The affected species of mangrove are *Avicennia marina* and *Rhizophora mucronata.*

By the constant disturbances of labourers, marine birds have given up their nests and migrated to other places. Foxes from the island have been disturbed due to human encroachment.

Labourers used to keep dogs for their watch and ward who predate on intertidal crabs (*Ocypoda* sp., *Gelasimus* sp.). The labour settlement has also destroyed clums of grasses and other marshy plants of the area. By doing this, they have spoilt the habitat of marine snake locally called 'Paidka'. The mining of beach sand has adversely affected the beach fauna and flora. The depredation extends to the areas where the loading of sand in barges takes place.

Labourers carry sea sand in locally known containers 'Tagara'. Spillover sand while loading the barges at low tide are washed over the reef flat during high tide thereby upsetting the reef ecosystems. The thickness of sand deposition varies from place to place on reef flats. In short, they have created an artificial reef ecology which are not at all suited to marine biota, which existed there earlier. (*Zostrea marine, Ulva fasciata, U. reticulata, Enteromorpa intestinalis, Dictyota* sp., *Hypnea musciformis, Gracillaria corticata, Gellidiella acerosa, Sargassum tenerimum, Sargassum cinerimum, Caulerpa recemosa, Padina* sp., *Udotea* sp., *Corallina* sp. and a number of other species of algae). Sedimentation has greatly affected their settling habitat. So also the fauna especially *Tetillia dactyloidea,* other sponges, colonies of *Sertularia* sp. and *Plumularia* sp., *Cerianthus* sp., *Stoichatis gigenteum, Discosoma* sp., *Zooanthus* sp., *Siderastrea lileacea, Siderastea radiance, Favite* sp., *Favia* sp., *Goniastrea* sp., *Nereis diversicolor, Eurythoe complanata, Eunice* sp., *Sabella* sp., Hermit crabs, *Neptunus pelagicus, Thalamita prymna, Atergatis integarimus, Thalamita crenata,* young ones of crabs and prawns, *Pinna* sp., *Octopus* sp., egg mass of *Sepia* sp., pearl oyster *Pinctada fucata, Astropecten* sp., *Asterina* sp., *Ophiothrix* sp., *Ikedella misakiensis* and *Ikedosoma pirotansis,* eggs of skate, soles, mullets etc. are affected due to considerable increase in suspended silt and mud in the water column.

It is interesting to note that for towing the 200 tonnes capacity barges they are using tugs. By powerful rotation of their propellars, churning of bottom sand and deep pits have occurred. Due to all these activities it is now seen that a part of the island is almost 'dead'.

3. *Dera island*

This is a lease point where the westernside of the lease area is attached to the reef, whereas the eastern side was covered with a luxuriant growth of mangrove. The deleterious effect at this place is almost similar to that of Jindra island. According to Parulekar and Untawale (1977), the mangrove vegetation has almost been wiped off, making motorable tracks, Coral reefs are extensively being dredged out.

4. *Goose reef*

Company is used to bring sea sand from this area by private machwas. Some amount of sand particles are scattered here and there which are dispersed in the whole area by the sweeping movement of high tide and low tide. They have filled rockycrevices and coral burrows which has killed burrowing animals in parts of Goose reef. The current has allowed settlement of silt and sand particles over the live corals and reef flat. Removal of sand resulting in sedimentation has had deleterious effects and also the disappearance of a number of benthic animals. There is also considerable decline in the population of pearl oyster *Pinctada fucata*, Sacred chank *Xancus pyrum* etc. from the area.

The only animals on the island saved are the more tolerant species such as *Octopus* sp., *Tetradon* sp., *Stoichactis gigenteum* and *Discosoma* sp.

5. *Dhani island*

Dhani island is located east of Salaya and opposite to Chudeshwar Salt Pans. In between the island and the land, there is a narrow channel called Chheja Creek. The extreme north eastern point is under exploitation. As mentioned earlier, here also, the reef flat has become almost barren and extensive mud flats have developed. The coral stones which were seen during 1977-1978 with plentiful rich flora and fauna are at present covered by 3-6 inches of mud deposition. This is due to the nonstop removal of sand and resulting increase in suspended silt and mud in the water column. Animals such as *Pinna*, *Eunica*, *Sertularia* and *Ikedosoma* are almost missing from this portion of the island. All the loose coral stones are covered by silt and mud.

Near the site of excavation, there are a number of scattered coral boulders showing the uprooting of the part of the reef where The Company used to keep their barges and tugs. Distinct indications of erosion are also seen here.

6. *Piroton island*

Excellent account of deleterious effects of mining of sea sand have been dealt with by Parulekar and Untawale (1976, 1978).

7. *Narara reef*

Company has ruthlessly exploited Narara reef which is now almost a dead reef.

The above-referred coralline Kaddas are best known for turtle nesting, fish breeding areas, prawn and other shellfish breeding and nursery areas, but the natural ecosystems have been upset.

A high degree of sedimentation in the area is the most important deleterious physical factor (Pillai *et al.*, 1979). Thus removal of calcareous sands from different coral beach and inshore areas play an important role in increasing sedimentation and decreasing of precious marine lives from Gulf of Kutch.

Among the above cited localities Narara reef, Pirotan island, Kalvan areas, Jindra area and Dhani area have been taken back from the company owing to irreparable damage of the area and they are now placed within the ambit of the marine park in the Gulf of Kutch.

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REEFS UNDER MUD*

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ABSTRACT

The impact of siltation on coral reefs constitutes a very serious problem and is bound to increase as new areas in the intertropical zone bordered by coral reefs are subjected to alteration ('developed'). The depauperated reef at Cahuita, Costa Rica serves as a model of a reef destroyed by terrigenous sediments resulting from watershed deforestation, and serves as a guide for marine parks delimitation. Coherent units of reefs and terrestrial environs must be considered when establishing a marine park or reserve. Watersheds of rivers near the reef must be included in the protected area.

INTRODUCTION

SILTATION has been identified as deleterious to coral reefs (Johannes, 1975), and is a problem bound to increase as new areas are being altered (' developed ') in the tropics. Poor land management for agricultural or residential use, dredgnig drilling for oil or gas, and deforestation of the watershed are the main sources of sediments. Destruction of coral reefs due to siltation has been reported in many countries, namely, Australia (Stephenson *et al.*, 1958); Puerto Rico (Kaye, 1959; Loya, 1976); India (Pillai, 1971); Hawaii (Johannes, 1972; 1975); Bermuda (Dodge and Vaisnys, 1977); Venezuela (Weiss and Goddard, 1977), East Asian Seas (Gómez, 1980); Thailand (Chansang *et al.*, 1981); Florida, U.S.A. (Marszalek, 1981); Truk (Amesbury, 1981); Brazil (Leão, 1982); Costa Rica (Cortès and Risk, 1984; 1985). In this paper, a description is made of the depauperated reef at Cahuita, Costa Rica in relation to deforestation and several considerations are put forward for future marine park's delimitation.

* Contribution of Centro de Investigación en Ciencias del Mar y Limnologial, Universidad de Costa Rica.

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CAHUITA NATIONAL PARK

Cahuita coral reef is located on the Atlantic coast of Costa Rica, Central America (9° 45′N-82° 48′ W). The reef is within the limits of the 'Parque Nacional Cahuita', created by Executive Decree No. 1236-A on September 24, 1970. The park consists of 1,100 ha of low land forests and 600 ha of reefs. This is the only well developed reef on the Atlantic coast of Costa Rica (Boza and Mendoza, 1981). Local inhabitants fish on the reef, and foreign as well as local students and tourists come to visit and study the reef. There is evidence that this unique resource is being seriously damaged by siltation (Cortes and Risk, 1984; 1985).

The coral reef at Cahuita can be characterized as follows : high concentration of suspended sediments and high rates of resuspension of bottom sediments (among the highest reported). The amount of carbonate material in the bottom sediments is relatively low, as well as the coral's growth rates, live coral coverage and diversity. Coral colonies are generally larger than in other areas studied. Coral recruitment is low and is only on vertical surfaces ; also, early mortality is very high. Most of the corals present are efficient at rejecting sediments and morphological changes seem to develop as adaptations to resist the effect of sediments or as a response to limited light (Cortès and Risk, 1984 ; 1985).

The currents along the Atlantic coast are from northwest to southeast (Risk *et al.*, 1980 ; Kinder, 1983) and they are continously transporting sediments from the rivers north of the reef especially from Rio La Estrella (Cortès and Risk, 1985). The minerals present in the non-carbonate fraction (illite, montmorillonite, feldspar) of the reef's sediments and sediments trapped in coral heads are essentially identical to the minerals present at Río la Estrella.

The amount of sediments carried by the Río La Estrella has probably increased in the last 15 years as result of watershed deforestation. The siltation problem in reef environments is bound to increase considerably in Costa Rica as well as in the tropics. About 50% of the total forests of the world are in the tropics. Destruction of the forests is proceeding rapidly with the consequence, among many others, of an increase in soil erosion. Sediments are negatively impacting the continental water environments as well as the marine environments (UNESCO/UNEP/FAO, 1978).

Until 1977, there were 15900 km^2 of forest in Costa Rica equal to 31% of the territory. Of these, 11,300 km^2 (71%) are protected by Law. The rest may completely disappear by 1985 at an annual rate of 70,000 ha (Hartshorn *et al.*, 1982). The need for protection of more marine environments is imminent, taking into consideration the ideas outlined in the following section.

Considerations for Marine Park's Delimitation

The idea of establishing Marine Parks and Reserves is recent. The first marine parks were created in the 1930's at Fort Jefferson, Florida and Green Island, Australia. By May, 1981 there were 58 parks and reserves in 17 countries out of the 100 countries in the intertropical zone bordered by coral reefs (Salvat, 1981).

The philosophy and problems of reef management were clearly addressed in the 4th International Coral Reef Symposium at Manila, Philippines, by several authors. Bradbury and Reichlet (1981) proposed that rational management of coral reefs, (development and conservation) can be reconciled through ecological theory. Two strategies for ecosystem managers were put forward : (1) ' Press for conservatism in formulating management policy ', this means ' minimum human impact on the system ', (2) ' Adjunct to this holding strategy, ecologists should continue to collect information about specific subsystems ', the idea is to understand the ecosystems for improved management. Salvat (1981), also touches two apparently contradictory points : conservation and development. This controversy is only apparent because in the near future the creation of ' coral reef parks and reserves appears to be an economic necessity '. Finally Kelleher (1981) explains a practical situation in which the Great Barrier Reef Marine Park Authority develops research programs for the park's planning and management. The idea of contracting other agencies to conduct the majority of its research is excellent and pragmatic.

In this section considerations for marine park's delimitation will be developed based on our experience from Cahuita. First, consideration should be given to the marine environment. If the reefs are small, the whole reef plus a buffer area should be protected. This will facilitate the implementation of management plans and guarding the reef. If the reefs are big, cohesive units from the biological, physiographic, management and usage points of view should be established. Secondly the terrestrial environs must be considered. If the area next to the reef is also a reserve, protection of the reef would be much easier and effective. Impacts originated in the adjacent land : sewage, siltation, pollutants, *inetralia*, will be under control as apposed to a reef next to land that is or might be 'developed' (dredging, filling, residential or agricultural projects). Finally, in areas with high rain fall and close to rivers, the watersheds of those rivers should be incorporated in the protected area (Cortès, 1983). The coral reef at Cahuita is completely protected as well as the surrounding terrestrial environments, but the reef is under chronic and acute stress due to sediments originated in the watershed of Río La Estrella, a river whose mouth is 10 km away from the reef.

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MARINE PARKS OF COSTA RICA, CENTRAL AMERICA*

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Abstract

Under the administration of the National Parks Service, there are twenty national parks and reserves, including two marine parks : Manuel Antonio and Cahuita. Aside from these two, there is a terrestrial park Tortuguero that protects a marine resource, the sea turtles. Finally, there are two islands (Isla del Coco, Isla del Caño) that have been made parks, but whose surrounding reefs are unprotected.

Succint descriptions of the marine parks are included and recommendations are put forward for the inclusion of the reefs of Isla del Caño and Cocos in the protected area. Two localities from the Atlantic coast are described and proposed as marine reserves : Isla Uvita, and the reefs and forests, between Manzanillo and Punta Mona.

Introduction

Costa Rica has a total 400,000 hectares of protected zones, that is, about 8% of the national territory. These areas are distributed as follows : thirteen National Parks, four Biological Reserves, one strict nature Reserve and one National Monument. Two of the parks are marine parks : Cahuita, on the Atlantic coast, and Manuel Antonio, on the Pacific coast (Fig. 1). There is also another park on the Atlantic coast, Tortuguero National Park, which is terrestrial, but, protects an important marine resource, the marine turtles, mainly the green turtle, *Chelonia mydas* and three other species that come to those shores to lay their eggs : *Eretmochelys imbricata*, *Caretta caretta* and *Dermochelys coriacea* (Boza and Mendoza, 1981). The Isla del Coco National Park was established in 1978, but oddly enough, it does not include its adjacent area covered with exhuberant coral reefs. At the present time (June, 1984), the appropriate government agency has under study a document by which the marine environment will become part of the park. It is important to note that Isla del Coco has been proposed to the World Heritage List of UNESCO as an important area to be preserved for human kind. Isla del Caño, a Biological Reserve, has not run with such good luck. The water environ of the island is totally unprotected up to now ; a proposal has recently been drawn to expand the Reserve so that it also includes the surrounding reefs.

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Manuel Antonio National Park

Manuel Antonio is the smallest park of the system, with a total of 682 hectares. It is located towards the middle of the Pacific coast of the country, in the tropical wet forest life zone (Boza and Mendoza, 1981). Its most spectacular feature are the white sand beaches, the forest and a 'cathedral like' rock. The intertidal zone, as in other areas of Costa Rica, is not very rich. But, outstanding for its abundance is the limpet, *Siphonaria gigas.* Other gastropods that can be found in the intertidal zone are : *Littorina aspera, Nerita scabricosta,* and *Fisurella virescens* as well as the barnacle *Tetraclita stalactifera.* After the massive death of 1983 (Glynn, 1983 ; Cortes *et al.*, 1984), the coral fauna is non-éxistent. Instead, the bottom is covered by algae and scattered individuals of the gorgonians, *Lophogorgia* sp. and *Pacifigorgia* sp. Before 1983, *Pocillopora damicornis, Psammocora stellata* and *Porities lobata* were observed.

Cahuita National Park

The coral reef at Cahuita National Park is the best developed reef in Costa Rica (Fig. 1). It is a typical fringing reef, with three main crests. An external crest runs northwest-southeast about 4 km, then bends inshore toward Puerto Vargas and it is separated from the shore 1 km at its maximum and 100 m at its minimum. An internal crest on the eastern side, about 500 m long and less than 100 m from the shore. Finally there is a small crest on the western side of Punta Cahuita. Several small patch-reefs, surrounded by *Thalassia* beds can also be found in the lagoon (Risk *et al.*, 1980).

Cahuita is the only protected reef on the Atlantic coast. It has 35 species of scleractinian corals (Cortés and Guzmán, 1984) and 25 species of octocorals (Guzmán and Cortés, 1984). Several studies carried out on this reef have shown that this reef is under stress due to the presence of sediments (Cortes and Risk, 1984). Other groups of plants and animals, as well as pollution by hydrocarbons are at present being studied by scientists of the Centro de Investigación en Ciencias del Mar y Limnología (CIMAR) of the Universidad de Costa Rica.

New areas for Marine Reserves

Aside from Cahuita, Manuel Antonio and hopefully Isla del Coco, corals and other marine organisms can be removed *ad libitum* from the reefs, both on the Atlantic and Pacific coast. The suggestion is made that the areas described below be considered as possible marine reserves in the near future.

Pacific Coast

The Eastern Pacific has few well-developed reefs. The best ones are found in Bahia Chiriqui, Panamá ; Islas Malpelo and Gorgona, Colombia ; Galápagos Islands, Ecuador ; and Islas del Coco and Caño, Costa Rica.

Isla del Caño (Fig. 1) is the best reef near-shore on the Pacific coast. As mentioned above, the 300 hectares of forests and beaches are protected but its marine environs are not. Since January, 1984, studies on the islands reef are being conducted. Preliminary results indicate that there is good reef growth, with 12 species of scleractinian corals down to a depth of 15 m. The octocorallarian fauna is rich but scarcely known : 'Nothing short of a comprehensive revision will serve to clarify the status of the numerous species reported over the past century' (Frederick M. Bayer, Smithsonian Institution, pers. com., 1984). Isla del Caño represents an excellent ground for biological and biogeographic studies ; it also constitutes an important area for fisheries and tourism. There is no question in regard to the urgency to undertake actions for the protection of its reefs. The inclusion of the reefs in the already protected terrestrial reserve should not represent great difficulty: (1) the whole island is a Natural Reserve, (2) opposition to the protection of the reefs will probably be minimal to non-existent.

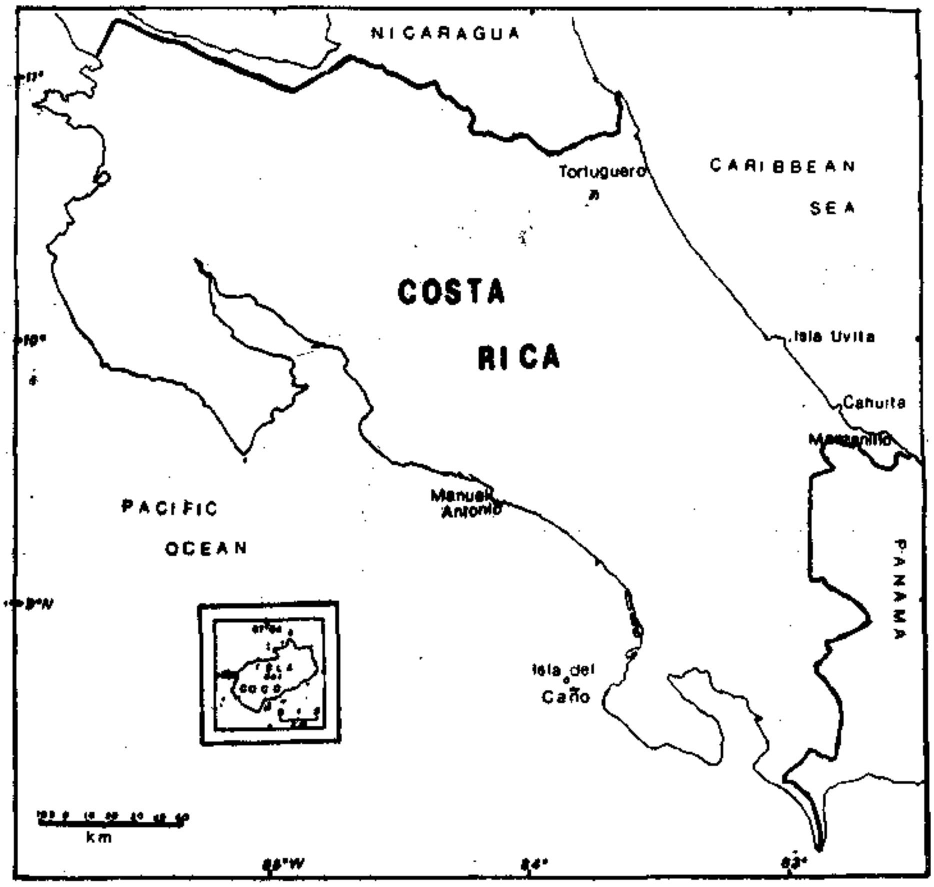

FIG. 1. Map of Costa Rica with indication of the main reefs on the Pacific and Atlantic Coast.

Atlantic Coast

Two zones are proposed as marine reserves on the Atlantic coast: Isla Uvita, and Manzanillo-Punta Mona (Fig. 1).

Isla Uvita is just off the port of Limón. Even though pollution is high around Limón and the island is just a few hundreds of meters away, the reefs at Uvita are surprisingly well developed. The probable reason for this is the deep channel with a strong current that separates them, bringing clean water to Isla Uvita and removing pollutants from Limón away from the island. The terrestrial environment is partly protected by the Port Authorities, but not the reefs. Boat loads of corals are periodically removed for decoration.

The reef complex between Manzanillo and Punta Mona is among the most extensive in Costa Rica. The reefs seem to be healthy and unaltered mainly because access is difficult and few people live nearby. However, a penetration road is under construction (July, 1984) to Manzanillo ; very soon loggers will start cutting down the virgin forests between Manzanillo and Punta Mona. Cutting down the forest in an area where it rains all year round will increase the amount of sediments in the creeks and nearby reefs. Opening of that area will also bring visitors and unrestricted collectors of corals and other forms of marine life. Because of the healthy condition of the reefs, their protection as well as the protection of adjacent forest is most urgent, because of the imminent dangers. Such task will not be easy since the land has to be bought and resources, already limited, must be dedicated to the protection of the area. Costa Rica constitutes no exception to the serious economic crisis affecting the developing world. Under such circumstances it becomes an almost impossible task to find the resources, not talking about interest or motivation, to protect these delicate and unique environments. Emphasis should be made on the fact that Costa Rica is too poor otherwise not to spend in protecting its natural heritage.

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THE IMPORTANCE OF MARINE PARKS FOR THE MANAGEMENT OF DUGONGS IN AUSTRALIAN WATERS

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ABSTRACT

Although the dugong is considered to be vulnerable to extinction, significant numbers still occur in the seas extending along about 15,000 km of Australia's northern coastline. In this region, dugongs are killed legally by traditional hunters, incidentally in gill-nets, and illegally, however, the status of Australia's dugong stocks is unknown. Life history studies based on carcass analysis indicate that dugongs have a low reproductive rate, and that man-induced mortality must be kept at a very low level for dugong population maintenance. Given the huge range of the dugong in Australia, and the multiple demands on the resources of this area, a desirable approach to management would be the development of a series of management areas along the lines of the Great Barrier Reef Marine Park.

SIGNIFICANCE AND STATUS

THE DUGONG *Dugong dugon* (Müller), one of the four extant species of Sirenia or seacows, is of particular interest as the only existing herbivorous mammal which is strictly marine. Dugongs are distributed in shallow, warm tropical and subtropical coastal waters in the Indian and Western Pacific Oceans as summarised by Nishiwaki and Marsh (in press).

The dugong is listed as vulnerable to extinction by the IUCN (Thornback and Jenkins, 1982). Uncontrolled deliberate and accidental exploitation has seriously depleted populations throughout its wide range. Over much of this range the dugong is now represented by relict populations separated by large areas where it is close to extinction or extinct.

Extensive aerial surveys conducted since 1974 have confirmed that sizeable populations still occur in the shallow seas around northern Australia (Heinsohn *et al.*, 1976a, 1978 ; Ligon, 1976 ; Marsh *et al.*, 1981, 1984a ; Elliott, 1981 ; Prince *et al.*, 1981 ; Anderson, 1982) between Shark Bay in Western Australia and Moreton Bay in Queensland (Fig. 1). It is likely that this region supports a major proportion of the world's dugongs.

Most dugong surveys have been essentially qualitative. Although they have identified localities which still support large numbers of animals (Fig. 1), most workers have not attempted to convert counts into population estimates because of the variably muddy water. It is not known whether dugong numbers are increasing, decreasing or stable at any of the major dugong habitat areas that have been identified in Australia.

This paper outlines the need for management of dugongs in Australian waters and the importance of marine parks as a means of accomplishing this end. It is based on more detailed accounts published elsewhere (Marsh, 1980, in press ; Marsh *et al.*, 1984 a, b, c, d).

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Legal situation

In Australia, dugongs are protected by State and Federal legislation. Only indigenous people are allowed to hunt them, and trade in dugong products is illegal. Apart from these restrictions, the legal situation differs somewhat in different States. For example, in Queensland only Aborigines or Islanders living on reserves and in certain shires are automatically allowed to hunt. Indigenous people living off reserves may, however, apply to take dugongs under permit. In the Northern Territory, all Aborigines can hunt provided they do so in 'traditional hunting areas'. In Queensland, hunters are not allowed to use 'noxious substance' or 'explosive devices'. These restrictions do not apply in the Northern Territory.

Most dugong habitat areas in Australia are so remote that these laws have not been policed effectively.

Dugong life history

Carcass analysis has been used to elucidate the life history parameters of the dugong. Specimens from about 160 animals from northern Australia have been examined (Marsh, 1980; Marsh *et al.*, 1984 b, c, d). Work is almost completed on specimens from more than 450 dugongs killed in an indigenous fishery in Torres Strait (Marsh and Hudson, unpublished). Maximum longevity is estimated to be 60-70 years and the minimum pre-reproductive period nine to ten years for both sexes. Estimates of mean calving interval based on (*a*) apparent pregnancy rate (*b*) accumulation rate of placental scars (*c*) calf counts during aerial surveys and from vertical aerial photographs, range from three to seven years for various populations. A simple population model has been developed to calculate the maximum rate of increase for populations with different combinations of calving interval, mortality schedule, and prereproductive period (Marsh *et al.*, 1984 a). This model indicates that dugong populations are unlikely to increase at a rate of more than 5% per year even with the most optimistic schedule of reproduction and mortality.

Thus no dugong population is likely to be able to sustain an unselective annual harvest of more than five per cent of females. Sexual dimorphism is slight (see Marsh, 1980). Although some indigenous fishermen claim that they can sex a dugong before catching it, such traditional skills are rapidly being lost. Protection based on a selective fishery for male dugongs would thus seem impractical.

If dugong numbers are to be maintained in Australia, man-induced mortality must be regulated within low levels.

Causes of Man-Induced mortality of Dugongs in Australia

The major immediate threats to dugongs are from direct hunting for food and other products, and from incidental captures in shark and other fish nets. Long term threats may result from destruction of coastal habitats and pollution.

Legal exploitation by indigenous people

Australian Aborigines and Torres Strait Islanders now mainly hunt dugongs from outboard-powered dinghies. Use of the traditional harpoon with a detachable head (wap) as described by Marsh *et al.*, (1981) is usual. In Queensland, some indigenous people admit to killing dugongs by shooting rather than drowning after harpooning. They justify this practice on humane grounds.

Modern hunting techniques have certainly reduced the effort required to hunt dugongs and have extended the availability of hunting grounds both in space and time. The increasing availability of freezers even in remote settlements has also increased the length of time that dugong meat can be kept. There is now considerable incentive to catch for the future as well as for immediate consumption.

Traditionally, hunting was the province of only a few men in a village. The hunters usually kept a tally of the number of dugongs caught, indicating that catching a dugong was a special event. These restrictions no longer apply in most communities. Now anyone who can organise the required equipment can hunt.

The breakdown of traditional society can seriously increase the impact of indigenous peoples on dugong numbers in other ways as well. At Hopevale, an Aboriginal community whose members hunt in the Starcke River area, young men without traditional skills but who believe they have the right to hunt, recently started shooting dugongs for sport to the consternation of community elders. Fortunately, this practice has been stopped.

In contrast, other factors undoubtedly mitigate against hunting on a large scale today in many communities. Some of the men are in regular employment which limits their hunting to non-working hours. Canteens selling alcoholic beverages have become the focus of the social life of numerous communities. Canteen attendance effectively prevents hunting at night. Boat usage is often severely curtailed by the lack of motor maintenance and price of fuel. The combined effects of these factors means that modern technology does not necessarily increase the dugong catch.

Until proper monitoring programmes are developed, it will be impossible to assess the impact of the present levels of non-commercial indigenous hunting on dugong populations in Australian waters. Our limited knowledge suggests that the impact of such hunting can change rapidly with the availability of western technology, particularly outboard motors.

Incidental exploitation

Dugongs are killed incidentally in the inshore gill-net fisheries of northern Australia. Reports of this incidental take give cause for concern, but it has not been possible to obtain precise figures. An informant involved in fisheries research, who interviewed fishermen along the west coast of Cape York in 1980, reported that 17 professional barramundi fishermen each caught between five and ten dugongs per year. One operator working on a seagrass bed in a river estuary allegedly accidentally caught 23 dugongs in one week before he removed his nets. Mr. Rod Garrett (Northern Fisheries Research Centre) reported that in the first 19 days of the 1982 commercial barramundi netting season, five of 40 operators based at Karumba in the Gulf of Carpentaria had each caught one dugong ; two of these five animals drowned. Over the period March 1979 to March 1983, Queensland Fisheries Research Branch personnel set gill-nets over a total of 135 nights in the Princess Charlotte Bay, Bathurst Bay, Ninian Bay region. Eleven dugongs were caught ; ten were released alive (R. Garrett, in litt.). Apart from these figures, the proportion of dugongs which die as a result of tangling in nets is unknown, but experience suggests that it may be significant (Heinsohn *et al.*, 1976 b ; Marsh and Anderson, 1983). Most dugongs are caught in nets set on coastal foreshore flats outside river estuaries, When one considers this anecdotal information in the perspective of the recent growth of the barramundi fishery, the implications for dugong populations are extremely worrying. Australian barramundi landings increased almost tenfold between 1969-70 and the peak in 1977-78 (Australian Bureau of Statistics, in Anon., 1982 a). As a measure of the increase in fishing pressure these figures are conservative as the catch per unit effort has declined.

In 1981, there were 98 licensed commercial barramundi fishermen in the Northern Territory and 11 Aboriginal community fishing licenses (Anon., 1982 b). In Queensland, the Gulf of Carpentaria barramundi fishery supports 159 fishermen. A further 403 fishermen are involved in the east coast mixed gill-net fishery (Anon., 1982 c).

Dugongs are also drowned incidentally in shark nets set for bather protection in Queensland. In 1964-65 (the first year of netting), 82 dugongs were drowned in the Townsville shark nets (Heinsohn, 1972). A total of 522 dugongs were drowned between 1964 and June 1983 in shark nets throughout Queensland (R. Paterson, pers. comm.). The number of animals that drown in shark nets each year has declined. The reasons for this decline have not been determined.

Illegal harvest

Dugongs are also taken deliberately and illegally, largely to supply meat to urban Islanders and Aborigines living in the coastal cities and towns of northern Australia. In Queensland, these people often resent the loss of their traditional hunting rights as they still crave dugong meat especially for ceremonial occasions.

An informant involved in fisheries research advised me that in November 1980, 28 dugongs were killed and frozen by fishing boat operators at a reef near Princess Charlotte Bay. In November 1981, the same crew killed another eight dugongs at the same reef. Such activities are lucrative as a dugong sells for about $A200.

It is very difficult to assess the extent of illegal exploitation. Dugong meat is not usually sold openly, but through informal networks of contacts. The situation is likely to be most serious in Torres Strait where the order of 200 or more dugongs are apparently taken each year by Islanders who own and operate cray-boats. Most of the meat is sold locally, but further quantities are apparently carried by Islanders to relatives in other areas.

If management authorities are serious about conserving Australia's dugong population, attempts must be made to stop this illegal exploitation.

Capture stress

As summarised in Marsh and Anderson (1983) there is evidence that dugongs may be susceptible to capture stress. This syndrome, which has been documented best in ungulates, but which is also thought to occur in manatees (R. C. Best, in litt.), causes animals to die within a few hours to several weeks of chase, handling and capture. Boats powered by outboard motors are becoming increasingly available in dugong habitats. Their use may significantly increase any risk of stress effects, either in the course of unsuccessful hunts, or during pursuit by curious non-hunters. The deleterious effects of capture stress are likely to be most serious for dugong populations close to urban development. The effects of capture stress may also reduce the survival chances of dugongs that are released alive from nets.

Environmental modification

Aerial surveys have shown that dugongs tend to occur in warm, shallow, sheltered, inshore and reef areas where extensive beds of seagrasses occur (Heinsohn *et al.*, 1977). Larkum and West (1982) list a number of possible or known causes of man-induced depletion of seagrass beds including the following:

1. turbidity increases associated with dredging,
2. turbidity increases associated with industrial or urban influences,
3. turbidity increases associated with eutrophication,
4. toxic chemicals,
5. hot water effluents,
6. oil spills,
7. activities of commercial fishermen using bottom trawls,
8. changes in salinity,
9. sewerage.

As Larkum and West point out, the evidence that these factors have caused depletion of seagrass beds is often less than convincing as many of the sites where depletion occurred were subject to multiple impacts. With the exception of the possible effects of commercial fishermen using bottom trawls, these factors currently affect a relatively small proportion of the dugong's range in Australia. However, the potential for such damage highlights the need for careful planning and management.

The limited evidence available indicates that dugongs calve in very shallow water (Marsh *et al.*, 1984 d), presumably to minimize shark predation. These areas are most vulnerable to the effects of development. For example, a beach area near Townsville where a dugong was seen calving in about 1950 (F. Griffin in Marsh *et al.*, 1984 d) is now scheduled as a site for a casino. The likely impact of the loss of inshore calving areas could be considerable.

NEED FOR MARINE PARKS OR OTHER MANAGEMENT AREAS

In Australian waters, the range of the dugong (Fig. 1) extends along of the order of 15,000 km of coastline and includes seas variously controlled by the Federal Government and three different State Governments and their associated departments and authorities. Both conservation and development are necessary in this region, and must be made compatible with each other. This will demand sophisticated resource-use planning on a huge scale. Such planning must recognize the traditional dietary and cultural needs of the indigenous inhabitants of the area.

I consider that this would best be achieved by the development of a series of marine parks or other management areas each of which embodied the concepts being developed for the Great Barrier Reef Marine Park (Kelleher and Kenchington, 1982). 'The Great Barrier Reef Marine Park is divided into sections each of which usually encompasses some thousands or tens of thousands of square kilometres. Each section is divided into zones, with highly protected zones being generally adjacent to or surrounded by, zones of moderate protection. Adjacent to or surrounding these are zones with very few restrictions indeed.'

The Great Barrier Reef Marine Park will eventually protect dugongs along a significant proportion of the eastern coast of Queensland. Ideally, parks should be developed on a similar scale along other parts of the Australian coastline. The Gulf of Carpentaria is an obvious example. This area not only contains very important fishing and prawning grounds, but also significant numbers of dugongs. In Some parts of the Gulf of Carpenteria, such as the McArthur River area (Fig. 1), dugongs are still a very important component of the traditional lives of the local Aborigines. However, the anecdotal information available suggests that more dugongs are killed each year incidentally and/or illegally by white Australians in this area than by the traditional hunters (J. Bradely, *in litt.*, 1984).

Effective management of Australia's dugong population, will entail keeping the traditional harvest within a level compatible with population maintenance, and the assessment of the impact of other activities on dugong numbers. Activities which are incompatible with dugong population maintenance will need to be excluded from at least some of the areas which support large numbers of animals (Fig. 1). The areas set aside will need to be large enough to protect the full range of necessary habitats, including dugong feeding, calving and resting areas. The development of effective zoning plans will require a knowledge of dugong movements and detailed habitat requirements. For example, dugongs use different sides of Shark Bay in summer and winter (Anderson, 1982 pers. comm., 1982). As our knowledge of

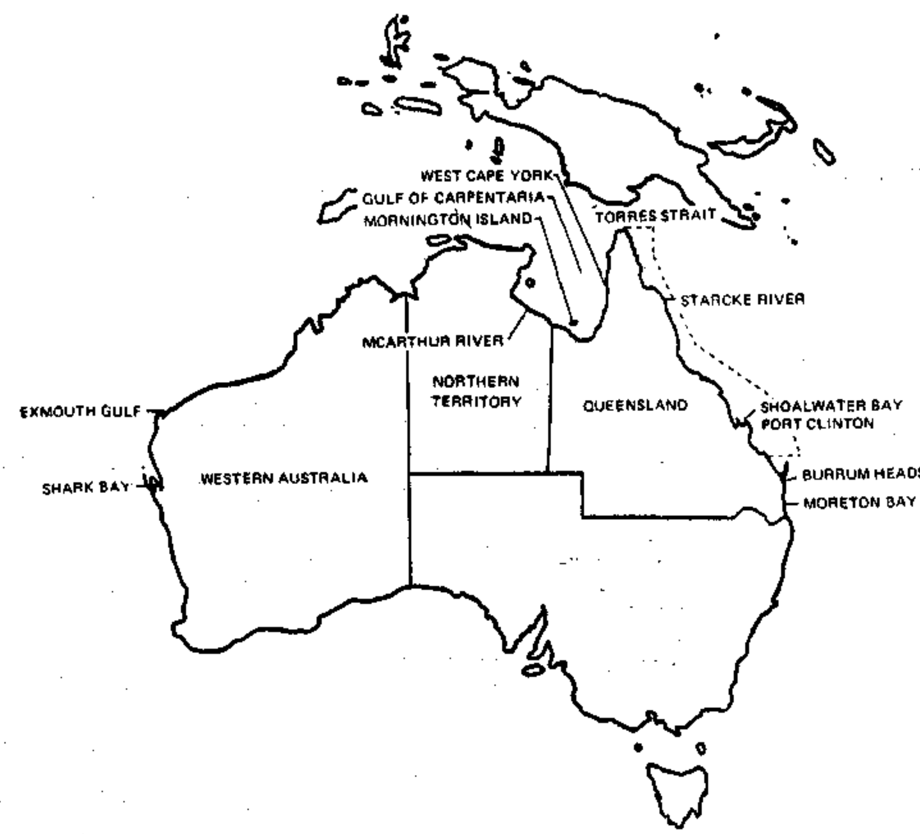

FIG. 1. Map of Australia showing major dugong habitat areas. Dugongs range from Shark Bay in the west to Moreton Bay in the east. Localities have been marked where more than 100 dugongs have been counted during a single aerial survey. The Queensland data are from Heinsohn and Marsh (1981) and Marsh *et al.* (1984 a); those from Western Australia are from Anderson (1982) and Prince *et al.* (1981). The McArthur River area, the most important area for dugongs yet identified in the Northern Territory (Elliott, 1981 and unpublished) has also been included. The boundary of the Great Barrier Reef Marine Park Region is outlined with a dotted line. The Gulf of Carpentaria and the boundaries of the States of Queensland, Northern Territory and Western Australia have also been indicated on the diagram as these have been mentioned in the text.

dugong biology is inadequate, zoning plans will also need to have provision for updating to take account of new information.

Several management areas are gradually being developed along these lines. One example is in the Cairns Section of the Great Barrier Reef Marine Park which is jointly administered by the Federal and Queensland Governments. The zoning plan provides for the protection of dugongs in the Starcke River area. The dugong habitat below low water mark is to be managed as a *Scientific Research Zone* in which collecting and net fishing are banned but where the indigenous people of the adjacent area will be allowed to hunt dugongs under permit (Great Barrier Reef Marine Park Authority, 1982 and pers. comm., 1984). Negotiations are in progress between the indigenous hunters and officers of the Great Barrier Reef Marine Park Authority and the Queensland National Parks and Wildlife Service Maritime Estate Branch to ensure that the hunting permits are issued under mutually acceptable conditions.

The establishment of marine parks will also lead to the development of research, surveillance, monitoring and, most importantly, public education programmes to ensure that management plans are effectively implemented. Legislative protection is obviously ineffective without enforcement. However, it is unrealistic to pretend that the surveillance of such a huge and remote area as the waters of northern Australia can ever be adequate to deter all offenders. As a result, in order to be effective, a dugong management programme will have to emphasize public education. Traditional hunters need to be encouraged to take the responsibility of regulating their own catch. Fishermen also need to be made aware of the need to minimize incidental mortality and illegal killing. All sectors of the community need to be made aware of the dangers of inducing capture stress by chasing dugongs with speed boats.

The effectiveness of marine parks and other management areas in conserving Australia's dugongs will be enhanced if an integrated management plan is developed for the whole region. Monitoring programmes are expensive and once optimized should be standardized to facilitate comparisons between areas. The development of public education programmes is also expensive, and although such programmes should be customized for different localities, it is desirable for each programme to benefit from the experience of the others.

Within Queensland, the Queensland Fish Management Authority has taken a commendable lead in this direction by establishing an interdepartmental committee with both State and Federal representatives which is considering the overall problem of dugong management. It is to be hoped that this committee is the forerunner of a more broadly-based body which will coordinate dugong management throughout northern Australia.

Managing the dugongs in Australian waters should be relatively simple compared with most of the rest of its range where human population density is higher, and the conflicting demands on coastal resources much greater and more complex. As an affluent nation whose waters support a significant proportion of world dugongs, Australia should be prepared to take a leading role in developing programmes to conserve these animals—or to take most of the blame if they become extinct.

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STATUS OF SOME ENDANGERED MARINE ANIMALS AND MARINE PARKS IN THE EGYPTIAN RED SEA

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THE EGYPTIAN Red Sea coast and islands have been surveyed during the last five years, with emphasis given to the endangered marine animals and their habitats. Efforts were also made to designate areas of great potentiality for marine parks and nature reserves.

Red Sea mammals are represented by two orders : Sirenia (one species of dugong) and Cetacea (about 12 species). Reptiles are mainly represented by turtles (5 species).

The Red Sea dugong, *Dugong dugong tabernaculi*, is found mainly in shallow water and lagoons with abundant vegetation of the sea-grass, *Diplathera uninervis*. It frequents only isolated places, abandons areas where they might be disturbed by people, boats, large predator animals or intruders of any kind. So far, this subspecies is restricted in its distribution to the Red Sea and extends into its two annexes, the Gulfs of Suez and Aqaba. They are extremely rare at the present time, but seem to have been much more abundant a century or more before. Females seem to be the commoner, or at least more often caught in the nets than males. Being very shy, dugongs are not easily observed in the sea in their natural environment.

There are possibly around a dozen species of toothed cetaceans in the Red Sea and the Gulfs of Suez and Aqaba. The majority of the animals comprise just two species, the bottle-nose dolphin, *Tursiops truncatus*, and humpack dolphin *Sousa chinensis*. Both these dolphins have been reported from the Suez Canal although *Sousa* has not been seen further north than the Bitter Lakes. Other species which have been seen in the Red Sea include *Kogia* (2 species), *Feresa, Pseudorca, Grampus, Stenella* (possibly 3 species) and *Delphinus*.

Five species of sea turtles occur in the Egyptian Red Sea and only three are recognized by local fishermen : *Eretmochelys imbricata, Chelonia mydas* and *Dermochelys coriacea*. *E. imbricata* is the most abundant although their occurrence in the Gulfs of Suez and Aqaba may be less common than the Red Sea proper. Nesting is widespread, mainly on islands along the Red Sea coast, Mainland nesting also occur at Ras Mohammed and Ras Benas. Exploitation of turtles, mainly for meat and eggs, is slight although historic evidences suggest that Egypt once had a thriving trade in turtle products.

The entire Red Sea is at stake from oil pollution and marine explosions. Endangered marine species have reportedly been killed, their prey items and habitats have been destroyed, and they have been disturbed and frightened away from countless places by underwater explosions.

There is insufficient information to understand either the short or long term effects of massive oil pollution and underwater explosions, but the environmental changes are clear enough. The future of the endangered marine animals is tied to the great need for more basic information and vigorous management of the marine environment.

Ras Mohammed, the small peninsula which form the southern tip of Sinai, is of exquisite natural beauty and surrounded by the most spectacular coral reef in the world. The area is used as nesting place for sea turtles, and as a resting station for migratory birds such as white stork. Ospreys and sooty falcons nest on the peninsula. The area is also noted for its clusters of mangrove trees, *Avicennia marina*, and the presence of the desert fox.

Therefore, Ras Mohammed was selected to be the first national marine park in Egypt. Announcement of its establishment was made in November 1983 and all measures were taken to protect and conserve its aquatic and wildlife. Several other areas significant for the different Red Sea ecosystems are proposed as nature reserve areas. These include Al-Ghardaqa, Wadi el Gimal, Hamata, and surrounding islands.

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TRADEOFFS IN CETACEAN CONSERVATION

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ABSTRACT

Concept of cetacean conservation range from numerical assessments of stocks and allowable crops, to views that accord cetaceans rights of existence which challenge human exploitation in all forms, and even casual intrusions into cetacean territories. Tradeoffs, between scientific knowledge and ignorance, between economic greed and species survival, between nationalism and planetarism, and between politeness and rudeness, characterize recent phases of human-cetacean relations. A historical overview of some of these tradeoffs is provided, and an opinion rendered : namely, that the natural energetics of the situation will, as the pendulum swings, soon restore to cetaceans much of the position which they once held in the oceans prior to the emergence of humans as the dominant species on the planet.

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