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DISTRIBUTION OF SOME OCEANOGRAPHIC FACTORS IN THE ARABIAN SEA OFF MANJESWAR AND THEIR POSSIBLE EFFECT ON OILSARDINE AND MACKEREL FISHERIES IN THE AREA*

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ABSTRACT

Studies on the vertical and monthly distribution of sea water temperature, salinity, dissolved oxygen and some other oceanographic parameters carried out at eight stations in the Arabian Sea off Manjeswar revealed some interesting features. Generally, the waters off Manjeswar within 50 m depth were found to be more or less isothermal during January, February and December. In May, September and October, vertical temperature gradients in the 50 m depth water column were comparatively high. The studies indicated the presence of the top of the thermocline between 10 and 15 m depths during September. The increase of salinity with depth was more pronounced during the period from March to November probably due to the occurrence of salinity stratification in these months. Near isohaline conditions were present together with a deep thermal mixed layer during January, February and December perhaps due to the mixing associated with strong winds.

Of all the important oceanographic parameters, water temperature and salinity of columnar waters appeared to have direct effect on the pelagic fisheries of oilsardine and mackerel in the area. Any deviation from their respective optimum values of columnar water temperature and salinity appeared to be responsible for the low catches of oilsardine and mackerel. Rainfall, pH, dissolved oxygen and transparency were found to have indirect effect on the pelagic fishery of oilsardine and mackerel.

INTRODUCTION

HYDROGRAPHIC conditions of the upper mixed layer in the sea play a dominant role in the behaviour of the pelagic fishes and hence their fisheries. The Karnataka-Kerala Coast on the west coast of India supports a rich fishery contributed by the oilsardine and Indian mackerel. The coastline near Manjeswar bordering Karnataka and Kerala is located in one of the most productive fishing zones. It is well known that the fisheries of oilsardine and mackerel are fluctuating from month to month, season to season and year to year. In the past, several attempts were made to find out the relationship between oceanographic parameters and oilsardine and mackerel fishery along the west coast in order to explain the observed fluctuations in their landings (Prabhu and Dhulkhed, 1970 ; Venkataraman and Narayana Rao, 1973 ; Murty and Vishnudatta, 1976 ; Suresh and Reddy, 1980).

In the present study, an attempt is made for the first time to understand the vertical and monthly distribution of certain oceanographic factors in the Arabian Sea off Manjeswar and their possible influence on oilsardine and mackerel fisheries in area.

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Material and Methods

Data on sea water temperature and salinity against depth were obtained in the Arabian Sea at eight stations along two sections, one off Someswar and one off Manjeswar (Fig. 1) to December 1984 except in the southwest monsoon months of June, July and August, during the cruises of the fishing vessel M.F.V. Dolphin of the College of Fisheries.

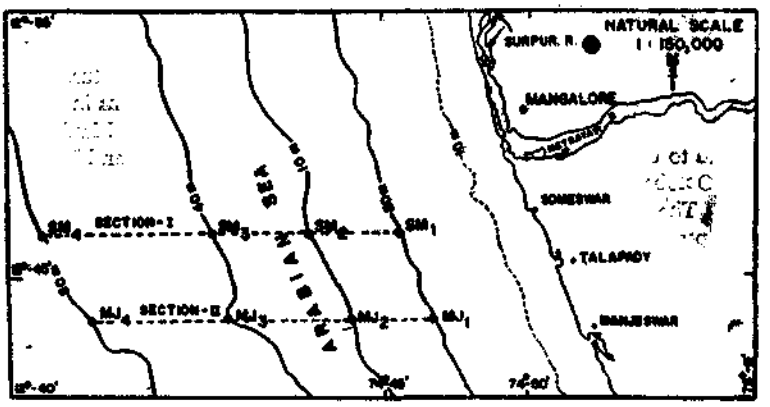

Fig. 1. Sampling stations in the Arabian Sea along two sections, one off Someswar and another off Manjeswar.

using Environmental Engineers STD recorder. Water samples for dissolved oxygen estimation were collected using Nansen reversing water bottles. Later in the laboratory, dissolved oxygen was estimated following Strickland and Parsons (1972). The pH of the water sample was determined immediately after collection using a Lovibond color comparator with thymol-blue disc. The extent of vertical sunlight penetration in the water was measured with the help of a Secchi disc and later they were converted to extinction coefficient values. Monthly landings of oilsardine and Indian mackerel in the region between Someswar and Manjeswar were obtained from the Assistant Director's Office (Fisheries), Mangalore. Oceanographic collections were made at monthly intervals for one year from January

Results and Discussion

Sea water temperature

Vertical temperature values in the waters off Manjeswar showed monthly and seasonal variations. In the winter period *i.e.*, January, February and December months, the surface temperature was low and the mixed layer was deep and extended to the entire water column ranging from 20 to 50 m depth depending upon the depth of the water. Inversion of temperature was noticed at certain depths during the months of January and February, otherwise, the waters were well mixed thermally (Figs. 2 to 5). This may be the result of strong winds associated with these months (Table 1). Varma *et al.* (1980) observed a deep mixed layer during February in the northern Arabian Sea. From March to May, the temperature at the surface gradually increased due to absorption of solar energy. A rapid decrease in temperature within a short range of depth was noticed particularly in September and October. After October, a net loss of heat

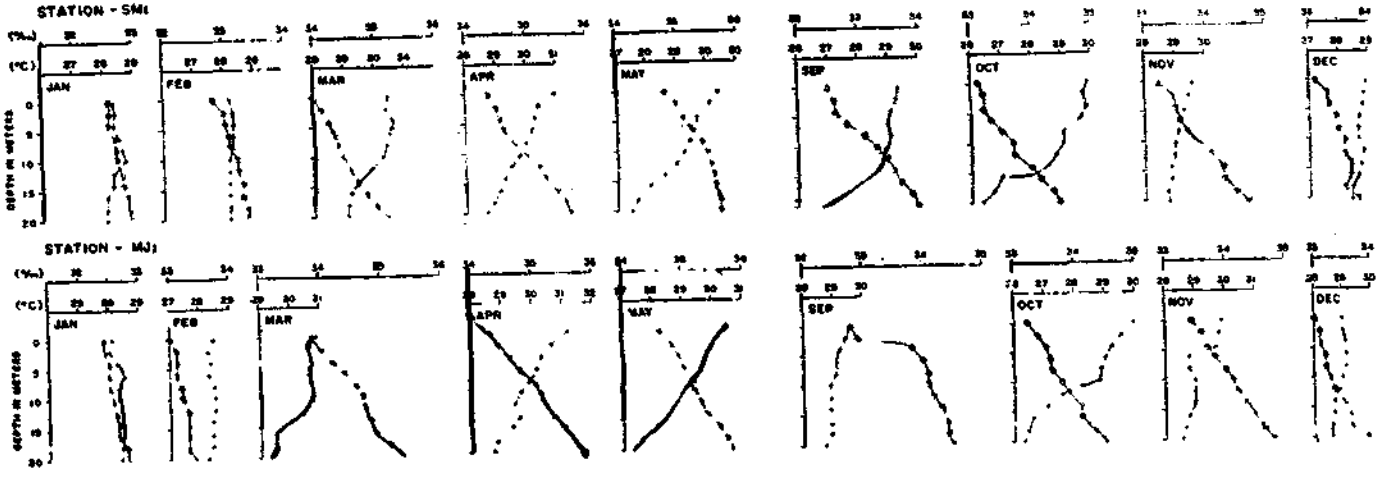

Fig. 2. Vertical profile of temperature and salinity for stations SM 1 and MJ 1.

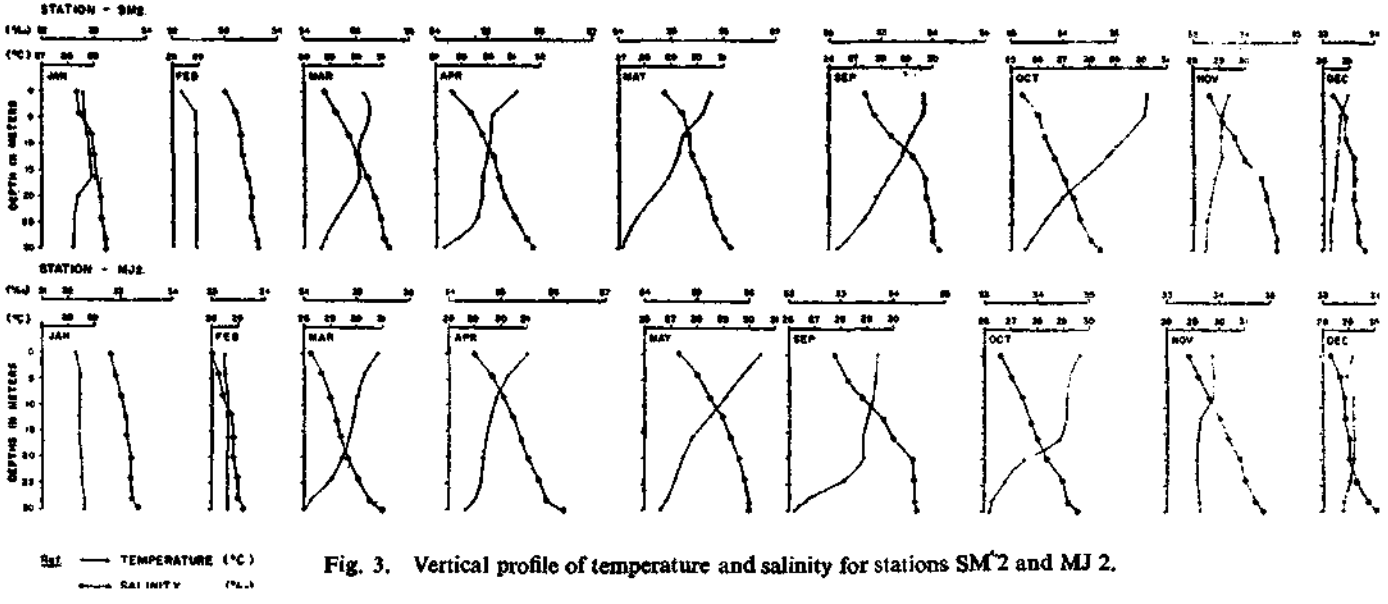

Fig. 3. Vertical profile of temperature and salinity for stations SM 2 and MJ 2.

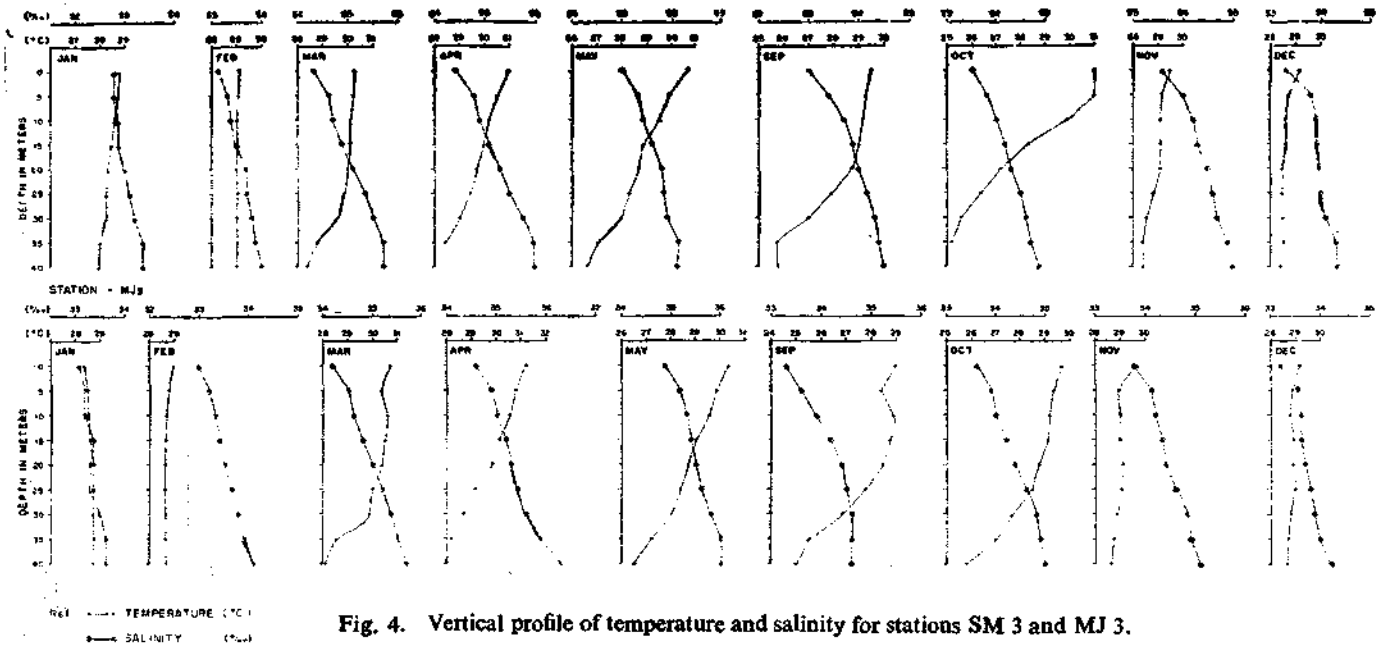

Fig. 4. Vertical profile of temperature and salinity for stations SM 3 and MJ 3.

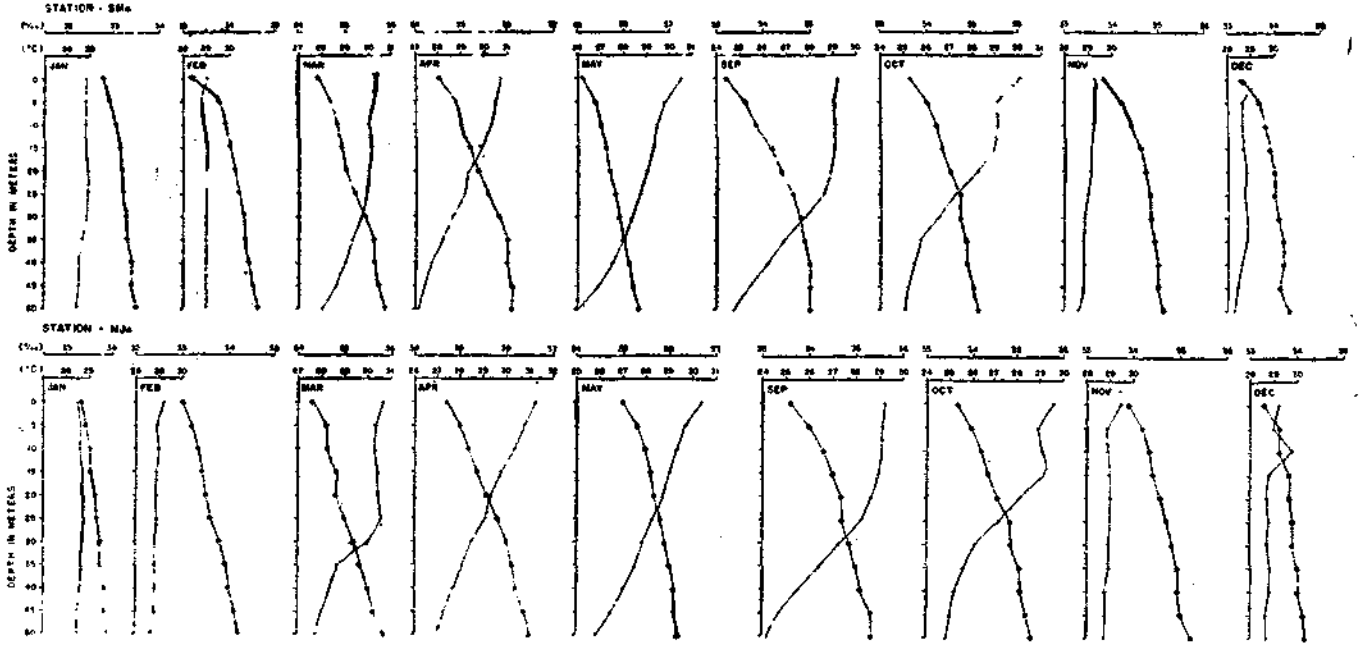

Fig. 5. Vertical profile of temperature and salinity for stations SM 4 and MJ 4.

TABLE 1. *Wind direction and wind speed (m/min) at the different stations located along the section I and II in* 1984

Section		Jan.		Feb.		Mar.		Apr.		May		Sep.		Oct.		Nov.		Dec.	
	Station	Di	Sp	Di	Sp	Di	Sp	Di	Sp	Di	Sp	Di	Sp	Di	Sp	Di	Sp	Di	Sp
I	SM1	ENE	230	ENE	285	E	70	E	45	NE	100	SE	90	SSE	60	ENE	140	NNE	195
	SM2	NNW	260	NE	270	Calm		SE	70	SE	85	S	120	ENE	82	ENE	170	N	194
	SM3	NNW	270	ENE	250	W	120	E	46	WSW	86	SSW	150	E	145	NE	256	NNE	96
	SM4	NW	190	ENE	220	W	130	Calm		W	160	S	170	NE	140	ENE	160	NE	152
II	MJ1	NE	200	NE	220	E	20	W	55	NE	105	WSW	60	W	70	E	160	N	168
	MJ2	NE	195	NE	190	W	145	Calm		ENE	96	WSW	210	W	80	E	220	NNE	106
	MJ3	NW	196	ENE	180	W	100	Calm		SE	120	WSW	120	WNW	80	E	140	N	96
	MJ4	WNW	180	ENE	170	W	80	E	29	WNW	146	SW	170	WNW	125	E	151	NNW	132

Di = Direction ; Sp = Speed.

energy from the sea together with mixing were probably responsible for the small vertical temperature gradients. Panikkar and Jayaraman (1966) observed that with the progress of the summer monsoon, there would be a gradual 'upward migration' of the thermocline, reaching 20 - 30 m and even surfacing in some areas towards the later of the summer monsoon and early postmonsoon. Observations on vertical temperature in the Arabian Sea off Manjeswar in present study showed broadly these features. Even though the observations were confined to a depth of 50 m only, the upper limit of the zone of sudden decrease of temperature which could be considered as the top of the thermocline was found between 10 and 15 m depths during September. This feature was noticed in October also in the area of investigation.

Salinity

In general, salinity increased from surface to bottom at all the stations in the sea off Manjeswar throughout the period of study (Figs. 2 to 5). However, the range of salinity from surface to bottom was not same in all the months. The vertical salinity range was lowest in the month of January in the entire area of observation. The salinity ranges were smaller comparatively in February and December months also. Mixing of waters due to winds could be the probable reason for the near isohaline condition and for the smaller vertical salinity gradients in these months. It is interesting to note that near isohaline condition was present with a deep thermal mixed layer during this period. Such features might also be brought about by sinking phenomena prevailing along the coast of Manjeswar during the winter season. Higher salinity variations from surface to bottom were found from March to November, with maximum ranges being generally in September and April. Narayanaswamy and Sarma (1982) observed increase in salinity from surface to bottom in the coastal waters along Gujarat Coast during October and November. Salinity stratification

TABLE 2. *Vertical distribution of dissolved oxygen (ml/l) at the different stations located along section I and II in the fishing grounds off Manjeswar in* 1984

Section	Station	Level	Jan.	Feb.	Mar.	Apr.	May	Sep.	Oct.	Nov.	Dec.
I	SM1	S	5.13	4.92	4.65	4.56	4.03	3.97	4.54	4.93	5.03
		M	5.03	4.69	4.62	4.43	3.91	3.62	4.29	4.85	4.88
		B	4.63	4.43	4.24	4.15	3.74	3.35	4.23	4.44	4.75
	SM2	S	4.85	4.83	4.65	4.53	4.01	3.84	4.63	4.93	5.03
		M	4.61	4.65	4.55	4.23	3.64	3.54	4.43	4.69	4.85
		B	4.58	4.43	4.38	4.17	3.55	3.09	4.22	4.46	4.74
	SM3	S	4.69	4.58	4.43	4.26	3.95	3.80	4.63	4.88	4.95
		M	4.49	4.44	4.15	4.01	3.52	3.74	4.34	4.74	4.86
		B	4.49	4.25	4.15	3.96	3.28	3.22	4.19	4.67	4.85
	SM4	S	5.15	4.18	4.51	4.26	3.71	3.70	4.55	4.83	4.89
		M	4.69	4.62	4.15	3.92	3.44	3.06	4.17	4.65	4.74
		B	4.69	4.15	3.92	3.69	3.06	2.92	4.03	4.55	4.74
II	MJ1	S	5.15	4.92	4.68	4.46	4.11	3.85	4.45	4.96	5.04
		M	4.90	4.89	4.40	4.28	4.02	3.63	4.43	4.65	4.95
		B	4.82	4.68	4.25	4.28	3.83	3.56	4.34	4.58	4.83
	MJ2	S	4.91	4.90	4.61	4.41	4.03	3.78	4.44	4.74	4.93
		M	4.89	4.68	4.38	4.26	3.61	3.37	4.23	4.58	4.85
		B	4.85	4.57	4.15	4.17	3.47	3.19	4.08	4.44	4.65
	MJ3	S	4.86	4.69	4.38	4.31	3.89	3.62	4.52	4.74	5.04
		M	4.64	4.62	4.15	4.09	3.46	3.22	4.23	4.56	4.87
		B	4.45	4.59	4.15	4.02	3.35	3.05	4.13	4.45	4.62
	MJ4	S	4.79	4.84	4.38	4.26	3.56	3.30	4.46	4.64	4.93
		M	4.62	4.58	4.15	3.88	3.37	3.08	4.33	4.63	4.84
		B	4.49	4.36	4.15	3.46	3.12	2.96	4.18	4.45	4.57

S = Surface water ; M = Mid-depth water ; B = Bottom water.

TABLE 3. *Extinction co-efficient values of the waters of the Arabian Sea off Manjeswar region during* 1984

Section	Station	Jan.	Feb.	Mar.	Apr.	May	Sep.	Oct.	Nov.	Dec.
I	SM1	0.78	0.34	0.24	0.27	0.29	0.31	0.31	0.45	0.68
	SM2	0.57	0.17	0.13	0.19	0.23	0.33	0.14	0.35	0.21
	SM3	0.24	0.14	0.11	0.14	0.19	0.31	0.14	0.37	0.20
	SM4	0.20	0.11	0.08	0.10	0.12	0.23	0.17	0.37	0.18
II	MJ1	0.57	0.31	0.40	0.27	0.30	0.34	0.23	0.44	0.85
	MJ2	0.45	0.21	0.13	0.13	0.16	0.34	0.23	0.43	0.51
	MJ3	0.23	0.17	0.07	0.15	0.17	0.25	0.19	0.35	0.89
	MJ4	0.19	0.13	0.12	0.08	0.13	0.24	0.16	0.36	0.19

occurred in these months, because in the sea sufficient energy to mix the waters was probably not available as opined by Trites (1956).

Dissolved oxygen

Generally higher values of dissolved oxygen were recorded during December and January (Table 2). The oxygen values showed a decreasing trend from January and reached the lowest during September. Later, these values increased from October and registered higher values in December. The lowering of dissolved oxygen in September during the present study could be attributed to the upwelling effect of subsurface waters with low oxygen content along Manjeswar Coast at this time. The oxygen values in the surface layers for all the stations exceeded the corresponding subsurface oxygen concentrations.

pH

The pH values in the area of study fluctuated from 8.0 to 8.6, with lowest values occurring generally during September. The possible reason for the reduction in September was the dilution of sea water due to the influx of fresh-water from land. In general, the surface waters showed more pH values than sub-surface waters. Similar variations of pH of coastal waters off Madras were observed by Rao *et al.* (1982).

Extinction coefficient

In the present study, relatively high extinction coefficient values were observed during January and December (Table 3). Extinction coefficient values were lowest in March and April. Comparative increase in the extinction coefficient values was noticed in September.

Oceanographic factors and oilsardine and Indian mackerel fisheries

The oilsardine and mackerel are well known to occur in the nearshore waters along the west

coast of India in the upper 20 m depth water column. In the area of investigation, the oilsardine and mackerel catches are obtained mostly by the purse seines which usually cover the top 20 m depth water column. Hence, the average values of temperature and salinity for eight stations in the two sections for columnar waters from 0 to 20 m depth were calculated for each month in order to find out the possible relationship if any, between these oceanographic parameters and oilsardine and mackerel landings.

As can be seen from Fig. 6 the oilsardine catches were maximum in the month of September with relatively high catches in value *i.e.* 29.16°C. Similarly the salinity values during March to May showed increasing trend from the optimum value of 34.08‰. In the months of October, January, May and February temperature values showed decreasing trend from the optimum value *i.e.* 28.83°C. The higher temperature and higher salinity values during the period from March to April coincided with decrease in fish landings. In January and February the low fish landings coincided with relatively low temperature and low salinity values observed during that period. During May, the oilsardine landings were lower, because the temperature was lower than the optimum value and the salinity was higher than the optimum. In the month of October,

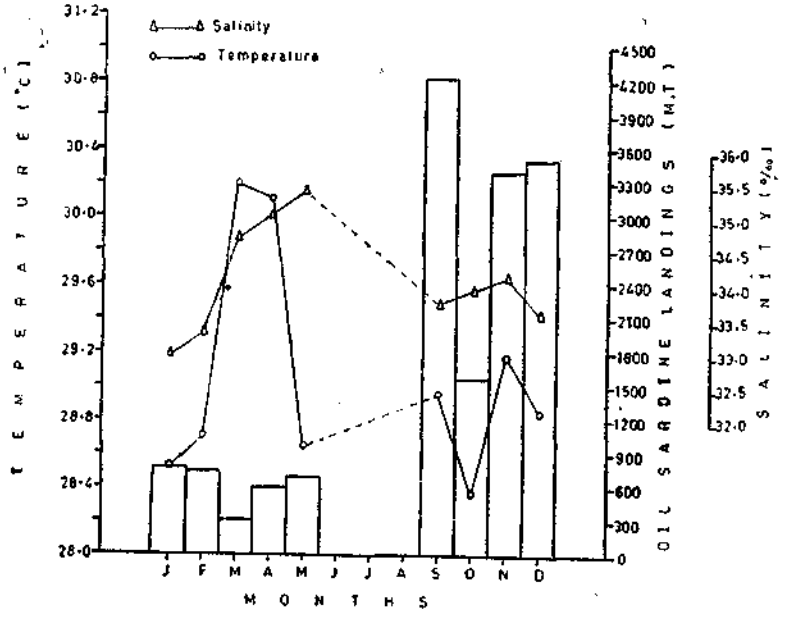

Fig. 6. Oilsardine landing in relation to temperature and salinity during different months of study.

December and November. The average columnar temperature and salinity ranged between 28.83 and 29.16°C and 33.53 to 34.08‰ respectively for the period of high fish landings. The temperature values during March and April showed increasing trend from the optimum the catches were low comparatively, because temperature was lower than the optimum value, while the salinity was within the optimum range.

From Fig. 7, it can be noticed that the catches of mackerel were maximum in the

month of September with relatively high values during October. The temperature range was from 28.37 to 28.94°C and the salinity range was from 33.70 to 33.89‰ during the period of better catches. These ranges are comparable with optimum values of earlier studies. Whenever the temperatures and salinities were lower or higher than the corresponding optimum ranges, the catches of oilsardine and mackerel were relatively low. Thus, the sea water temperature and salinity appear to play vital role in the availability of oilsardine and mackerel in the waters between Someswar and Manjeswar.

The dissolved oxygen in the water when it is in deficiency, will influence the availability of fish in the sea. When the oxygen minimum layer starts to rise due to the seasonal start of upwelling, fish migrate in front of it in shallow water or rise into the surface (Laevastu and Hela, 1970). In the present study dissolved oxygen was generally low throughout the water column in September. This could be one of the possible reasons for the maximum catches of oilsardine and mackerel during September in the sea off Manjeswar.

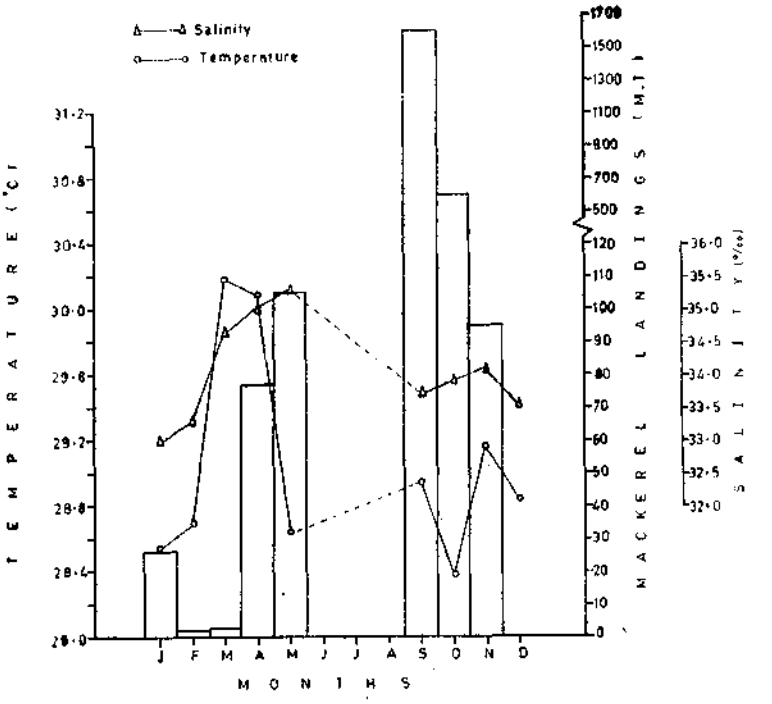

Fig. 7. Mackerel landing in relation to temperature and salinity during different months of study.

The effect of transparency on fishery depends on the type of material which is responsible for its increase or decrease. In the present study, during the period of good landings of oilsardine and mackerel, transparency of water was considerably lower in general as indicated by the relatively high values of extinction coefficient.

The fluctuations in rainfall in the region from month to month cause variations in salinity, temperature and many other hydrographic factors. So, the effect of rainfall on the fluctuations of oilsardine and mackerel would be indirect in the area of study.

REFERENCES

LAEVASTU, T. AND I. HELA 1970. *'Fisheries Oceanography'*. Fishing News (Books) Ltd., London : 238 p.

MURTY, A. V. S. AND M. N. VISHNUDATTA 1976. The seasonal distribution of some oceanographic parameters off southwest coast of India relevant to pelagic fisheries. *Indian J. Fish.*, **23** (1 & 2) : 97-104.

NARAYANASWAMY, G. AND R. V. SARMA 1982. Physical characteristics of the coastal waters between Navapur and Umbharat, West coast of India : Part II Vertical homogenity of temperature and salinity. *Mahasagar*, **15** (3) : 139-147.

PANIKKAR, N. K. AND R. JAYARAMAN 1966. Biological and oceanographical differences between the Arabian Sea and Bay of Bengal as observed from Indian region. *Proc. Ind. Acad. Sci.*, **5** (B) : 231-240.

PRABHU, M. S. AND M. H. DHULKHED 1970. The oilsardine fishery in the Mangalore zone during the seasons 1963-'64 to 1967-'68. *Indian J. Fish.*, **17** (1 & 2) : 57-75.

RAO, I. M., D. SATHYANARAYANA AND T. BALASUBRAHMANIAN 1982. Chemical oceanographic studies of coastal waters off Madras. *Indian J. Mar. Sci.*, **11** (4) : 333-335.

STRICKLAND, J. D. H. AND T. R. PARSONS 1972. A practical handbook of sea water analysis. *Bull. Fish. Res. Bd. Canada*, **167** : 311 p.

SURESH, K. AND M. P. M. REDDY 1980. Variations in oceanographic factors and their possible relation to fluctuations in oilsardine and mackerel catches off Mangalore Coast. *Indian J. Fish.*, **27** (1 & 2) : 1-9.

TRITES, R. W. 1956. The oceanography of Chatam Sound, British Columbia. *J. Fish. Res. Bd. Canada*, **13** (3) : 385-434.

VARMA, K. K., V. KESHAVADAS AND A. D. GOUVEIA 1980. Thermohaline structure and water masses in the northern Arabian Sea during February-April. *Indian J. Mar. Sci.*, **9** (3) : 148-155.

VENKATARAMAN, G. AND K. V. NARAYANA RAO 1973. On the mackerel fishery of Calicut during the years 1959-60 to 1967-'68. *Indian J. Fish.*, **20** (2) : 448-475.