J. mar. biol. Ass. India, 1974, 16 (3) : 700-707

EARLY STAGES OF UPWELLING AND DECLINE IN OIL-SARDINE FISHERY OF KERALA

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ABSTRACT

In February 1972, a sudden decrease in oil-sardine fishery was observed in the southern zones of Kerala. The area of the decline in oil-sardine fishery gradually shifted towards north and by April Cochin area was found to be affected. A hydrographic survey covering 26 stations in the shelf region between Cochin and Trivandrum was made in April, 1972. The survey indicated early stages of upwelling along the southern regions off the Kerala Coast.

INTRODUCTION

THE ANNUAL oil-sardine catch which occasionally constituted as much as a quarter of marine fish landing in India, in the past, fluctuates widely. Nearly 85% of the oil-sardine is landed in Kerala, with a maximum landing near the coastal region around 11°N and a gradual decrease in the catches on both the northern and southern sides of the region (Antony Raja, 1969). Many reasons are assigned for the regional, long and short-term fluctuations in the catches (Hornell, 1910 ; Chidambaram, 1950 ; Subrahmanyan, 1959 ; Sekharan, 1962 ; Murty, 1965 ; Murty and Edelman, 1966 ; Annigeri, 1969 ; Bensam, 1969).

In regions south of Calicut, there is a general decline in the sardine fishery after January. The trend noticed here is a decline in the southern regions first which gradually shifts towards north. In 1972, this decline was rather sudden and of a greater magnitude than those of the previous years. The decline was observed in zones near Quilon in February. By March, the zones near Kayamkulam and Alleppey were affected and by April the oil-sardine fishery of the Cochin area was also found to be affected. In an attempt to find out the reason for this decline in the fishery, a hydrographic survey was made in April, 1972, covering 26 stations in the shelf region off the coast between Cochin and Trivandrum. This paper is a discussion of the results of the survey.

I am indebted to Dr. S. Z. Qasim for suggesting the problem and for the encouragement, during this work. I have been very much benefited by the discussions with Shri K. Balan, C.M.F.R.I., Cochin and Dr. V. V. R. Varadachari, N.I.O., Goa. The facilities for collection of the hydrographic data were provided by the Integrated Fisheries Project.

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Material and Methods

Research Vessel *VARUNA* of the Integrated Fisheries Project was utilised for the collections of the oceanographic data from 5 sections (Fig. 1). The sections shown are nearly 35 km apart, the distance between two nearby stations in a section being 15 km. The hydrographic data from all the 26 stations were collected within four days. Water samples were collected from standard depths using Nansen bottles. Two protected thermometers were used with each Nansen bottle. Temperature was read on board the ship and salinity and dissolved oxygen determinations were made on the shore. In the treatment of data, the observations are considered synoptic.

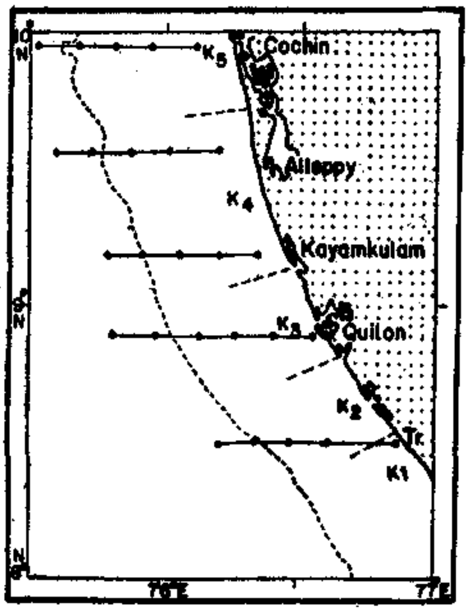

Fig. 1. Station positions in the Arabian Sea off the south-west coast of India. K_1, K_2, K_3, K_4 and K_5 are the fishery zones. The dash-line in the 180 m depth contour.

The data on oil-sardine landings at different zones of Kerala in different months were collected and supplied by the Fishery Resources Assessment Division of the Central Marine Fisheries Research Institute, Cochin.

Results

The area of observations, locations of the hydrographic stations and some of the fishing zones on the southern parts of Kerala are shown in Fig. 1. The fishing zones, numbered from south to north have the following extents : K_1 and K_2 each 42 km, K_3 45 km, K_4 63 km and K_5 65 km. In K_1 and K_2 zones, oil-sardine is seldom landed while there is some fishery in all other zones. The monthly oil-sardine landings averaged for years 1967 to 1971, for zones K_3, K_4, K_5 and K_6 for months January to June are shown in Table 1.

Table 1. *Monthly average of oil-sardine landings (tonnes) during* 1967 *to* 1971.

Zones	January	February	March	April	May	June
K_3	2451	347	285	18	43	1
K_4	1301	1174	1205	431	192	324
K_5	4786	3280	1671	541	423	319
K_6	7959	3881	2421	1798	716	454

The yearly landings from 1967 to 1971 and for 1972, for the same period are shown in Fig. 2. In January 1972, the sardine landings in K_3 and K_4 zones were 115 tonnes and 705 tonnes respectively. By February the fishery in K_3 zone decrease to 5 tonnes. There was no improvement in the fishery here during the next month. In K_4 zone, landing was nil for March and April. In April, the oil-sardine catch was only 69 tonnes in K_5 zone whereas in both March and May the landings were of the order of 900 tonnes. A detailed survey of the environment, it was thought, might give some reason for the unusual decline in oil-sardine fishery—from 18000 tonnes, average for a year for the previous 5 years for zones K_1 to K_5 for the period January to May, to only 6000 tonnes in 1972.

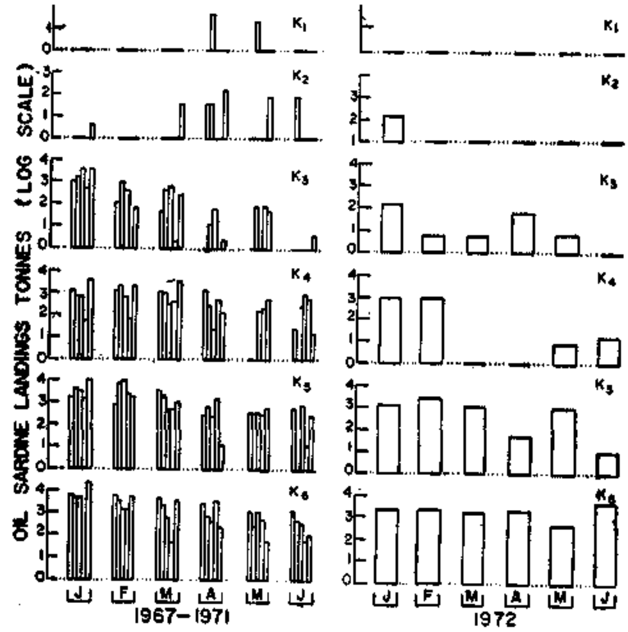

Fig. 2. A comparison of fish landings in zones K_1 to K_6, from January to June, between the years 1967 to 1971 and 1972 alone.

The results of the survey are shown in horizontal sections in Figs. 3 to 5. The environmental properties like temperature, salinity and dissolved oxygen are presented at level surfaces of 0 m, 10 m, 20 m and 50 m. Fig. 6 represents the vertical sections of sigma-t at the sections off Trivandrum, Quilon, Kayamkulam, Alleppey and Cochin.

Temperature

The horizontal distribution of temperature at the surface, 10 m, 20 m and 50 m are shown in Fig. 3. In the major portion of the shelf area, temperature varies from 29° to 30°C. But in the area east of 76° 30′E, there is a water mass with an offshore to onshore temperature gradient. Temperature near the shore is much lower than in the offshore area. A similar feature is observed at 10 m; but the low temperature tongue is much more extended towards the north. The 29°C isotherm which is found near the shelf edge, about 75 km off Trivandrum is found only 25 km off Cochin. At 50 m, temperature gradient off Trivandrum is much more intense. The 25°C isotherm is found near the coast between Trivandrum and Quilon.

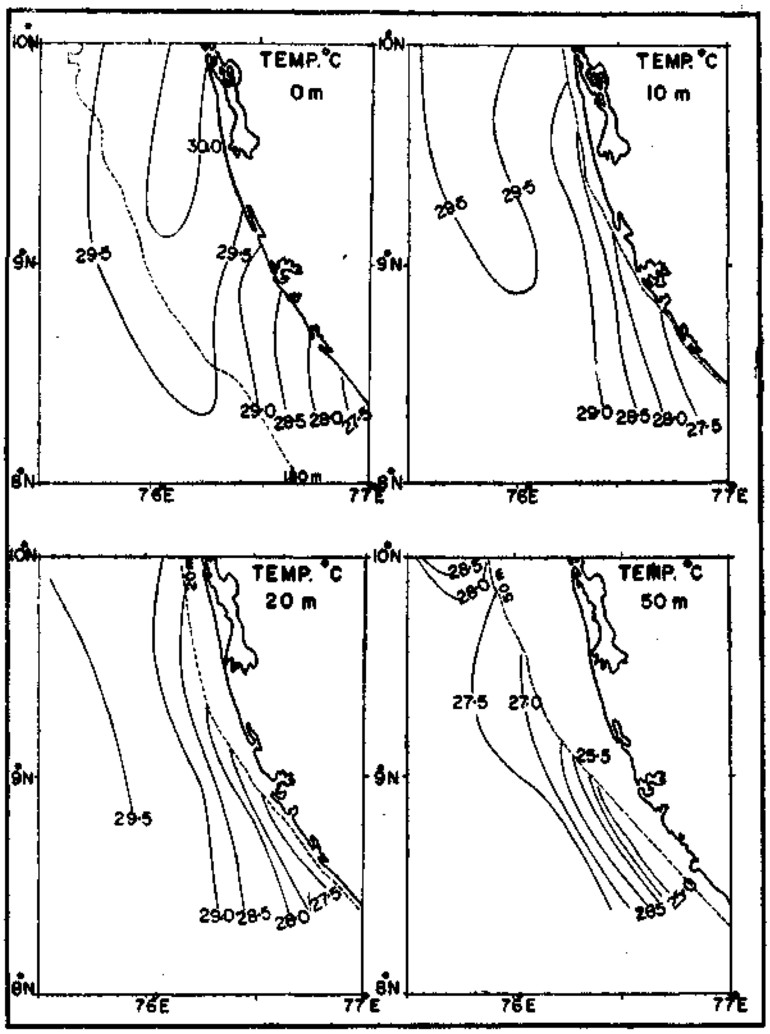

Fig. 3. Horizontal distribution of temperature at depths 0, 10, 20 and 50 metres. The dash lines represent depth contours.

Salinity

The general pattern of horizontal salinity distribution is shown in Fig. 4. At all depths except 50 m salinity values show an onshore to offshore gradient. Higher salinity values are observed in a belt near the coast, mainly in the southern region.

At 50 m depth the 35.4‰ isohaline is found just outside the shelf at all the areas north of Quilon. But in areas south of Quilon, a large area between 50 m contour and the shelf edge is also covered by this high saline water.

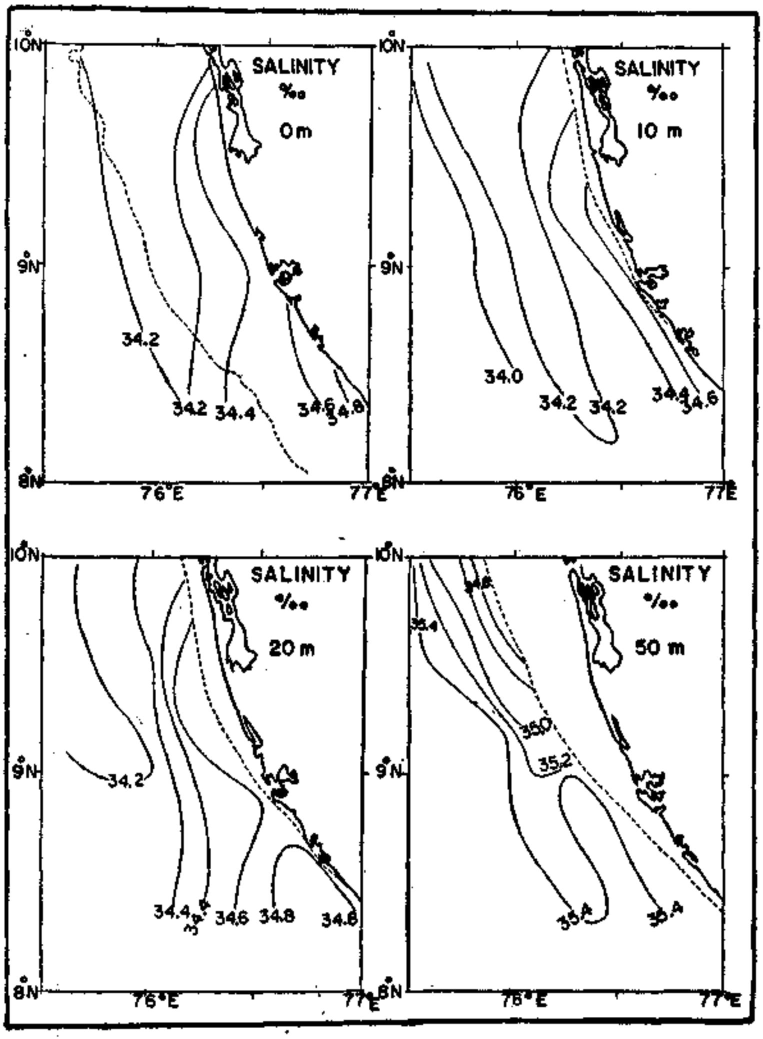

Fig. 4. Horizontal distribution of salinity at depths 0, 10, 20 and 50 metres.

Dissolved Oxygen

The pattern of distribution of dissolved oxygen at various depths are shown in Fig. 5. At the surface, most of the area in the shelf region is filled by a water of dissolved oxygen more than 3.5 ml/L. But a small area near Trivandrum to north of Quilon has less dissolved oxygen. Here the values are about 3.5 ml/L.

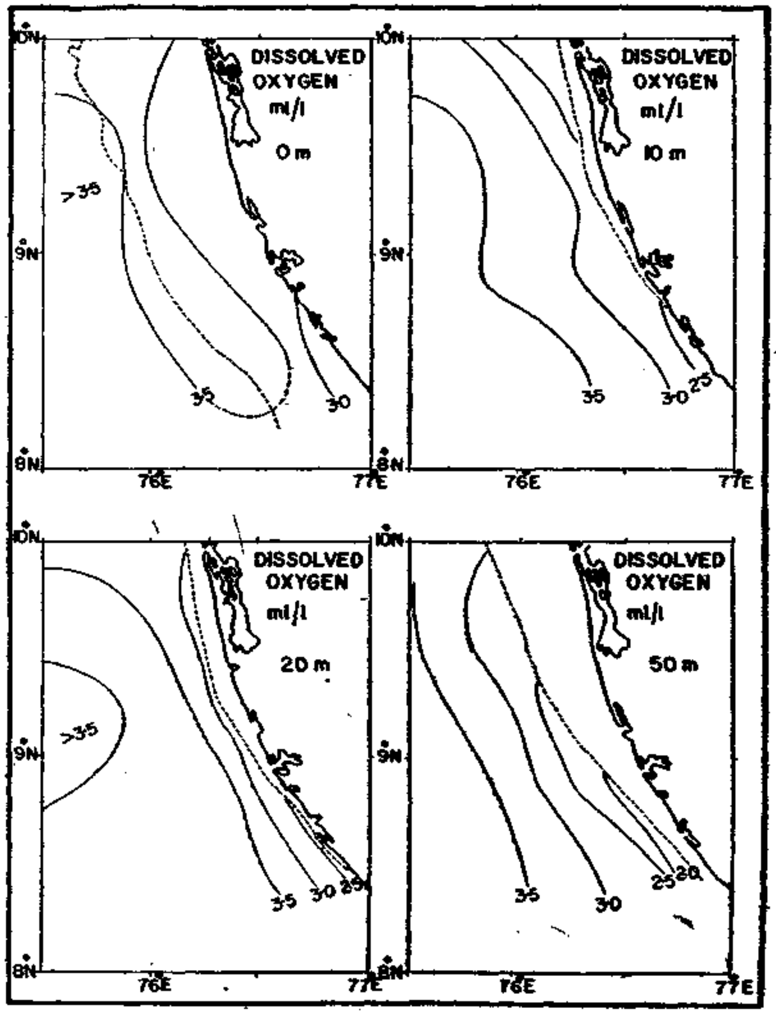

Fig. 5. Horizontal distribution of dissolved oxygen at depths 0, 10, 20 and 50 metres.

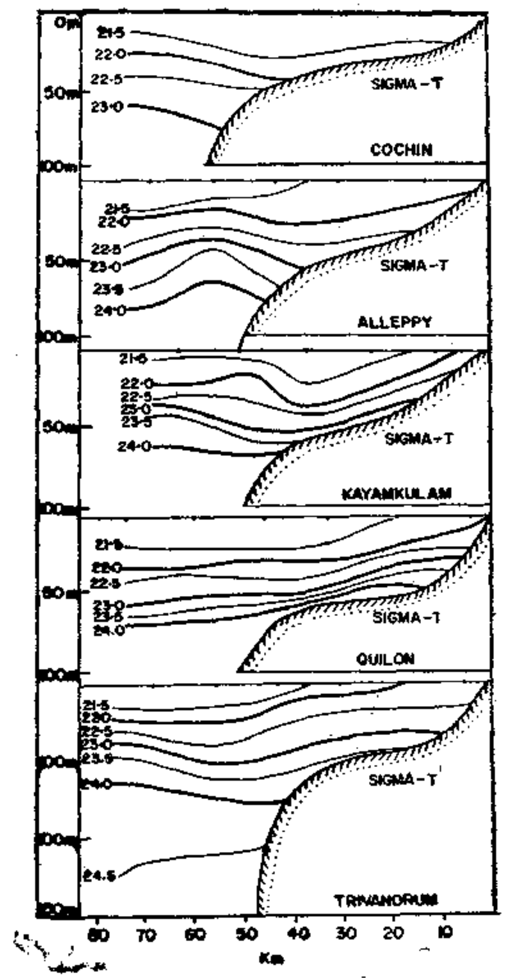

Fig. 6. Vertical sections of sigma-t off Cochin, Alleppey, Kayamkulam, Quilon and Trivandrum.

The pattern of distribution of dissolved oxygen at 10 m is also similar to the one at the surface. But the low oxygen tongue near the southern region has dissolved oxygen content of only 2.5 ml/L. At 50 m, oxygen concentration in the tongue of dense water near the southern region is as low as 2.0 ml/L.

The vertical sections of sigma-t are shown in Fig. 6. All the sections off Trivandrum to off Alleppey show a prominent upslope of isopycnals towards the shore. This is clearly the result of upwelling.

Discussion

It is generally accepted that the oil-sardine fishery starts with the entry of adult fishes in inshore areas by June-July. Later, by October/November, the juveniles enter the fishing zones in large shoals, but by January/February they get reduced in numbers. The decrease in the fishery starts in the north and gradually shifts to the south (Chidambaram, 1950; Antony Raja, 1969). An examination of Fig. 2 shows that for regions south of Calicut, the decline in the fishery is in the reverse direction, *i.e.* from south to north.

Many reasons are assigned for the rapid decrease of the fishery after January. The main reasons are stated to be lack of food items and rise in water temperature from January to March which force the sardines to migrate outside the fishing areas (Chidambaram, 1950). Many workers consider that there are optimum ranges in temperature and salinity, 27-28°C and 22.8-33.50‰ respectively, which are favourable for the oil-sardine to continue in an environment (Chidambaram, 1950; Nair, 1952; Sekharan, 1964; Mukundan, 1967; Annigeri, 1969; Bensam, 1970) and deviation from these conditions are unfavourable. Bensam (1970;) has observed that the wide fluctuations in temperature and salinity in 1962-1963 were associated with rapid fall in catches as a whole and juveniles in particular. The scarcity of juveniles in the inshore areas prior to September-October, according to him, is due to the prevailing low values of temperature and salinity which appear to act as a barrier restricting the entry of the fish to coastal waters. Sudden change in environmental condition might be influencing their migration, rather than any particular temperature or salinity.

Upwelling along the west coast of India generally starts by February and gradually reaches the surface layers by May (Sharma, 1968). This is applicable to the centre of the shelf. In general, upwelling starts early in the south (Varadachari, Murty and Sankaranarayanan, 1974). It is possible that in any particular year upwelling may occur earlier or later, and the duration and intensity of the upwelling may vary from year to year. This is evident in the present instance. For example, Sharma (1968) observed the 28°C isotherm at a depth of 50 m off Quilon and 27°C isotherm at a depth of 75 m. In Fig. 2, it is seen that the 28°C isotherm in April, 1972 is very near the surface off Quilon and 27°C isotherm is found at a depth of 20 m near the shore. It is probable that upwelling in 1972 started earlier than usual or the intensity of the upwelling might have been more than usual in these regions. The front between the upwelled water and the relatively warmer surface water might have moved northwards, resulting in the decline of the sardine fishery in these zones.

There is a decrease in the oil-sardine fishery after January in other areas also (Annigeri, 1969; Bensam, 1970). It must be pointed out that by February the surface current all along the Malabar Coast turns southerly (Anonymous, 1952). If the fish moves with the current, it is possible that a north to south decline in the fishery will be observed in the northern fishing zones. The fishes will be moving southward till they come across the front of upwelled water, then they might be forced to move offshore.

Subrahmanyan (1959) and Annigeri (1969) have noticed that the oil-sardine fishery decreased when the phosphate content of the water increased. This increase in phosphate might have been caused by intense upwelling in a year. The need for understanding the details of the current circulation as the first step in the prediction of pelagic fisheries have been stressed earlier (Murty, 1965). Knowledge of the vertical circulation seems to be important in predicting pelagic fisheries in general and oil-sardine fishery in particular.

REFERENCES

ANONYMOUS. 1952. *Indian Ocean, Oceanographic and Meteorological data. IInd edition*, K.N.M.I. Publ. No. 135.

ANNIGERI, G. G. 1969. Fishery and biology of oil-sardine at Karwar. *Indian J. Fish.*, **16** : 35-50.

ANTONY RAJA, B.T. 1969. The Indian Oil-sardine. *Bull. Cent. mar. Fish. Res. Inst.*, **16** : 1-128.

———, 1969. Estimation of age and growth of the Indian Oil-sardine, *Sardinella longiceps* Val. *Indian J. Fish.*, **17** : 26-42.

BENSAM, P. 1970. On the fluctuations of the oil-sardine fishery at Cannanore during 1961-1964. *Ibid.*, **17** : 132-148.

CHIDAMBARAM, K. 1950. Studies on the length-frequency of the oil-sardine *Sardinella longiceps Cuv.* and *Val.* and on certain factors influencing their appearance on the Calicut Coast of Madras Presidency. *Proc. Indian Acad. Sci.*, **31** (5) : 252-286.

MUKUNDAN, C. 1967. Plankton of Calicut inshore waters and its relationship with coastal pelagic fisheries. *Indian J. Fish.*, **14** : 271-292.

MURTY, A. V. S. 1965. Studies on the surface mixed layer and its associated thermocline off west coast of India and the inferences thereby for working out a prediction system of the pelagic fisheries of the region. *Ibid.*, **12** (1) : 118-134.

——— AND M. S. EDELMAN 1966. On the relation between the intensity of the south-west monsoon and oil-sardine fishery of India. *Ibid.*, **13** : 142-149.

NAIR, R. V. 1952. Studies on the revival of the Indian Oil-sardine fishery. *Proc. Indo. Pacif. Fish. Coun. Sec.*, **2** : 115-129.

SHARMA, G. S. 1968. Seasonal variation of some hydrographic properties of the shelf waters off the west coast of India. *Bull. Nat. Inst. Sci. India*, **38** : 263-276.

SEKHARAN, K. V. 1962. On the oil-sardine fishery of the Calicut area during the years 1955-56 to 1958-59. *Indian J. Fish.*, **9** : 679-700.

SUBRAHMANYAN, R. 1959. Studies on the phytoplankton of the west coast of India. Part 1. 'Quantitative and qualitative fluctuation of the total phytoplankton crop, zooplankton crop and their inter-relationship, with remarks on the magnitude of the standing crop and production of matter and their relationship to fish landings.' *Proc. Indian Acad. Sci.*, **50 B** : 113-187.

VARADACHARI, V. V. R., C. S. MURTY AND V. N. SANKARANARAYANAN 1974. Physical characteristics of waters and water masses off the west coast of India during late spring. *Indian J. mar. Sci.*, **3** : 1-4.