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THE INDIAN OIL SARDINE FISHERY: A REVIEW

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Introduction

The Indian oil sardine is one of the major marine resources of our country contributing about 15–25% of the total all-India marine catches. Hence, the role it plays in the economic life of the fishermen is significant. Since the beginning of this century, with the accumulation of valuable data, we have acquired a relatively wide spectrum of knowledge of this species, which will be of immense value in decision making for the rational exploitation of the resource. It may be recalled here that during the past several decades, this resource has been encountering wide fluctuations, both seasonal and annual which have been its characteristic feature.

During the present quinquennium there have been conspicuous changes in the fishing strategy for the major pelagic fishes such as the oil sardine and the mackerel, related to the advent of synthetic fibres for net making and the machanised purse seine crafts, as a result of which some of the traditional gears which were employed for successful fishing during the past several decades, have become rather obsolete. Although purse seine has extended the area of fishing operations, resulting in additional exploitation of oil sardine, mackerel and some other valuable pelagic resources such as the whitebaits, lesser sardines, horse mackerels, tunas, black pomfret, tachysurids, etc., during these years, its impact on the traditional fisheries is being felt to some extent in different areas.

Since the turn of the century, several investigators have studied the various biological aspects of the oil sardine fishery which have been well documented. The present review has been attempted with a view to highlight the trends in the production, research results and prospects relating to the oil sardine resource.

The sardine fishery and production

The traditional fishery of oil sardine has been found restricted to a narrow strip of 10–25 km of the coastal sea. Artisanal gears such as boat seines, shore seines, gill nets and cast nets have been employed for the fishery. But towards the close of the past decade purse seines have been introduced along the southwest coast for efficient exploitation of the resource.

Widely fluctuating trends have been observed in the landings of the oil sardine right from the early years for which catch statistics are available. The fishery was a failure during the years 1908–09 to 1911–12 and from 1914–15 to 1918–19. It was exceptionally good during 1922–23 and 1923–24 when the total production of its oil and guano along the west coast of India reached the colossal figures of 20,000 and 57,000 t respectively. Though above average during 1925–26, the fishery was poor in the subsequent seven years. Though revived during 1933–34, the catches declined remarkably during the next fifteen years (lowest being 8.8 t in 1946–47). Eventhough improved during 1950 and 1953–55 they were poor in 1951–52, 1956, 1958–59 and 1962–63. In 1957, the catch was exceptionally good. In 1960–61 the catches were rather good. The landings indicated a tremendous improvement during 1964–68 with an all-time bumper yield of 3.01 lakh tonnes in 1968. While the catch being very good during 1969–71, it was below average during 1972–74. In the ensuing five years, the catches were average but declined in 1980. During 1981 to 1983 they improved remarkably with the betterment of the stock abundance (Figs. 1 & 2).

It is a remarkable feature that Kerala being the largest oil sardine yielding state, its sardine landings in relation to the total marine catches (Fig. 4) to a great extent reflected a mirror image of the all-India oil sardine catch trend during the period from 1956 to 1983 as discernible from Table 1 and Fig. 2.

All-India percentages of indigenous oil sardine catches in the total catches during 1964–71 were markedly above average. They were below average during

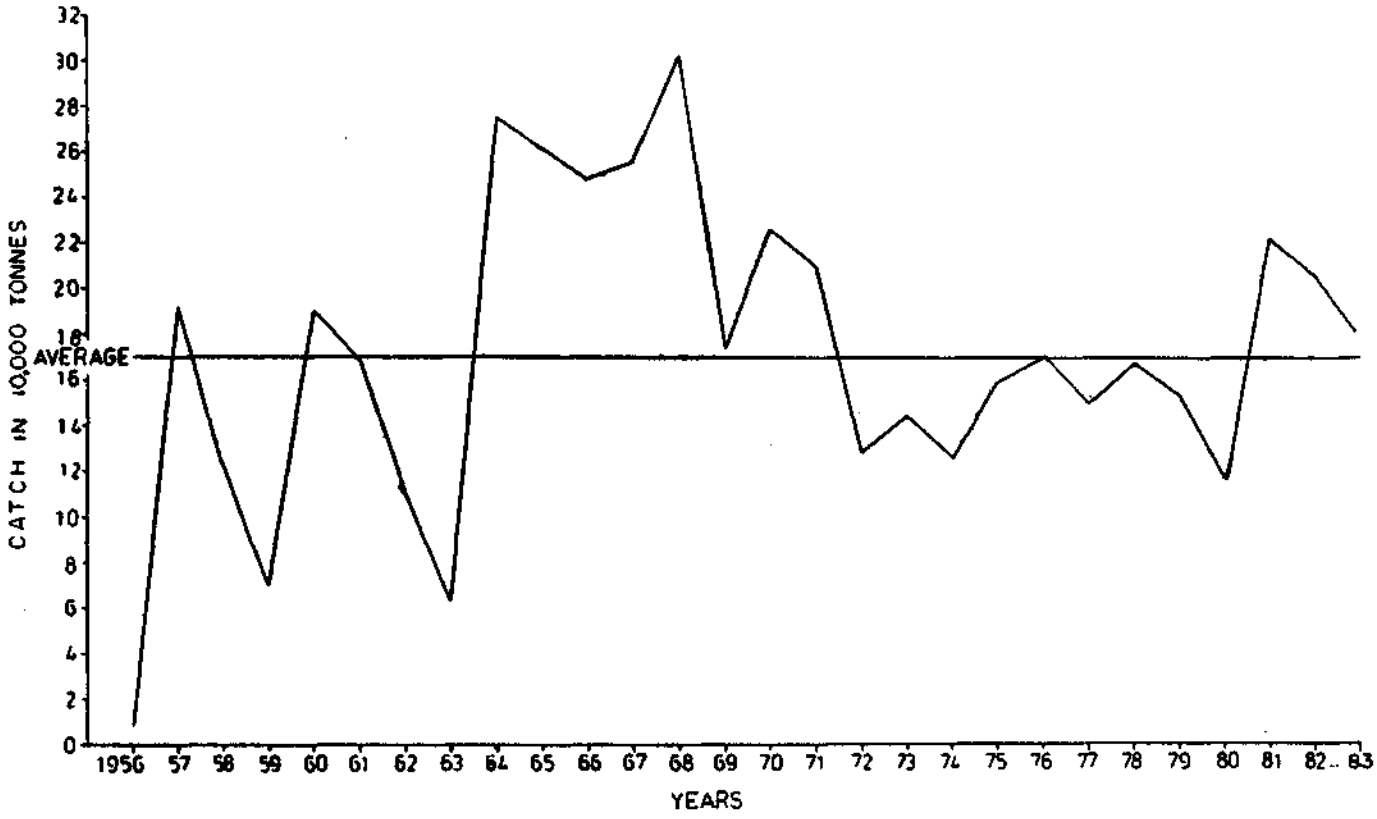

Fig. 1. All-India annual oil sardine landings.

1972–83; this striking decline in percentage composition may be attributed to increased landings of other fishes consequent on the proliferation of mechanised vessels all along the maritime states.

In Kerala also during 1964–71, percentages of oil sardine catches in the state's total all-fish catches manifested above the average trend (as that of All-India oil sardine catch trend). From 1972 to 80 and in 1983 the oil sardine catches recorded below average values; massive landings of other fishes by the intensified operations of trawlers would have effectively masked the oil sardine catches during that period. However, above average catches noticed during 1981 and '82 were mainly due to the increased landings by purse seiners. (Table 1 & Figs. 3 & 4).

Fishing areas: Large scale shoaling of oil sardine has been observed off the Kerala and Karnataka coasts. Within the Kerala zone, the area especially around the 11° N latitude accounts for the densest abundance. Normally, the fishing activity is found restricted to the region of about 3 to 20 km from the shore, and during the period of peak fishery, it may be even nearer to the shore. The usual depths at which shoals are encountered and captured range from 5 to 25 m.

Biology

Studies made earlier and the detailed investigations carried out recently have thrown light on various aspects of biology of the oil sardine such as the age and growth, length-weight relationships, meristic and racial aspects, reproduction, sex composition, maturation, fecundity, spawning, larval life, food and feeding, distribution, local movements and migration, shoaling and related behaviours, fisheries and the trends of fishery fluctuations etc.

Age and growth: Divergent views have been expressed by various investigators about its age, growth rate and life span on the basis of studies of age-marks found on scales, otoliths, opercula and length-frequency analysis of the fish. In general, it has been proved conclusively that the fish grows at a rapid rate during the first twelve months; and growth is at the highest during the intial two-three months of its life. The results obtained by various authors are enumerated in Table 2.

Table 1. *All-India and Kerala annual percentage composition of oil sardine catches among other fihses during* 1956–82

Years	ALL-INDIA			KERALA		
	Oil sardine catch (t)	Total landings of oil sardine & other fishes (t)	Percentage of oil sardine.	Total oil sardine (t)	Total fish landings including oil sardine (t)	Percentage of oil sardine
1956	7,412	7,18,779	1.03	5,065	1,52,213	3.33
1957	1,91,469	8,75,516	21.87	1,75,851	3,10,411	56.65
1958	1,23,731	7,55,994	16.37	1,18,971	2,95,135	40.31
1959	69,234	5,84,587	11.84	62,036	1,92,625	32.21
1960	1,89,016	8,79,681	21.49	1,86,219	3,46,684	53.71
1961	1,67,884	6,83,569	24.56	1,66,005	2,68,624	61.80
1962	1,10,299	6,44,244	17.12	91,203	1,92,470	47.39
1963	63,647	6,55,484	9.71	58,950	2,03,242	29.00
1964	2,74,333	8.59,582	31.91	1,90,401	3,17,973	59.88
1965	2,61,863	8,32,777	31.44	2,19,170	3,39,173	64.62
1966	2,47,214	8,90,311	27.77	2,02,800	3,46,744	58.49
1967	2,56,324	8,62,631	29.71	2,35,410	3,64,129	64.65
1968	3,01,446	9,02,948	33.38	2,47,048	3,45,301	71.55
1969	1,74,249	9,13,630	19.07	1,39,983	2,94,787	47.49
1970	2,26,997	10,85,607	20.91	1,91,683	3,92,880	48.79
1971	2,09,261	11,61,389	18.02	1,94,977	4,45,347	43.78
1972	1,27,568	9,80,049	13 02	1,04,426	2,95,618	35.32
1973	1,44,395	12,20,240	11.83	1,22,783	4,48,269	27.39
1974	1,26,676	12,17,797	10.40	1,02,135	4,20,257	24.30
1975	1,59,240	14,22,693	11.19	97,183	4,20,836	23.09
1976	1,69,262	13,52,855	12.51	1,23,937	3,31,047	37.44
1977	1,50,130	12,59,782	11.92	1,17,356	3,45,037	34.01
1978	1,68,078	14,03,607	11.97	1,19,937	3,73,339	32.13
1979	1,53,971	13,88,380	11.09	1,16,834	3,30,509	35.35
1980	1,15,744	12,49,837	9.26	69,667	2,79,543	24.92
1981	2,21,026	13,78,457	16.03	1,46,986	2,74,395	53.57
1982	2,05,294	14,20,624	14.45	1,43,215	3,25,795	43.96
1983*	1,83,706	15,44,389				
Average	1,70,410	10,40,909	16.47	1,39,468	3,22,791	43.21

* Figures provisional for 1983.

Apart from the length-frequency based studies on the fish, the problem of age and growth was studied in detail by scale method. And, on the basis of scalimetry, the time of ring-formation and the annual occurrence of each annulus or "ring" were found out and this knowledge was used as a tool for the determination of the age of the fish. Studies on the otoliths of the fish also have yielded some reliable clue to the problem of age determination. Majority of the investigators agree that the growth is very rapid during the first twelve months. Balan (1964) on the basis of detailed scale studies found that the fish attains an average length of 14.3 cm on completion of one year and 16.4 cm when it is 2 years and 18.4 cm when it is three years old.

Food and feeding: The fish is a plankton feeder. Among the phytoplankters, *Fragilaria oceanica, Pleurosigma, Coscinodiscus* and *Biddulphia* were dominant. Copepods, nauplii, cladocerans, larvae of bivalves and dinoflagellates preponderated among the zooplankters. Copepods formed the principal food of the juvenile fish. Intensity of feeding was found high during June-October coinciding with the rapid growth

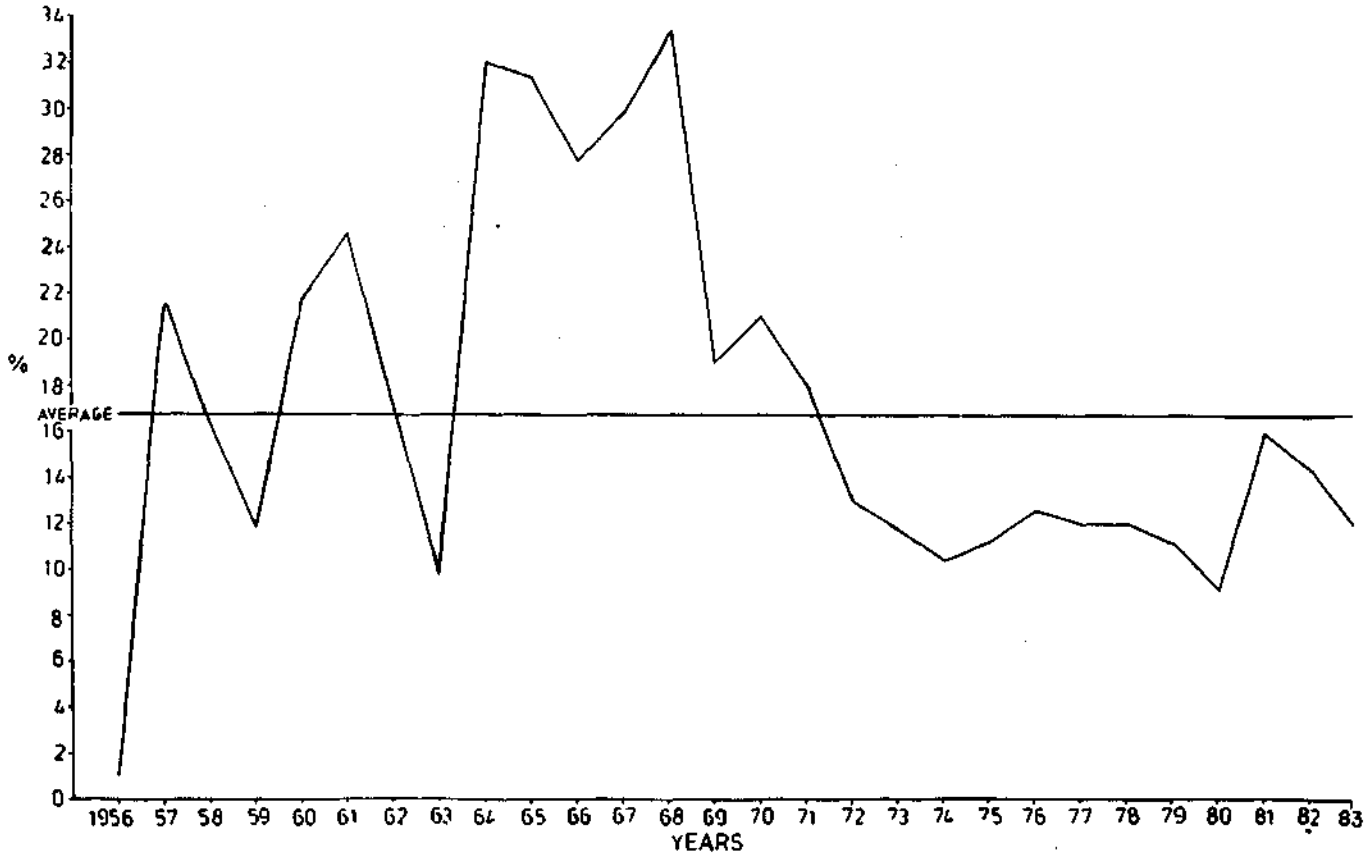

Fig. 2. Annual percentages of All-India oil sardine landings, among all other species.

Table 2. *Total lengths (in cm) of oil sardine at various ages, as observed by different authors*

Authors	Years				Remarks
	1	2	3	4	
Hornell & Nayudu (1923)	15.0	16 0	—	—	Estimated 125 to 140 mm growth in 6 months. Suggested a life span of 2½ years.
Devanesan (1943)	6.5	—	—	—	Presumed a life span of 14 years when the fish are 18 cm in length.
Chidambaram (1950)	10.0	14.5	18.3	20.5	About 4 years life span.
Nair (1949, 1952 & 1960 a)	10.0	15.0	19.0	—	The fish 21 cm long being in the fourth year.
Balan (1964)	13.0	16.0	17.5	—	Based on average length frequency during 1955–64. The 17.5 cm long fish completed 3 years.
	14.3	16.4	18.4	—	Based on scale studies (by back-calculations).
Raja (1969)	15.0	17.8	—	—	They attain 60–95 mm, 95–110 mm, 110–125mm and 125–140 mm, at the end of one, two, three and six months. The mean length of 18.5 cm attanied on completion of 2½ years (length–frequency).
Sekharan (1965), Prabhu & Dhulkhed (1967), Sekharan & Dhulkhed (1967) and Bennet (1969)	—	—	—	—	They indicated that the juveniles measuring about 100 mm are one-year olds and those between 100 and 150 mm. length are in the second year.
Bensam (1968)	—	—	—	—	Juveniles register very rapid growth before they are 12 months old.

Oil sardine landings by the indigenous gear *(Thangu vala)* at Fisheries Harbour, Cochin.

A deck-full of oil sardine and other fishes aboard a purse seiner moored at the Fisheries Harbour, Cochin.

Auctioning of oil sardine catch from a carrier boat at Fisheries Harbour, Cochin.

Oil sardine strewn as 'waste' during glut at the Fisheries Harbour, Cochin.

Scooping oil sardine catch for unloading from a carrier boat at Fisheries Harbour, Cochin.

Oil sardine iced and packed in baskets ready for loading in lorry at Fisheries Harbour, Cochin.

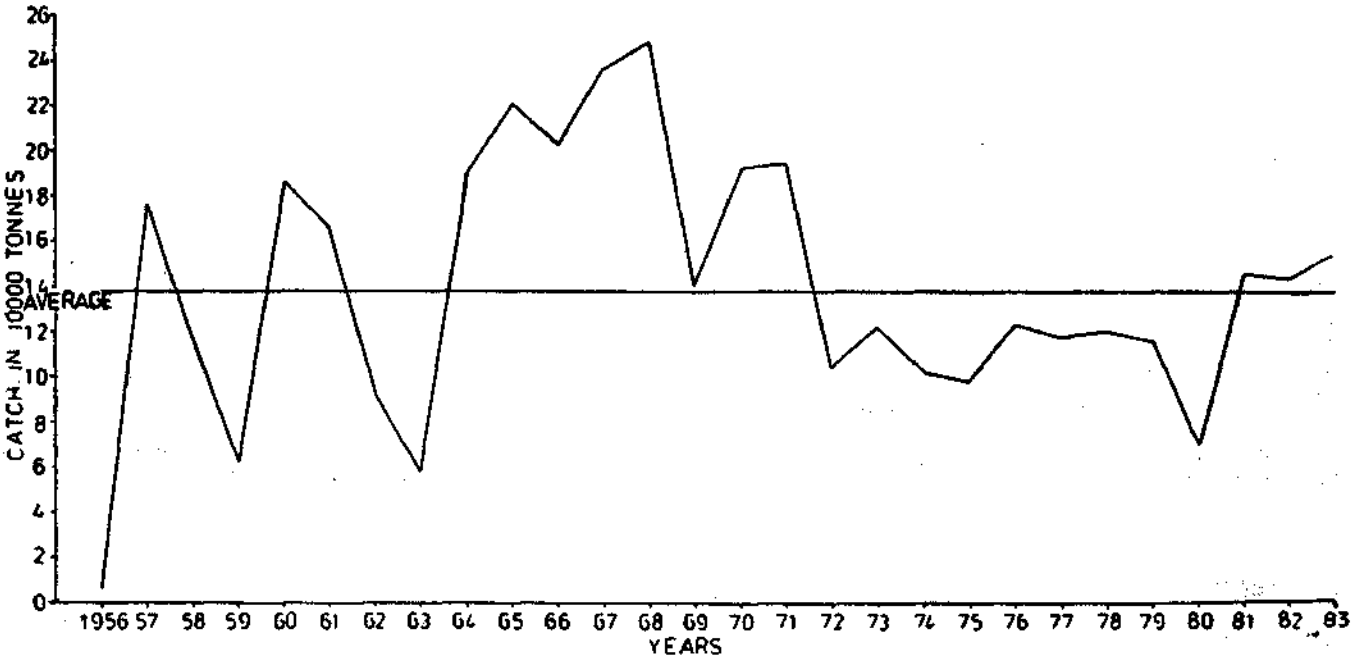

Fig. 3. Annual oil sardine landings in Kerala State.

rate during the period and it declined during November-March. During the period of spawning, starvation was invariably noticed among the adults (Nair, 1960 b).

Spawning: According to most of the investigators, eventhough the period of spawning extends from May to November, its peak is during June to August. Normally, the spawning was found to take place at about 15 km from the shore, in a depth range of about 30 m. In this regard the abundant occurrence of the gravid, the spent and the juvenile fish in the nearshore waters off Kerala and Karnataka states lends support to findings of the various authors. According to Raja (1971) a conspicuous incidence of follicular atresia of ovaries may cause a marked decrease in the egg stock. He attempted to correlate the atresia to low average daily rainfall during spawning nights and inferred that the average daily rainfall below 20 mm would result in a large-scale follicular breakdown and cause a decrease in the egg and larval production. But none of the later investigators has so far reported incidence of the atresia in the ovaries of the oil sardine.

Fecundity: The average fecundity (No. of ripe eggs) values, according to the different authors, range from 37,000 to 80,000. The body weight-fecundity and total length-fecundity regressions have already been studied (Balan, 1966). In view of the significant role the fecundity plays in the egg and larval production potentials and the subsequent recruitment of the juveniles into the fishery and the year to year changes in fecundities, a correct estimate of the same is essential.

Variations in sex ratio as observed by different authors are given in the attached Table 3. Post-spawning mortalities were also found affecting sex composition to some extent as reported by many investigators earlier. Differences in its ratio may be attributed to differential growth also, but need to be established.

Maturation: The fishery in the nearshore waters commences with the abundance of the maturing fish (IV & V stages), followed subsequently by the juveniles during August-September. Normally, occurrence of fish in stage VI in the commercial catches has been rather rare. After spawning during June and July, the partly-spent fish occur during August-September followed by the spent ones in October and the latter continues till December. After January, these fish from the spent-recovering stage II start developing progressively during February, March and April as stages III and IV. After maturing to stage V during May, the spawning act would get consummated any time with the onset of monsoon rains and conducive hydrobiological conditions. Juveniles from stage I during August-September pass on to stage II during October-December. Subsequently, like the once-spawned adults, the juveniles also pass on

to the III and IV stages during January to April and advance to the stage V in May to enter the active virgin spawning phase in June with the onset of monsoon rain. After completion of their spawning, they also pass on to the maturation stages similar to those of the once spawned fish.

Table 3. *Fecundity and sex ratio of oil sardine, quoted from different authors*

Authors	Fecundity	Sex ratio
Hornell & Nayudu (1923)	—	Dominance of females up to size at first maturity; reduced sexual segregation among ripe fish.
Devanesan (1943)	70,000–80,000	—
Devanesan & Chidambaram (1948)	70,000	Ratio equal below 20 cm length.
Chidambaram (1950)	—	Females dominated above 20 cm size; equal proportions of sexes up to 20 cm.
Nair & Chidambaram (1951)	75,000	—
Nair (1960)	78,000	Sex ratio almost equal among juveniles and spawners.
Balan (1966)	48,119 (average)	Females preponderated during 1959 to 1965 (excepting in 1963) in boat seine catches at Cochin.
Balan (1973)	—	No significant dominance of either sex in purse seine catches during 1969–1971 at Cochin.
Balan, *et al.*, (1979)	—	In 1978, females dominated at Calicut, Cochin and Karwar. Males dominated at Mangalore.
Raja (1969)	—	No seasonal differences in sex ratio; no sexual dominance among juveniles. Females were distinctly more among overall population of recovering spawners.
Raja (1971)	37,000–38,000 (average)	—

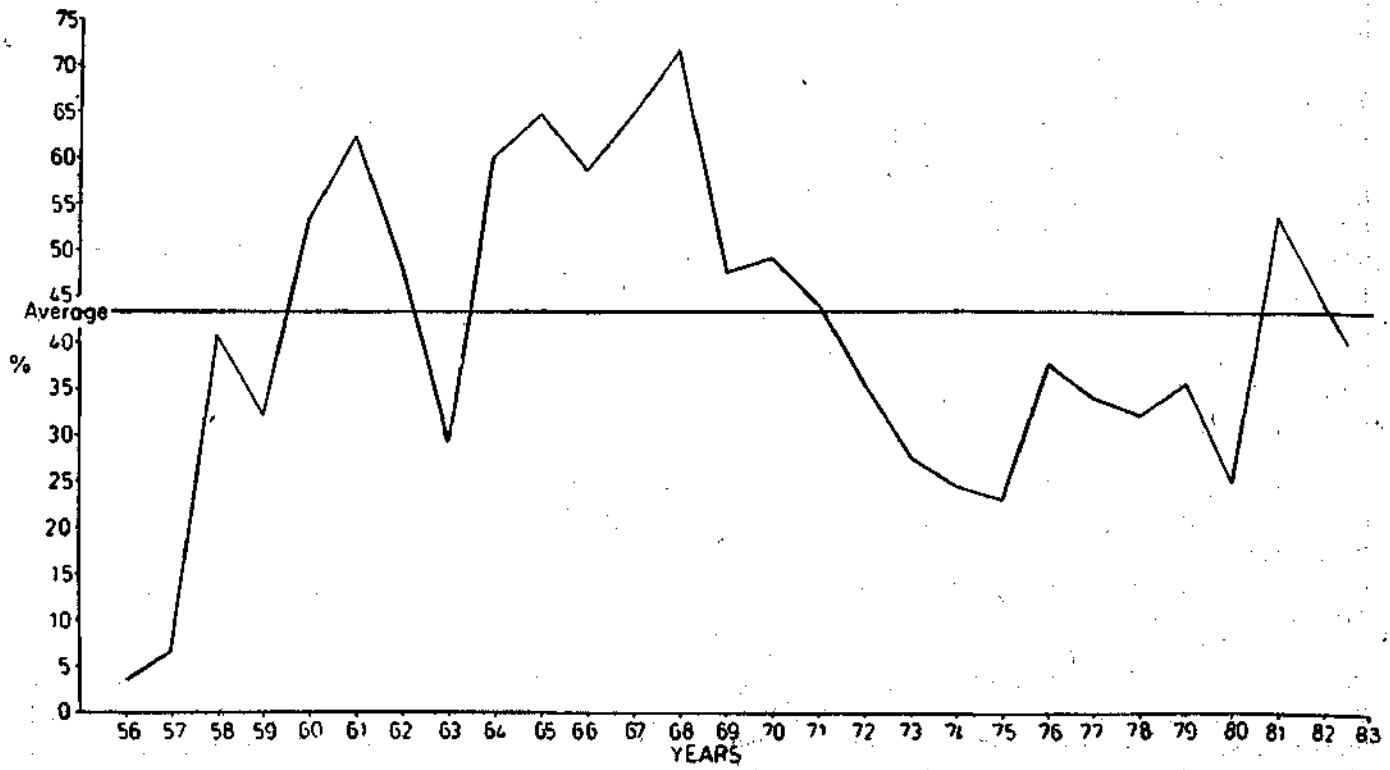

Fig. 4. Percentages of annual oil sardine landings among all other species, in Kerala.

Egg structure: The maximum and modal sizes of the intra-ovarian eggs were found to vary respectively between 1.20 to 1.23 and 0.97 mm. The transparent ripe intra-ovarian egg has a yellow oil globule (0.09–0.13 mm in diameter) which may be found occasionally broken up into 2 or 3. The planktonic eggs were found to range from 1.02 to 1.70 mm in diameter.

Its larval history was also studied by Nair (1960 a) though not comprehenisvely.

Shoal behaviour: Our present knowledge of this important aspect of biology of the fish is limited to what was observed by Balan (1961) wherein the various categories of the sardine shoals and their behaviour patterns or traits were indicated in detail. A clear knowledge of their behaviour and distribution in space and time based on echo-trace studies and shoal-scouting and mapping is an essential pre-requisite for the fish detection and for designing suitable fishing gears and effective fishing strategies.

Recruitment: As the fishery fluctuations are normally a manifestation of abundance of the 0-year and 1-year classes, the situations existing in the early recruitment phase may mainly influence the recruitment pattern in the exploited phase of the fishery each year. The fecundity potential, the success or failure of spawning, natality, survival of the spawn and larvae can also in their turn effect changes in the recruitment level.

The population abundance: According to the C.M.F.R.I Annual Report (1968), the fishing mortality (F) was only 0.7, whereas the yield per recruit attains the maximum when it is double the present F. The total mortality "Z" has been reported varying between 0.09 and 1.88 in which the natural mortality was 0.26. No significant differences in growth parameters were noticed between the different fishing centres and a single equation can represent the data for the entire west coast which is: $L_{\infty} = 207$ mm., $k = 0.53$ on yearly basis and $t_0 = -1.33$ years.

Banerji (1973) estimated the total annual oil sardine stock in the fishing grounds as 4,40,000 t and the average standing crop as 2,10,000 t. The corresponding figures as estimated by Sekharan (1974) for the years 1960–71 were 8,10,000 and 3,90,000 t respectively. Balan *et al.* (1979) stated that the total stock level should be about four lakh tonnes based on the average annual crop and should be above two lakh tonnes based on the average of 10 years' (1969–78) oil sardine landings (1,31,440 t) in Kerala. It is also in agreement with the earlier (1972–76) estimates made by UNDP/FAO Pelagic Fisheries Project, Cochin.

Causes of the fishery fluctuations

Fluctuation in abundance of the resource of the oil sardine was ascribed to the success or failure of its spawning by Chidambaram (1950) and Raja (1969) while Hornell (1910) opined that it may be due to changes in diatom production or food availability to the fry and prevalence of favourable hydrological conditions. While "over fishing" that was deemed responsible according to Devanesan (1943) and heavy fishing of the immature fish and the periodic offshore migrations according to Sundara Raj (1934 & 1937) and Nair & Chidambaram (1951), it was due to the destructive fishing of the immature fish (Devanesan & Chidambaram, 1943). Abundant availability of *Fragilaria oceanica* was attributed as the principal causative factor for the sardine abundance according to Nair (1952) and Nair & Subrahmanyan (1955).

It appears reasonable to infer that since the fishery is supported largely by the 0-year group, the fluctuation in a season would be dependent on the rate of juvenile recruitment of the same season, i.e., on the strength of the juveniles resulting from major spawning of the same year, thus indicating that if spawning was not quite successful, it would be found reflected in the juvenile fishery of the same year and not after some years as Chidambaram (1950) suggested. Raja (1969) stated that greater incidence of "*Corpora atretica*" would cause reduction in the potential egg stock for release which he correlated to abnormally low average daily rainfall during spawning fortnights. Murty and Edelman (1970) stated that the intensity of monsoon, on the west coast of India over and above its critical value would be favourable not only for enrichment of sea by nutrients but also by dissolved oxygen.

Thus, an increase in the strength of the monsoon over its critical limit would be favourable for an increase in the sardine catch and below the critical value, the catches were found to decline.

The overfishing problem as suggested by some authors would mean that with an increase in the effort, there would be a decreasing catch per effort. Banerji (1973) found no relationship between the abundance and fishing effort and stated that the present level of fishing mortality is only half of that associated with maximum sustainable catch.

"Availability" changes also, being generally influenced by oceanographic and biological factors, have very often been found to play an important role in causing success or failure of the sardine fishery in the coastal waters since the operations of the fishing crafts are at present confined to the nearshore shallow areas.

In the light of the factors already enumerated, in general, the southwest monsoon and the resultant biological, oceanographic and meteorological conditions seem to be responsible for the catch fluctuations to a large extent. Nevertheless, with the existing knowledge, it is rather difficult to categorically establish any particular causative factor responsible for the yield fluctuations.

Prospects

On the basis of the data that are so far available, it can be reasonably inferred that the resource potential of oil sardine off our west coast is quite high despite its inherent seasonal fluctuations in abundance. Conservation of the resource and proper management of the fishery needs attention in view of its wide fluctuations coupled with the increasing intensity in fishing effort. Hence a few important aspects which should receive closer attention for a proper management approach in the fishery may be mentioned.

First of all identification of the nature of the population whether there are homogeneous populations or subpopulations or geographic variation, if any, in the different regions off the west coast needs consideration.

Difficulties have been experienced in aligning certain size groups or age groups occurring off Calicut and Mangalore with the pattern of maturation cycle and of growth obtained at other places such as Cochin, Karwar etc., indicating urgent necessity for taking up intensive studies on the population parameters at different centres of the fishery especially in view of their seasonal migrations.

The spawning survey of the sardine needs special attention since our present knowledge of the exact time, duration, area and depths of spawning (including the conducive environmental factors), distributions of the spawn, larvae and larval history are rather fragmentary.

It is imperative that detailed investigations have to be carried out on a continuing basis to understand the impact of intensive purse seining on the oil sardine catches of indigenous gears and on the consequent economic conditions of the fisherfolk of the Karnataka and Kerala States so that proper resource conservation measures, if found necessary, may be taken at the proper time. It may be recalled here that during the past five years, since the introduction of the purse seiners at Cochin, due to the unlawful fishing by purse seiners in the nearshore water where generally, the indigenous crafts operated has often given rise to frequent conflicts at sea. It is a matter of constant complaint by artisanal fishermen that their catches as well as prices realized from their poor catches go down miserably due to the indiscriminate and unrestricted operation of the purse seiners (Jacob *et al.* 1982). Regulatory measures restricting the depth zones for operation of the different gears together with the study of the resources position in the different areas in order to render proper advices to the fishing industry are quite essential.

The relationship of these fishes with the environmental parameters is quite well known. The recent (1982–83) large-scale wide-spread occurrence of catastrophic "El Nino" phenomenon in the major oceans, and the seas of the Asian continent manifesting with an abnormal increase in sea temperature and with concomitant changes in other hydrographic parameters, have probably markedly influenced the resource fluctuations of the oil sardine also. Thorough investigations on the resource in relation to these changes in environmental features have to be necessarily carried out on a continuing long term basis.

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