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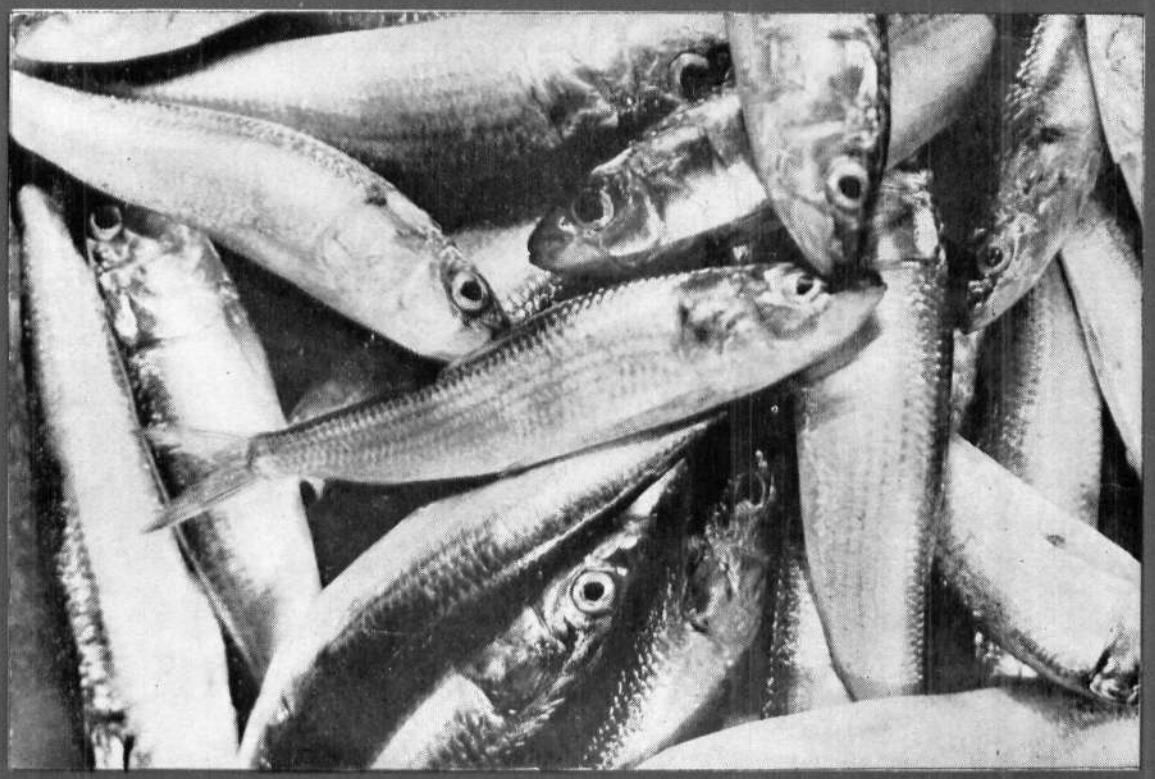

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THE MARINE FISHERIES INFORMATION SERVICE: Technical and Extension Series envisages the rapid dissemination of information on marine and brackish water fishery resources and allied data available with the Fishery Data Centre and the Research Divisions of the Institute, results of proven researches for transfer of technology to the fish farmers and industry and of other relevant information needed for Research and Development efforts in the marine fisheries sector.

Abbreviation – *Mar. Fish. Infor. Serv. T & E Ser., No.* 14: 1979

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Cover photo: Indian oil sardine

THE INDIAN OIL SARDINE*

Introduction

The indian oil sardine, *Sardinella longiceps* Val. sustains one of the major pelagic fisheries of the country. Though the fish occurs all along the peninsular region in varying quantities, the highest abundance has been noticed off the Kerala and Karnataka coasts, especially between Alleppey and Karwar. The traditional fishing season commences by August and continues till March along this region. With the development of purse seine fishery, the season has been extended even up to June.

Wide fluctuations, from year to year, were noticeable in the magnitude of its catches. During 1961-68 the sardine catches ranged from 9.71 to 33.38% of the total marine fish landings of the country, the annual average being 2,10,376 tonnes. The all India annual average catch of the sardine during the subsequent ten years from 1969 to 1978 was 1,65,586 tonnes, though within that period the highest catch (2,26,997 tonnes) was in 1970, which formed 20.9% of the total marine landings.

Investigations conducted so far showed that the oil sardine shoals are confined mainly within the 15 km coastal belt, denser shoals being sighted frequently in the shallower nearshore waters, from where they are largely exploited in Kerala and Karnataka States. The fishery yield is largely from the commerical sizes ranging between 100 and 200 mm.

It is possible that the sardine harvest could be further increased by augmenting and deploying the fleet strength of purse seiners all along the Kerala and Karnataka coasts during the monsoon period also. Of course, its impact on the sardine stock has to be watched carefully and monitored from time to time for the benefit of the fishing industry.

Though the sardine fishing has been done till recent years principally by the indigenous gears and crafts, the advent of purse seiners has made tremendous improvements in its landings on the west coast, especially in the state of Karnataka. In that state, the proliferation of purse seining activity has effected a marked reduction of the sardine landings by the indigenous gears such as the Rampan *(Mar. Fish. Infor. Serv. T & E ser.* 12, 1979*)*, "Kollibale" , cast net and "Yendi". However, the impact of the purse seining conducted off the Karnataka region has not been seriously felt by the artisanal fishermen of the central and southern Kerala State.

All India oil sardine production

During the decade from 1969 to 1978, the highest all India oil sardine catch, was made in 1970. In the succeeding year also, the landing was very good. Thereafter the catch decreased. The landings during 1978 was estimated at 1,68,078 t. against 1,50,130 t. of the preceding year. The annual production during the years from 1974 to 1976, as shown in Table I revealed an increasing trend yielding 1,26,676, 1,59,240 and 1,69,262 t. respectively. In 1977, of the country's total oil-sardine catch, 78.17% came from Kerala State alone which had harvested the most lucrative sardine catches throughout the 1969-78 seasons.

Statewise production (Figs. 1 & 2)

Gujarat

No oil sardine landing occurred during the period 1970-1978, but for a small catch in 1969 (Table 1).

Maharashtra

The catches in the state though generally small, were above the average during 1972, 73, 75 and 76; it was only 108 t. in 1977, and no landings in 1978.

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* Prepared by V. Balan and R. Reghu in consultation with K. V. N. Rao. The chapter on stock assessment is by K. Alagaraja. Basic data from centres other than Cochin were provided by V. S. Rengaswamy and N. G. Menon-Calicut, M. H. Dhulkhed-Mangalore and G. G. Annigeri-Karwar.

Table 1. *Statewise oil sardine landings in tonnes during* 1969-78

Year	W. Bengal & Orissa	Andhra-pradesh	Tamil Nadu	Pondi-cherry	Kerala	Karna-taka	Goa	Maha-rashtra	Gujarat	All-India Total
1969	247	—	18	—	1,39,983	33,580	—	399	23	1,74,250
1970	—	—	46	—	1,91,683	33,834	1,134	300	—	2,26,997
1971	2	—	45	—	1,94,977	11,836	1,994	407	—	2,09,261
1972	—	—	146	—	1,04,426	15,610	3,793	3,593	—	1,27,568
1973	38	125	45	—	1,22,783	15,495	3,426	2,483	—	1,44,395
1974	4	564	—	—	1,02,135	20,784	2,106	1,083	—	1,26,676
1975	—	131	—	—	97,183	52,701	7,526	1,699	—	1,59,240
1976	—	112	—	—	1,23,937	41,451	1,385	2,377	—	1,69,262
1977	—	—	714	—	1,17,356	31,145	807	108	—	1,50,130
1978	—	—	36	—	1,19,937	46,707	1,398	—	—	1,68,078
Average	29.1	93.2	105.0	—	131,440.0	3,0314.3	2,356.9	1,244.9	2.3	1,65,586

During 1974, 75 and 76, the landings obtained were 1,083, 1,699 and 2,377 t. respectively contributing about 1% in the all India catches.

Goa

Generally, the catches were small in magnitude in this state. However, they were above the state's average during the years 1972, 1973 and 1975. In 1978 a total of 1,398 t. was landed, whereas the catches were only 807 t. during the previous year. In 1974, the landing was below the average. In 1975 and 1976, the catches were respectively 7,526 and 1,385 t. the highest being in 1975 for the state. In 1978 the best catch was during the final quarter, the purse seiners contributing the bulk of the catches.

Karnataka

The landings in Karnataka were below the average from 1971 to 1974. During the ten years viz., 1969–78, the highest catch was made in 1975, as in Goa, when

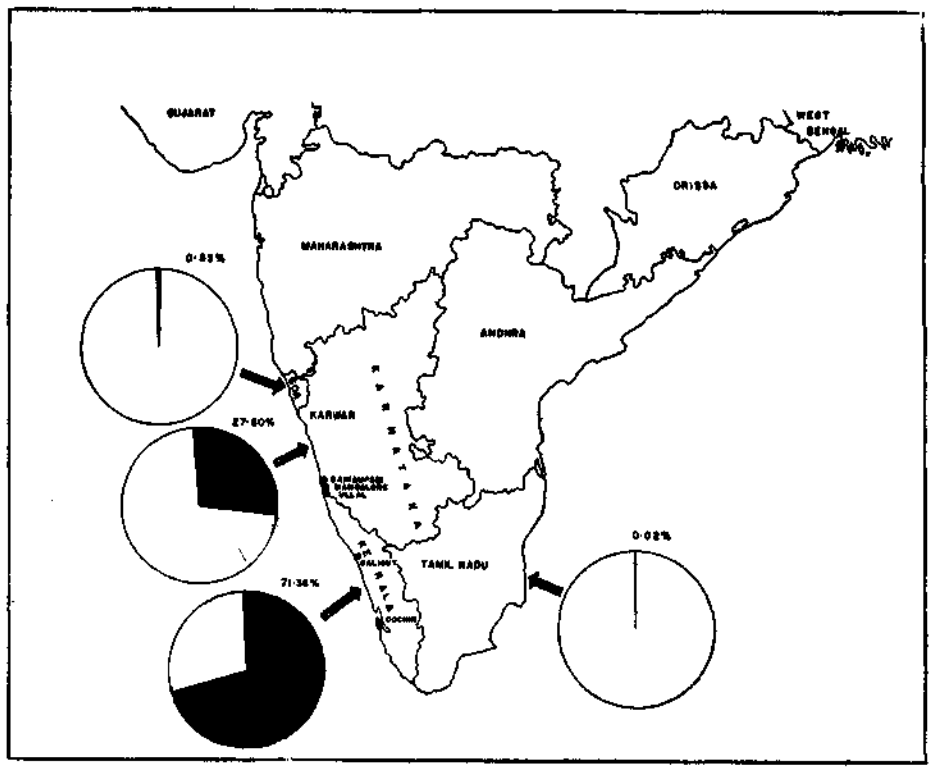


Fig. 1. Statewise annual oil sardine landings (percentage) in 1978

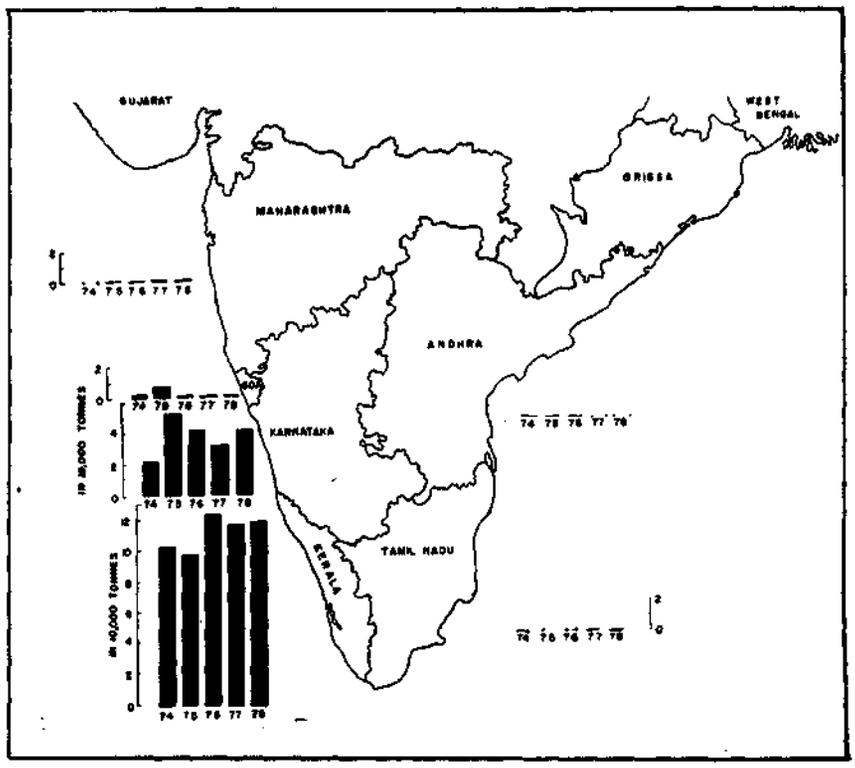


Fig. 2. Statewise annual oil sardine landings (tonnes) during 1974-78

it recorded 52,701 t. contributing 33.09% to the all India sardine landings. In the ensuing two years, the catches were almost average in magnitude. The landings improved tremendously and were the best during the last quarter (24,092 t.) of 1978, yielding a total of 46,707 t. for the year forming 27.78% of the all India sardine catches. The purse seiners at the Mangalore region solely boosted the state's catches during the 1978 season, their best catches being in September-October. Out of the annual total sardine catch of the entire Karnataka state in 1978, 80.17% was contributed by the purse seiners of the S. Karnataka region (Mangalore, Malpe and Ganguli centres). The corresponding contribution from the purse seiners of the N. Karnataka (Karwar) was only 0.05%. Viewing the magnitude of the catches on an overall basis, this state contributed the next highest catch compared to that of Kerala only.

Kerala

The major landings in the country during the decade came from this state alone. It is quite significant that in 1971, the highest sardine catch (1,94,977 t.) was made, contributing 93.17% to the all India oil sardine production. The state's annual average catch during 1969-78 was 1,31,440.0 t. In 1970, a very good landing of 1,91,683 t. was made. The landings during 1972-78 were below the average for the state. However, the catches in 1977 and 1978 formed 78.17 and 71.36% respectively in the total oil sardine yields of the country. It may be added that at Cochin, a catch of 333 t. was made by the purse seiners alone during 1978 (Fig. 3). During the final quarter of 1978, the state's highest

Fig. 3. Carrier boat with oil sardine catch from purse seiner at Cochin.

catch (75,595 t.) was made (forming 63.02% of the annual total); the smallest yield was during the second quarter, their general trend remaining the same as in the Karnataka and Goa States.

Tamil Nadu

The landings during the 1969-78 period were very poor for this state, the percentage contribution towards the all India sardine catches remaining very low. During the years from 1974 to 1976, there was no landing of oil sardine in this state. In 1978, the landing was remarkably poorer than that in 1977, the figures respectively being 36 and 714 t. In 1978, the catches were obtained only during the first and second quarters.

Andhra Pradesh

A small catch of 125 t. was landed during the years 1969-1973. The landings in 1974 amounted to 564 t. against only 131 t. of 1975. In 1976, only 112 t. was obtained, though there were no oil sardine landings in the succeeding two years in this state. Hence its percentage contribution to the all India production was relatively very small during the ten year period.

Orissa and West Bengal

The sardine landings were the smallest in these two states. A very meagre catch was made during 1969 and 1973 only. There was no landing of oil-sardine in these states after 1974.

Union Territories

There was no oil sardine landing in the Union Territories of Pondicherry, Andaman & Nicobar Islands and the Lakshadweep during the years from 1969 to 1978.

The oil sardine catch in relation to total marine fish landings

The total marine fish catch in the country during 1978 was estimated as 14,03,607 t. of which 11.97% was oil sardine. In 1977, 1976, 1975 and 1974 the percentage values respectively were 11.91, 12.51, 11.19 and 10.40. Thus, in the past five years, the annual percentage contribution of the oil sardine showed a range from 10.40 to 12.51 only.

Statewise, the oil sardine catches in Maharashtra formed only 0.01% of the total marine fish landings in 1977 against 0.18% in 1976. For 1975 and 1974, the corresponding percentages were 0.12 and 0.08 respectively.

In Goa, the percentages of oil sardine in the total marine fish catches for 1974 and 1975 were 0.17 and 0.53 respectively. In 1976, it was only 0.10%. In 1977 and 1978, the corresponding figures were 0.06 and 0.10 respectively.

In Karnataka, the corresponding percentages for 1974 and 1975 were 1.7 and 3.7 respectively. During 1976 and 1977, the values were 3.06 and 2.47. In 1978, however, the percentage rose to 3.32.

In the state of Kerala, the corresponding percentage values for 1974 and 1975 were high being 8.38 and 6.83 respectively. During 1976, the percentage rose to 9.16. In 1977 and 1978, the values were 9.31 and 8.54% respectively.

In Tamil Nadu during the years 1977 and 1978, their percentage contribution was less than 1.00. In Andhra Pradesh, the corresponding percentages were only less than 0.1 between the years 1974 and 1976.

Gears and catch per net

Observations on the various gears used and the catches per net were made at a few important centres. The bulk of the sardine catches at Cochin was made by the one-boat boat-seine "Thangu vala", its catch per net in 1978 being 280.0 kg. (Fig. 4a). This gear accounted for 78.5% of the total sardine catches there. For Ayila vala (gill net used for catching big sized sardine and mackerel) the percentage of the sardine catch was 9.3; its catch per net being 75.1 kg for 1978. In regard to the purse seine, the corresponding figures were 12.2% and 1120.5 kg per net during the year.

At Calicut (Fig. 4 b) Pattenkolli (boat seine) was the major gear accounting for 90.3% of the total sardine catch of 1978 season (6,292 t.), catching at a rate of 393.2 kg per net. Gill net Mathichala vala accounted for 9.6% of the catches, the catch rate being 116.8 kg per net. The cast net was also operated in September, landing 242.3 t.

Along the Karnataka coast during the second half of 1978, the increased purse seiner fleet landed heavy catches of oil sardine at Mangalore, Ganguli and Malpe centres (S. Karnataka), the total for the year being 37,449 t. against 31,145 t. of the previous year. At Mangalore alone 17,325 t. were landed

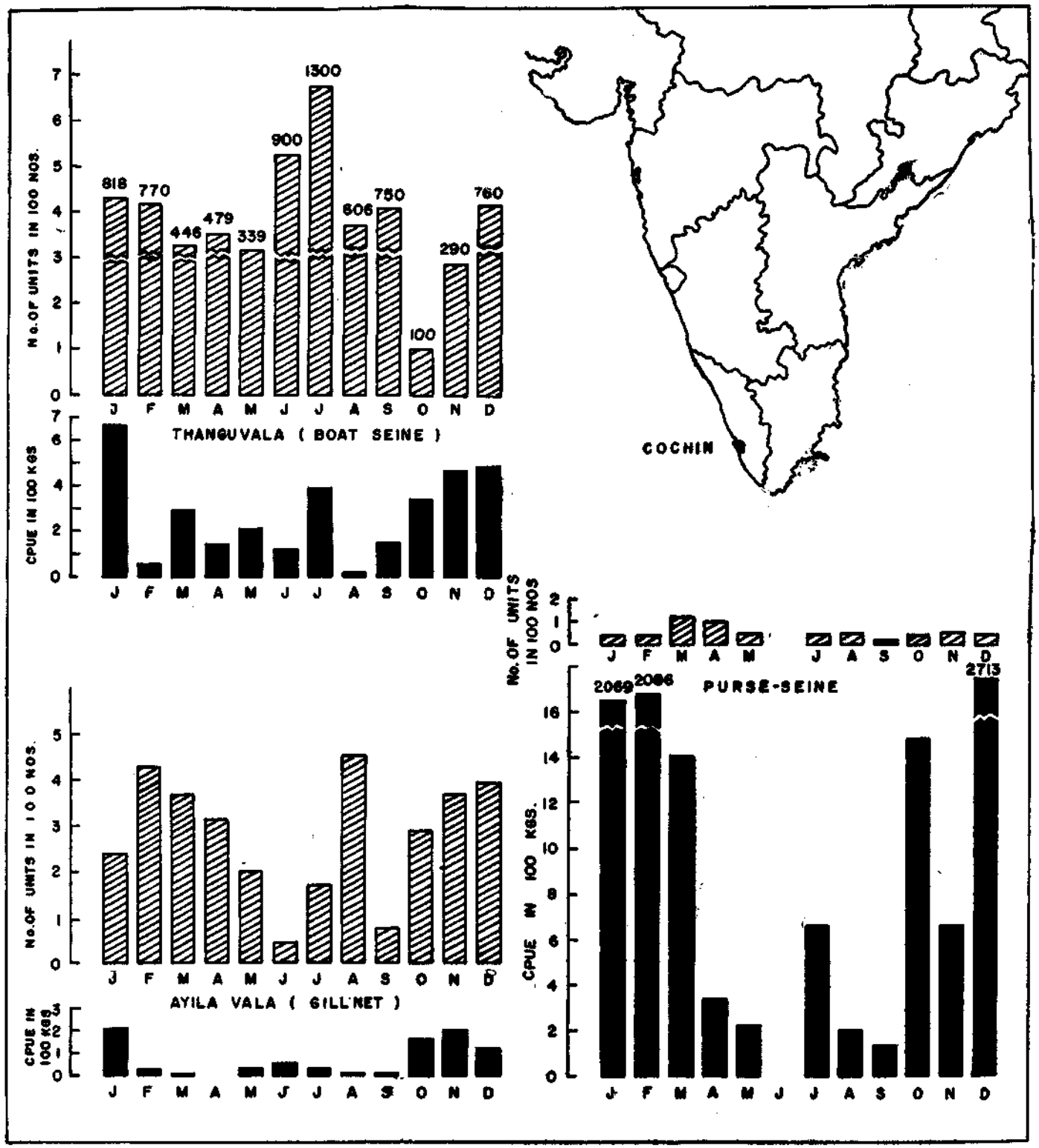


Fig. 4 a. No. of gears and monthly catch per net at Cochin during 1978

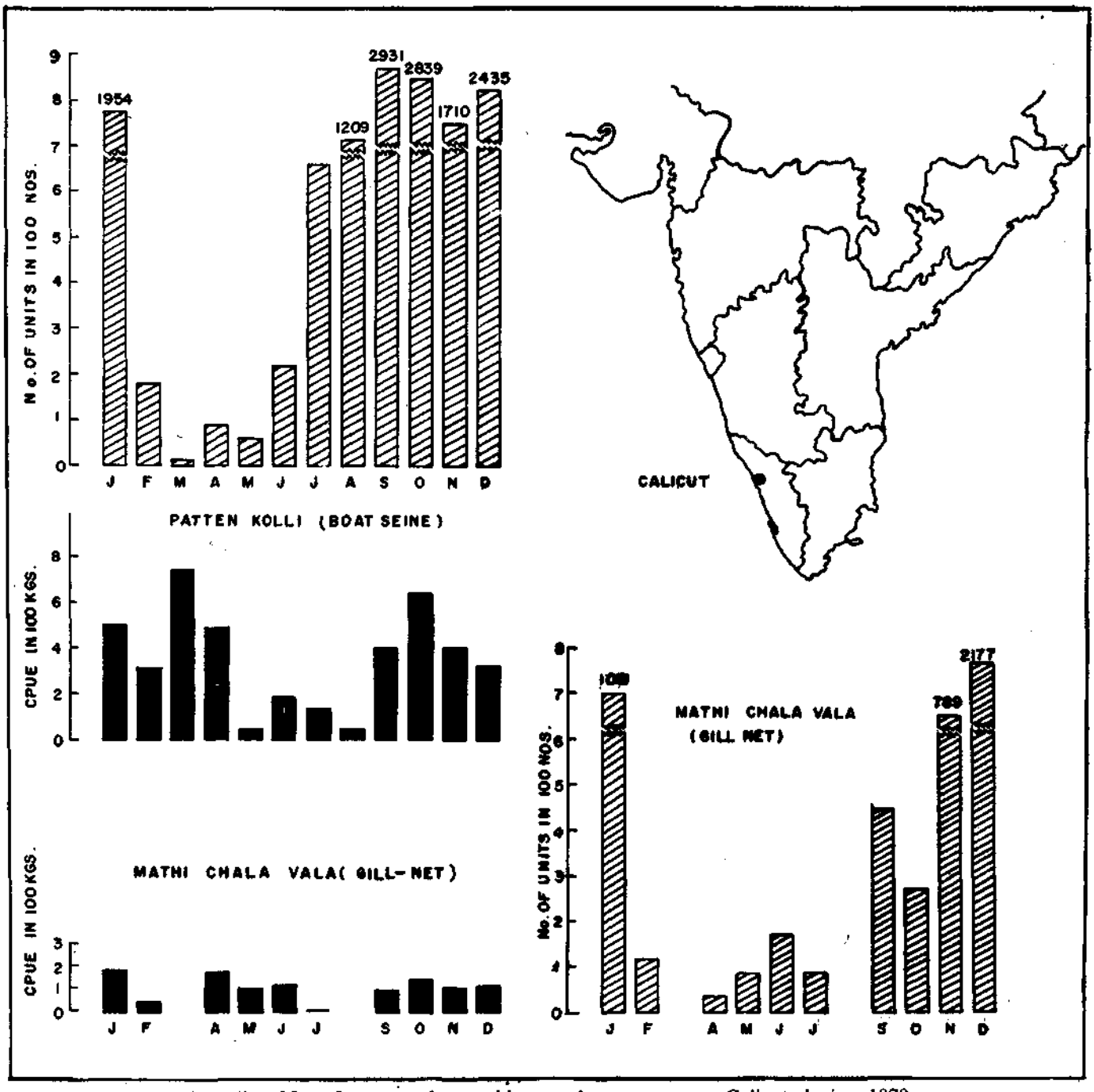


Fig. 4b. No. of gears and monthly catch per net at Calicut during 1978

against 1,938 t. in the previous year by purse seiners which formed 46.26% of the sardine catch for that region, at the high rate of 2,709.1 kg per seine during the year (Fig. 4 c). Among the various year-classes, the 0-year group alone formed 86.09% of the catch of purse seine. During the November-December period most of their catches were reduced to fish meal, consequent on glut conditions. It may be added that heavy concentrations of purse seine operations in the Bolur-Suratkal area adversely affected the Rampan catches there. Consequently, indigenous gears at Ullal and Baikampady (neighbourhood of Mangalore) landed poor catches (16.7 and 48.6 t. respectively) during 1978.

At Karwar (Fig. 4 d) during 1978, the sardine catches in purse seine and indigenous gears accounted for 291 t. against 96 t. of the previous year. The

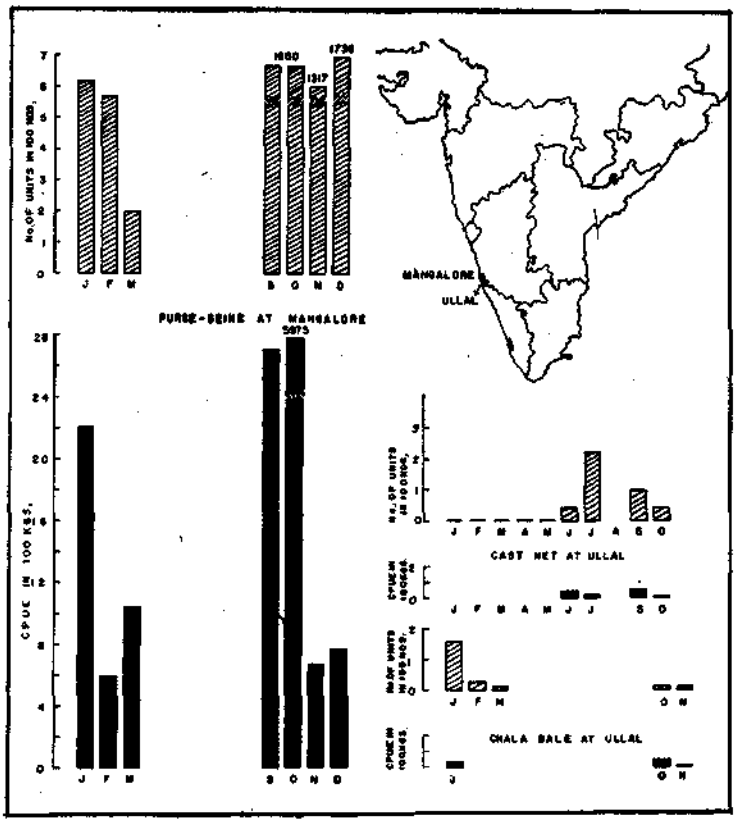


Fig. 4c. No. of gears and monthly catch per net at Ullal and Mangalore during 1978

percentages of the sardine contributions by Rampan, yendi, cast net and purse seine respectively were 11.82, 79.88, 0.09 and 8.21 in 1978. Their catches per net respectively for the year were 186.96, 273.55, 91.70 and 860.7 kg.

Seasonal distribution

The 1977 season persisted almost up to February of 1978 in the country; the fishery of 1978 season commenced in July. The landing was at its peak during August to October. The lean period for the sardine fishery was from March to June.

In the Cochin region, the fishery in 1977 lasted up to March of 1978. The fishery was rather protracted during the year. Though January 1978 had the highest catch (for all the gears combined), the poorest was in August, with only 14 t. Though the catch was lean between April and June period, it was above the average in July.

Along the Calicut coast, though the catches were poor from March to June, the bulk landings were obtained in September and October of 1978.

Relatively good catches were made in the Mangalore region between September and December of 1978 (augmented mainly by purse seiners). However, the catches were poor between February and May.

In the Karwar area, though the previous year's fishery persisted feebly up to February of 1978, the catches were very poor between March and June. The landing was much below the average in September, with further decline in the subsequent months.

Length distribution in 1978

The total length distribution as observed in a few selected centres in the Kerala and Karnataka states ranged between 50 and 215 mm, and this widest range was noticed at the Cochin centre in the Thangu vala catches. At Cochin, the youngest recruits (70 mm mode) started occurring in July. In September, the fast growing juveniles having the 100 and 105 mm modes occurred. The bigger fishes of mainly the 150, 165 and 180 mm modal groups entered the fishery in the subsequent months (Fig. 5 a).

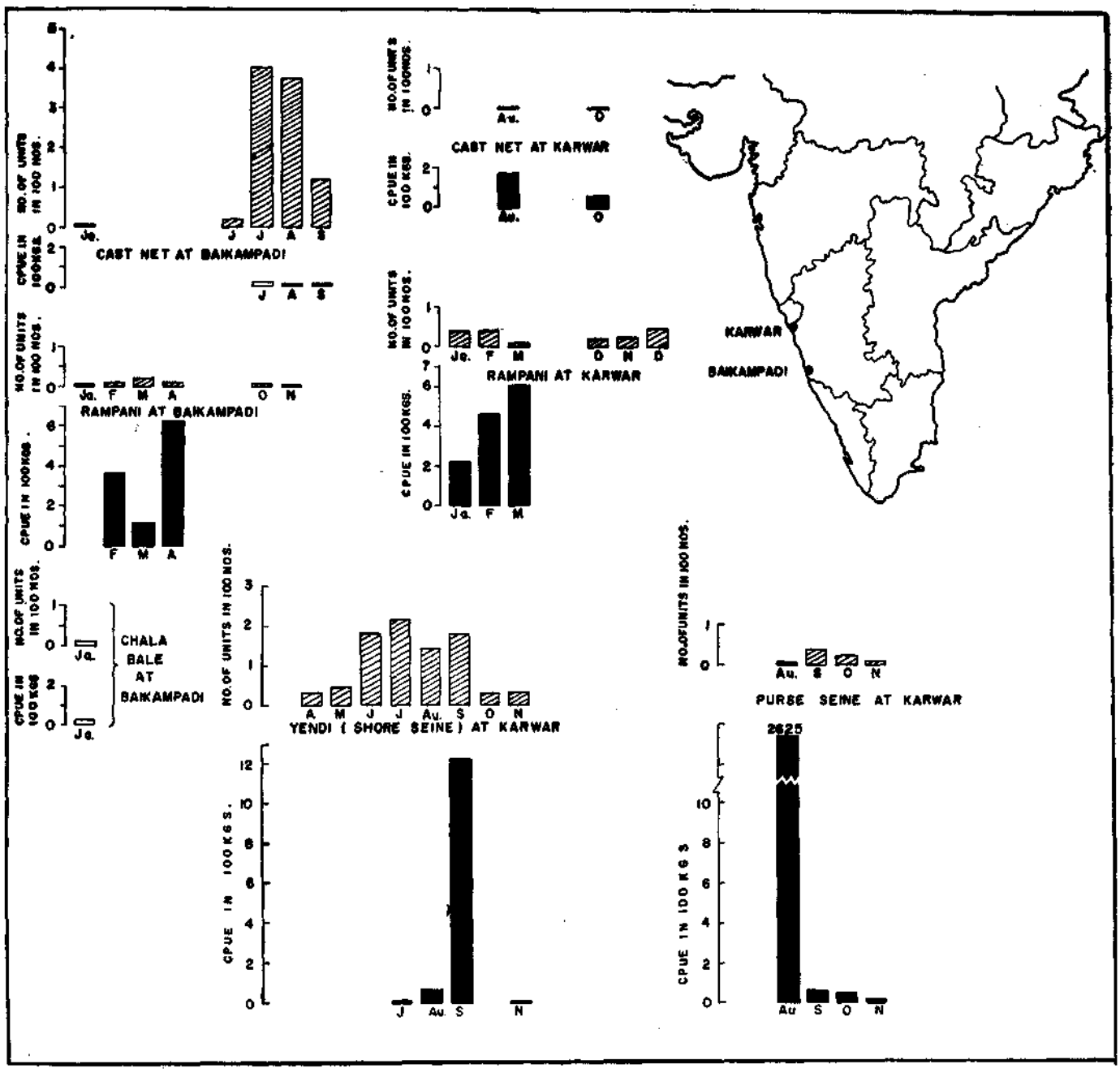


Fig. 4d. No. of gears and monthly catch per net at Baikampady and Karwar during 1978

At Calicut, the youngest recruits (65 mm total length) entered the commercial catches in August 1978. The 115, 125 and 110 mm modal sizes supported the catches from September to November. The juveniles having the 95 and 100 mm modal sizes were seen in January. These fishes were the fast growing 0-year group which were recruited towards the end of 1977. During the period from May to August and October of 1978, there was a dominance of big-sized fish (having the 175 to 200 mm modal length range) also.

In the purse seine catches of Mangalore though the juvenile recruits having the 100 mm mode appeared in August, the fish having the modal ranges from 100 to 140 mm dominated during 1978. The bigger sized sardines whose modal lengths ranged from 160 to 195

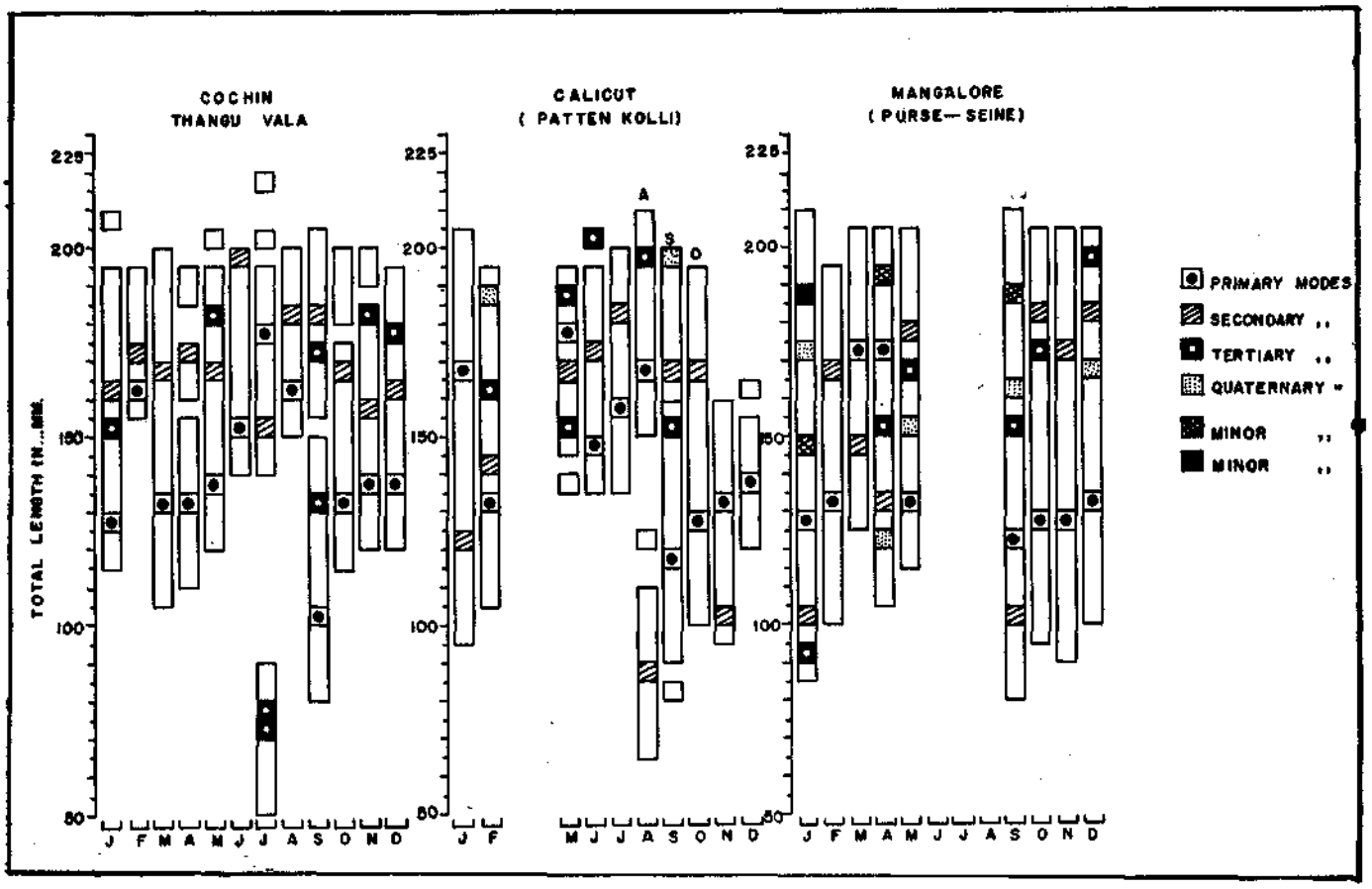


Fig. 5a. Monthly total length ranges and length modes during 1978 at Cochin, Calicut and Mangalore.

mm were also landed in appreciably good quantities. In the cast net catches, though the total length range was from 80 to 130 mm, the mode was at 100 mm. In the Rampan catches, in addition to the 100 mm, the 125 and 155 mm modes occurred. In the occasional trawl catches, the fish having the 135, 170 and 185 mm modes were obtained.

At the Karwar region, in purse seine catches, four dominant modal lengths, viz., 115, 125, 150 and 180 mm were noticed within the total length range of 75 to 195 mm (Fig. 5 b). In the cast net catches at various centres, the total lengths ranged from 80 to 150 and 165 to 210 mm, while the dominant modes were in the 95-135 mm sizes. In the Rampan catches, while the total length ranged from 75 to 205 mm, the prominent modal lengths were in the range 110 to 190 mm during the twelve months. In the yendi catches, though the total length ranged from 50 to 210 mm., the preponderant length modes were in 70-185 mm.

Growth

At Cochin the shifting of length modes from 70 to 135 mm from July to December period revealed a growth increment of 65 mm during the five months and this appears quite normal with the commercial sizes during that period of the year. The growth among the new recruits at Calicut also appears to be 50 mm in four months from August to December of 1978. In the Mangalore area, during the three months from September to December, the growth increase was 35 mm. The trend in growth among the 0-year class at Karwar region also was the same as that of Mangalore, being 35 mm (from 115 to 150 mm) during the August to November period.

Age composition

The size class structure in the commercial catches (based on length frequency studies) at selected observation centres, in the important gears used are given in Table 2. The commerical fishery consisted mainly of 0-year old fish during 1978 at the Cochin, Calicut,

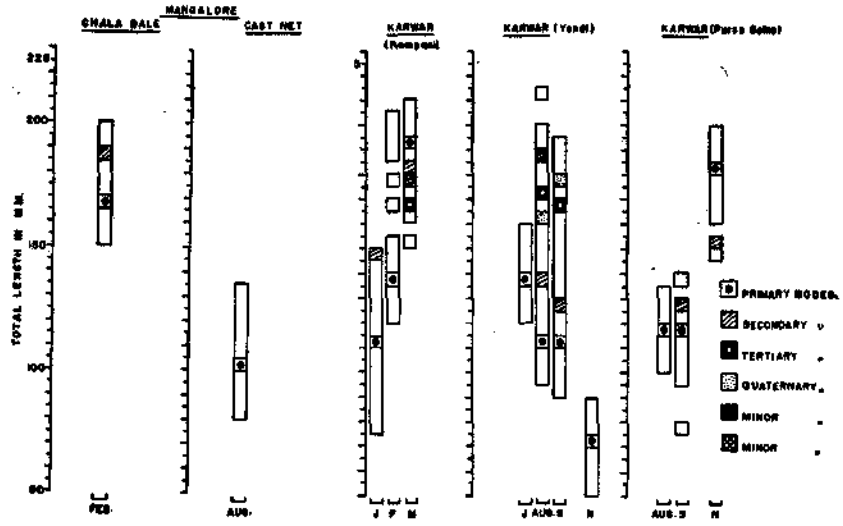


Fig. 5b. Monthly total length ranges and length modes at Mangalore and Karwar during 1978

Mangalore (Ullal and Baikampady) and Karwar centres. Whereas in 1977 the 0-year recruits dominated at Calicut and Baikampady, the 1+year olds (145 to 170 mm) preponderated at Cochin. However, a marked dominance of the 2+year and above fish (175 mm and above) was noticeable at Karwar in the Rampan catches.

Table 2. *Catch in numbers, of the sardine, per net, in different size classes at selected observation centres.*

Place (Net)	Years	0-yr 140 mm	1+ yr (145-170 mm)	2+yrs & above above 170
Karwar	1978	8,517	487	552
(Rampan)	1977	83	1,509	4,860
Karwar	1978	1,544	53	6
(Yendi)	1977	—	—	—
Karwar	1978	12,810	16	11
(Purse seine)	1977	—	—	—
Karwar	1978	9,022	—	—
(Castnet)	1977	—	—	—
Ullal	1978	1,706	572	220
(Castnet)	1977	—	—	—
Baikampady	1978	32,891	397	—
(Rampan)	1977	44,727	17,601	14,413
Mangalore	1978	97,796	10,651	5,149
(Purse seine)	1977	—	—	—
Calicut	1978	14,271	1,978	1,294
(Pattenkolli)	1977	9,187	3,680	4,197
Cochin	1978	7,522	3,061	576
(Thangu vala)	1977	4,326	8,651	1,884

Age studies by scale method

Detailed age studies by means of scales carried out at Calicut centre indicated that the sardine having 148.5 mm mean length have completed one year, those having the 170.8 mm mean length two years and those having the 195.2 mm mean length three years respectively during 1978. In the preceding year, the mean lengths corresponding to the 1+yr, 2+yr and 3+yr olds were 158.3, 180.8 and 194.6 mm respectively. During 1975 and 1976 the mean lengths for 1+, 2+ and 3+ years were 155.0 & 158.8, 179.2 & 180.0 and 192.0 & 187.6 mm respectively, closely agreeing with those of 1977 and 1978. It was also noticed that the growth was relatively rapid among the 0+yr and 1+yr old fish and that there were variations in growth rate during the different parts of the year.

Maturation and sex composition (Fig. 6)

At Cochin the stage I and spent-recovering fishes predominated in the first quarter of 1978, while stages III to V were dominant in the second quarter. Though in a large part of the third quarter, the "spent-recovering" stages were dominant, the "indeterminate" stage outnumbered the others during September. Appreciable quantities of stage I and "indeterminate" ones continued to occur during the rest of the year. The fish in oozing stage (VI) is generally not met with in the catches at Cochin. There was a striking preponderance of females throughout the year excepting in August (Fig. 6).

Among the young fish at Calicut the "indeterminate" stage and stage I dominated during the first quarter and from August to the end of the year. Due to the early spawning, the "partly-spent" stage preponderated in June, July, August and September (89.1,

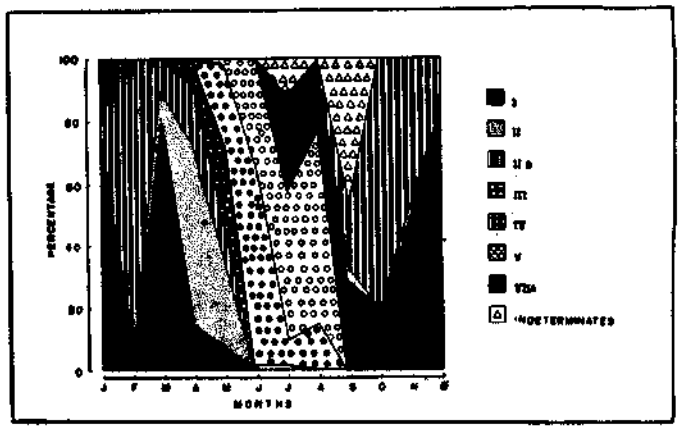


Fig. 6. Monthly percentages of maturity stages of oil sardine at Cochin during 1978.

90.2, 91.3 and 49.2% respectively). In October, the "spent" stage dominated (52.83%). Among the adult fish whose sexes could be determined, the females were predominant in February, July and December; whereas, the males were dominant in June only.

In the Mangalore area, the "partly-spent" stage dominated among the adults in January. From February to May stages I-IV were predominant. During the June-October period, the stage V and "partly-spent" ones outnumbered the rest. With the recruitment of the young fish in August and September, the "indeterminate" stage became predominant. The spent stage was dominant in December. The belated occurrence of the spent ones indicated a protracted nature of spawning in that area. Males outnumbered the females in January, May, June and from October to December.

The stage I was prominent in January, November and December at Karwar. Stages II and III were noticed during February and March. From August to September, the "indeterminate" stage, stage I and spent-recovering ones occurred in appreciable quantities. The partly-spent fish preponderated in July only. In the catches of most of the principal gears, a dominance of females was observed on pooling the entire sex data of 1978.

Vertebral studies

Systematic vertebral counts of the oil sardine made during 1977 and 1978 at Karwar from the Rampan catches indicated a range of 45 to 48, the peak frequency being at 47. The studies on the purse-seine catches also yielded the same results there.

Food

Studies on the food and feeding habits of the fish at Calicut and Cochin centres indicated that it feeds mainly on planktonic micro-organisms. The different items of plankton, either the phytoplankton or the zooplankton, predominated in its diet according to their abundance in its environment during the different periods of the year. Copepods, nauplii, crustacean remains, larval bivalves, tintinnids, dinoflagellates, *Fragilaria oceanica* and certain other diatoms were the major items noticed in the diet.

Assessment of mortality

Length frequency data obtained at Cochin and Calicut during 1976 to 1978 have been analysed. In the case of Calicut data for 1976 and 1978 monthly length frequency distributions indicated modal values repeated over three months successively. In addition, it was also observed that the distribution of modal values during January-March was found to be more or less repeated during July-September. In the case of Cochin for 1976-78, similar trend was noticed indicating the possibility of two distinct spawning seasons with a duration of three months each. Possibility of gear selectivity playing a role in this regard is ruled out as the gear concerned is *Pattenkolli vala*, a non-selective boat-seine.

When the length frequency data for Cochin for the years 1976-78 were analysed using probability paper method, five length groups with means at 67.5, 115.0, 140.0, 166.0 and 195.0 mm respectively were observed in the first year. In 1977 also, five groups were found with means at 106.0, 133.0, 157.0, 180.0 and 202.0 mm. However, in 1978, there were six groups with mean lengths at 66.5, 96.5, 106.5, 130.5, 157.5 and 186.5 mm respectively. In the case of data from Calicut during 1976, similar analysis indicated five groups with their mean lengths at 78.5, 94.0, 138.0, 168.0 and 182.5 mm respectively. From this it is clear that there is no uniformity in the mean length values of the groups.

Detailed age and growth studies by scales on this species as mentioned earlier, indicated three distinct age classes during 1978 with mean lengths at 148.5 mm, 170.8 mm and 195.2 mm respectively. Comparing these results, it may safely be said that the mean lengths of the first three age groups are at 140.0, 180.0 and 205.0 mm respectively. Using these values, the important growth parameters have been estimated.

Mortality rates

Resolving the multimodal curves into unimodal ones facilitates assigning the frequencies to individual unimodal groups. In the case of length frequency data from Cochin during 1976 and 1978, the group pertaining to the age three was not represented. However, in the 1977 data, this group was available but in very small quantities (0.6% of the total). Hence, in the present analysis, a broad classification having two groups only was made so that those coming under one-year group were all kept under the first group and the rest (above that size group) under the second group. The percentage contributions of these groups are given below:

	Year	Ist year group %	Above Ist year group %
Cochin	1976	92	8
	1977	21	79
	1978	55	45
Calicut	1976	58	42

Here also there is no uniformity between years. However, percentage distributions of Cochin in 1978 and of Calicut in 1976 agreed well with each other. Inconsistencies in percentages between years in Cochin may be due to the pelagic nature of the stocks or insufficient sampling or both. At Cochin, the percentages of frequencies for the groups upto mean length at 157 mm and the rest for the years 1976 to 1978 were as follows:

Group/Year	Percentage			
	1976	1977	1978	Average
1. Upto 157 mm mean length	92.0	81.0	98.0	90.0
2. Above 157 mm	8.0	19.0	2.0	10.0

From the scale studies, the frequencies for 2+year and 3+year olds from the samples obtained at Calicut are presented below:

Age/year	Frequencies					
	1975	1976	1977	1978	Total	%
2 year	380	311	189	118	998	88.0
3 year	20	35	30	55	140	12.0

From the above, considering the three sets, viz., 81%&19%; 90%&10% and 88 & 12%, the corresponding total instantaneous mortality rates (Z) are 1.47, 2.21 and 1.97 respectively.

Beverton and Holt *(Rapp. p.v. Reun. Cons. perm. int. Explor. Mer.* 140 (1): 67-83, 1956) have indicated another method of obtaining estimates for "Z" using only the estimates of K, L_{max} $\bar{l}$ and l_c, where $\bar{l}$ stands for the mean length caught, l_c for the length at first capture, L_{max} for maximum attainable length and K the growth parameter. Accordingly, the estimates of Z were obtained for comparisons as shown below:

	Cochin			Calicut	
	1976	1977	1978	1976	1978
$\bar{l}$	159.15	140.17	131.06	149.83	134.47
l_c	87.5	52.5	52.5	52.5	67.5
Z	0.68	0.57	0.57	0.46	0.78

The range of values for Z was found to be from 1.30 to 3.45 by several investigators in the fishery of different areas along the west coast. Here, we have two sets of Z values; one based on probability paper method and the other on Beverton and Holt's method *(op. cit.)* the ranges being 1.47-2.21 and 0.46-0.78 respectively. The last range does not come nearer to any of the other two. However, this range cannot be ignored for the following reasons. The other two ranges are based on age-length distribution study which is not an objective one to be free from personal bias. Many workers have attempted age-length distribution studies without coming to any final agreement. The values of Z obtained in the range 0.46-0.78 are based only on estimates of growth parameters and as such the reliability of these Z values may be relatively more. If that is the case, these Z values irrespective of the present level of indigenous fishing, clearly indicate that total mortality is comparatively less and would not have deleterious effect on the stocks. This has been corroborated by the sustained level of landings of this species for the past ten years. The ranges of survival rates for the corresponding ranges of Z values are given below for ready reference. (Range is indicated in the ascending order of values)

Instantaneous mortality rate	Ranges of values of Survival rate	Source
0.46–0.78	0.49–0.63	Present estimate based on Beverton and Holt's method.
1.47–2.21	0.11–0.23	Present estimate based on probability paper method.
1.30–3.45	0.03–0.27	Previous investigations by different authors.

Assessment of stock

Considering $\frac{F}{Z}$ ie., $\frac{\text{Instantaneous fishing mortality}}{\text{Total instantaneous mortality}}$ as 0.25, 0.50, 0.75, 0.90 and 1.00, rough estimates of stock on the basis of average of ten years' catch estimates were obtained. Taking the rate of exploitation $U = \frac{F}{Z}(1 - e^{-Z})$ and Z values as 0.62 and 1.84, being the mid-values of the first two ranges mentioned earlier, average annual stock and average standing stock have been estimated as given below:

Z	$\frac{F}{Z}$	F	U	$\frac{Y^*}{U}$ (tonnes) Average annual stock	$\frac{Y^*}{F}$ (tonnes) Average standing stock
0.62	0.25	0.16	0.12	10,95,333	8,21,500
	0.50	0.31	0.23	5,71,478	4,24,000
	0.75	0.46	0.34	3,86,588	2,85,739
	0.90	0.56	0.41	3,20,585	2,34,714
	1.00	0.62	0.46	2,85,739	2,12,000
1.84	0.25	0.46	0.21	6,25,904	2,85,739
	0.50	0.92	0.42	3,15,952	1,42,870
	0.75	1.38	0.63	2,08,635	95,246
	0.90	1.66	0.76	1,72,947	79,181
	1.00	1.84	0.84	1,56,476	71,435

Y^* = 1,31,440 tonnes, the average of ten years' (1969-78) landings estimates of oil sardine in Kerala State.

During the last decade (1969-78), the maximum catch recorded was 1.95 lakh tonnes in 1971 in Kerala State. This clearly indicates that the average annual stock should be above 2.00 lakh tonnes. In the light of this, the values of F against Z=1.84 should be at the most 1.38. Stock estimates obtained by Pelagic Fisheries Project (FAO), Cochin earlier, indicated the stock level at about 4.00 lakh tonnes. This estimate is obtained when Z=0.62 and F=0.46. (In case of Z=1.84 the corresponding F value is estimated at 0.75). Hence, so far as indigenous effort is concerned it may safely be said that the present effort pressure will not have adverse effect on the sardine stocks. However, the recent proliferation of purse seiners off Karnataka State and the presence of a few off the Kerala State may have to be taken note of for detailed studies to see their impact on the stocks. Consequent on purse seining, marked decline in the landings of indigenous gears has already been reported recently along the Karnataka region.

Forecast

From the existing catch trends it is indicated that the sardine catches during the 1980 season would not be far from the average of the last decade. In the light of the stock assessment studies it may be mentioned that increase in fishing effort would result in better catches.

NEWS—INDIA AND OVERSEAS

Use of pig manure for fish farming in Taiwan

The Food and Fertilizer Technology Centre at Taipei is recommending the technique of carbon manuring as ideal for raising fish. The technique has encouraged many farmers in Taiwan to integrate fish raising with pig farming. By the use of pig manure as fish food one hectare of well-managed fish pond may produce annually upto 5 tonnes of carp and tilapia.

The technique involves mixing manure with water and spreading it in a regular manner over the surface of the fish pond. Regular distribution of manure, preferably in fresh condition, has to be made at very

short intervals, since the carbon content is the highest at this stage. In order to avoid depletion of oxygen in the pond it is very essential that application of manure, particularly that which is nonfermented, be carefully regulated.

World Fishing 28 (5): June 1979

International consortium for fisheries and aquaculture development

A consortium of five U. S. universities has been organised to help other nations use the seas and fresh water bodies to expand their food supplies. Members of this organisation, known as the "Consortium for International Fisheries and Aquaculture development" include Michigan State University, University of Michigan, University of Arkansas, University of Hawaii amd Oregon State University. Harvey L. Moore of Oregon State University is the co-ordinator for the consortium. According to him this consortium is the first of its kind and there are several nations which border oceans or have vast fresh water bodies that could yield far greater quantities of food. The consortium would concentrate on increasing world food production and solving food and nutrition problems of the developing countries of the world.

Commerical Fish Farmer 5 (5): July, August 1979

Chinese/American agreement in aquaculture

In a recent agreement between U.S. and Chinese governments, exchange visits by U.S. and Chinese aquaculture scientists in early and mid 1980 have been ratified. The U.S. representatives from Government, private and academic communities will be visiting China in early 1980. In turn in the summer of 1980 Chinese scientists will visit NOAA laboratories which specialise in the pathology of fish and shell fishes.

The agreement also envisages exchange of knowledge in several oceanographic and fishery areas. The other parts of the agreement provide for the assistance of the U.S. in establishing a Chinese Marine Data Centre, a joint U.S./Chinese study in sediment dynamics and bottom-layer oceanography, an observation by the Chinese of U.S. tuna fishery activities and the development of a Marine Environmental Service.

Commerical Fish Farmer 5 (5): July & August 1979

Taiwan to implement insurance plan for eel farms

The government of Taiwan has agreed in principle to an insurance system for the protection of the country's big eel culture industry. Initial plans call for the system to be managed by the Co-operative Enterprises Administration. Details of the system are being worked out by the Taiwan Provincial Farmers Association.

Protection will be comprehensive and will cover losses of fry and adult breeding stock due to natural causes or disasters as well as losses of adult eels during shipment to foreign importers.

Fish Farming International 6 (2): June 1979

Low density stocking advised in shrimp farming

In a paper presented at the tenth annual conference of the Shellfish Association of Great Britain a Dutch scientist Dr. R. Boddeke put the case for low-density stocking as the basis for the development of the farming of penaeid shrimp in tropical areas. The paper is based on first-hand experience of a big prawn farming project in north-east Brazil and on studies of another project in Ecuador. Both are based on low density stocking of relatively large ponds and supporting local unskilled workers rather than specialised and highly paid technical staff. Harvesting also was carried out by labour intensive methods.

Instead of intensive culture, Dr. Boddeke advocates extensive culture when there is space. His stocking density of 18 per sq. cm at postlarval stage reduces risk of epidemic disease and stress. It also enables the prawns to feed well on naturally occurring diatom food, the growth of which can be artificially stimulated. In the Brazilian project 1100 ha of ponds were fed from brackish water canal and naturally occurring seed gathered by local labour from the estuary stocked in the ponds. The important factor is the selection of the right prawn which would find enough natural food and flourish under artificial rearing conditions. This project in Brazil had been shown to be more efficient than the relatively sophisticated 300 hp shrimp trawlers fishing in the area both in terms of productivity and quality.

Fish Farming International 16 (2): June 1979

Preventive for 'red water'

The Fisheries Agency of the Japanese Government is subsidising tests in the use of bentonite to prevent red water development in bays in western Japan. The red tide frequently causes great damage to fishery activities in the waters of Japan. It has been confirmed that the drug is effective in preventing it.

The tests, which will take two years to complete, will be made on various aspects of the problem, especially the assessment of damage to the environment and the effects on fish and shell fish when the drug is extensively applied to the sea surface.

World Fishing 28 (4): April 1979

Radiophonic scare crow

A new method has been found for protecting fish ponds from birds. Ridiophone—Parod, the production branch of Radiophone Ltd. of Israel has developed a radiophonic scare crow, known as TATD which operates automatically and broadcasts the distress calls of predatory birds.

World Fishing 28 (4): April 1979

Devil rays landed at Cochin and Munambam

Two large devil rays belonging to the species *Manta birostris* (Walbaum) were landed at Cochin Fishing harbour and Munambam on 18.10.1979 and 23.10.1979 respectively. Both were caught in gill nets operated by mechanised boats in 30–50 m depth region.

The morphometric measurements of each are given below:

Measurements (cm)	Specimen at Cochin	Specimen at Munambam
Breadth across disc	615	490
Length of cephalic horns	61	68
Length of tail	135	—
Distance between cephalic horns	91	90
Height of dorsal fin	29	—
Length of pelvic fin	37	—
Weight (approximate) in kg	1000	500

Both were females and the specimen landed at Cochin had a foetus weighing about 15 kg. The rays were observed by Shri P. K. Mahadevan Pillai at Cochin and Shri K.C. Yohannan at Munambam.

Larval rearing of Indian prawn adapted to local conditions at CMFRI, Narakkal

New procedures developed at the Prawn Culture Laboratory (PCL) of CMFRI, Narakkal have yielded very good results. Development of mass cultures of locally available phytoplankton and zooplankton organisms for feeding the larval stages of prawns has been successful and large quantities of seed prawns of *P. indicus* (Naran) have been produced. The newly developed method dispenses with the dependence on conventional food organisms like *Skeletonema costatum* and nauplii of *Artemia salina*. Nearly 1,00,000 prawn juveniles thus produced at the laboratory have been distributed to the local prawn farmers.

Repeated spawning of broodstock prawns at CMFRI, Narakkal.

Recent experiments conducted in the Prawn Culture Laboratory (PCL) of CMFRI at Narakkal has shown that the Indian prawn *P. indicus* can spawn repeatedly within short periods. When adult prawns collected from the culture ponds were subjected to unilateral eye ablation and kept in special pools containing circulating sea water they attained maturity and fully spawned viable eggs within 10 days. After spawing the very same prawns rematured and spawned again repeatedly at intervals of 5 to 20 days. These observations go a long way in the process of large scale seed production for developing prawn culture among coastal farms.

PRELIMINARY REPORT ON A RECONNAISSANCE SURVEY OF THE MAJOR COASTAL AND MARINE ECOSYSTEMS IN GULF OF KUTCH*

Introduction

The region of Gulf of Kutch was possibly more an arid zone in the pleistocene, almost approaching to a desert condition, than what it is at present. The gulf is believed to be the result of a wide indentation or subsidence that allowed encroachment of the sea in the geological past. The whole area is still supposed to be seismically unstable. The Gulf of Kutch covers an area of *circa* 7,350 sq. km with a maximum depth of 60 m. The tidal range varies from 3.06 to 5.89 m with an average of 4 m. The intertidal zones are sandy and muddy or with sandstones of vast expanse and prolonged exposure. There is a clear indication of a relative change in the levels of land and sea in the past as is evidenced by the presence of raised coral reef at Okha still intact near the Railway Station. Whether this relative change is due to a local disturbance or part of a global phenomenon in the holocene is still a disputed question.

Our knowledge of the marine biology of the Okhamandal coast at the dawn of this century is mainly due to James Hornell who submitted a report to the erstwhile Government of Baroda in 1909. Subsequently many workers have dealt with the marine ecology, biology and geology and living resources of this area. The present report is based on a six weeks survey carried out in the Gulf of Kutch mainly around Okha and Jamnagar in 1978 with a view to obtaining additional information on the major marine and coastal habitats, particularly the coral formations and the mangroves. The prevailing physical features, animal communities and the visible ecological impact on the ecosystems due to human interference are briefly discussed.

*By C. S. Gopinadha Pillai and M. S. Rajagopalan of Central Marine Fisheries Research Institute, Cochin and M. A. Varghese of the Marine Biological Station, Port Okha. Dr. N. D. Chayya and his colleagues of the Gujarat State Fisheries rendered all possible help during the survey both at Okha and Jamnagar.

Intertidal sandstones

The coast of Okha has a vast expanse of intertidal elevated sandstones. At low tides these get exposed to considerable width. At Okha near the Marine Biological Station a general paucity of the fauna is observed on these sandstones, while at Adatra there is a profusion of animal life with a clearcut zonation of certain groups. The uppermost or the littoral fringe zone harbours *Littorina* spp. along with a few hermit crabs. Below the littoral fringe there is a level platin, 50 to 70 m wide that harbours mainly gastropods such as *Astrea semicostata, Thais rudolphi, Nerita* spp., *Cerithidea fluviatilis* and *Trochus niloticus.* This represents the upper eulittoral zone. Besides molluscs the common animals noticed are a few crabs. Below this a distinct zone of small barnacles (Fig. 1) of 30 to 40 m width is seen. The surface coverage is roughly 50% on an average. Nodular and encrusting calcareous algae are found mixed with the barnacles which also aid in the calcification of the sandstones here. Below the zone of barnacles there is a distinct zone (width 20 to 30 m) of the sedentary mollusc, *Vermetes.* The tubes of this mollusc form a thick encrustation and is found mixed with the tube dwelling polychaete, *Eunice tubifex.* Calcareous algae are also present. In the fringe zone both barnacles and *Vermetes* mingle. The lower part of the sandstones bed, below the zone of *Vermetes* shows signs of erosion by wave action getting themselves cut into knife-edged hollows (Fig. 2). The subtidal zone has a thick growth of algae mainly *Caulerpa recemosa.* The area below the sandstone was chiefly muddy in February 1978 harbouring mostly *Cerithium* spp. In the rock pools of the sandstones there are patchy growth of corals including *Favia pallida, Goniastrea pectinata* and *Platygyra daedalea.* A species of mussid coral *Acanthastrea* (probabaly *A. hillae)* was also noticed. Its presence is noteworthy since the species is known previously only from the Pacific.

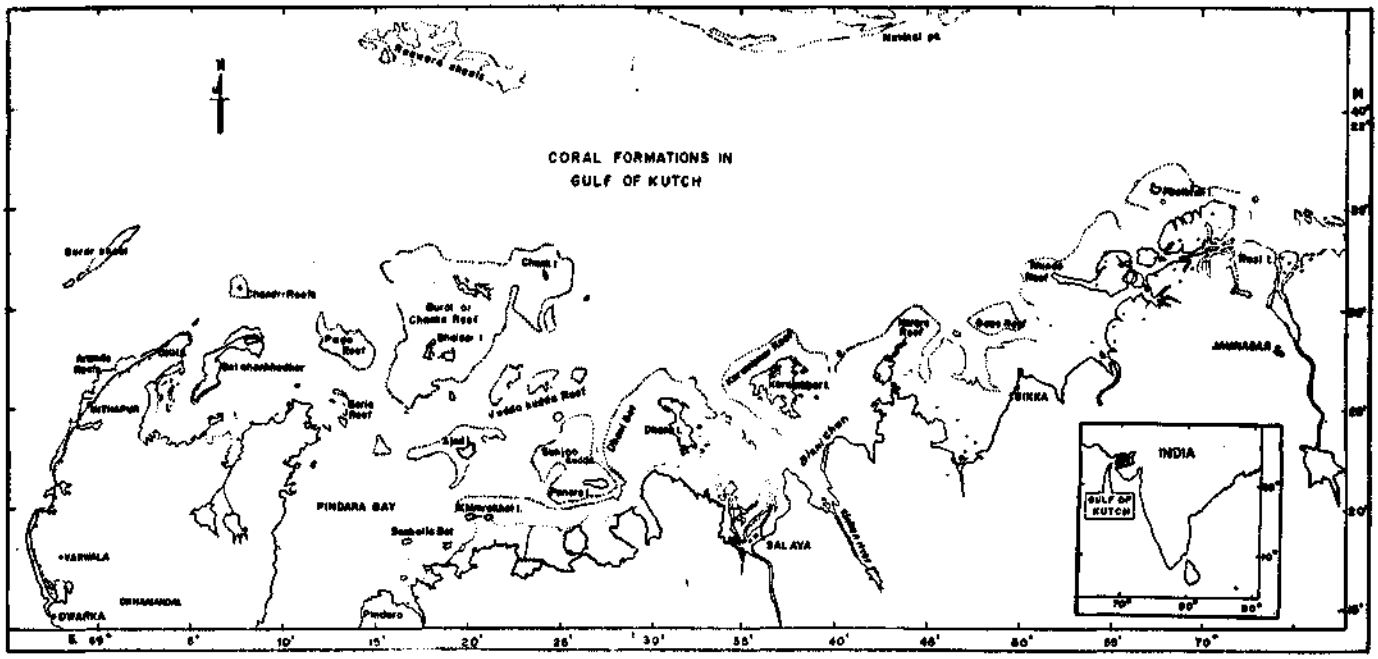
The intertidal zones of Poshitra at several places is sandy and with mud flats. At Dholani there is abundance of *Crassostrea ?cristagalli* (Fig. 3). They grow there in the shape of "miniature atolls" 3 to 4 m long and wide with the walls about 0.5 m thick and high, enclosing a central pool of water. The upper layer get exposed at low tide and they are surprisingly analogous to a coral atoll in growth form.

Coral formations

Fringing barrier or atoll types of reefs do not occur in the Gulf of Kutch. The present day coral growths of this area are of patchy type either on intertidal sandstones or on the surface of wave-cut, eroded, shallow banks, extending between longitudes 69 to 70°E and latitudes 22°20′–35′N (Map). The coral formation of Gulf of Kutch represent one of the extreme

Morphology of the patch reefs

The growth of corals in Gulf of Kutch, as already stated, is confined to intertidal sandstones or on the surface of totally submersible wave-cut banks. When exposed, the shores are delimited as in Paga and Boria by a sand bar about 0.5 m above the general level of the bank. The sand bar is composed of a mixture of calcareous and siliceous sand, the former mainly derived from the fragments of molluscan shells, corals and calcareous algae. There is a central lagoon–like area holding water to a depth of 0.25 to 0.5 m where corals and other animals thrive. A vague similarity in shape can be drawn to a typical coral atoll. There is no terrestrial vegetation both in Paga and Boria as is the case with several other small banks. The surface is often strewn with loose boulders which are mostly derived from the erosion of the land.



Gulf of Kutch showing the areas of coral formations

northern limits of corals in the Indian Ocean, excepting some parts of the Red Sea and the Persian Gulf. Observations were made at Okha, along the mainland coast and at Paga (Long. 69°10′E; Lat. 22° 28′N), Boria (Long. 69°14′; Lat. 22°24′N) both of which are shallow banks and Pirothtan Island (Long. 69° 58′E; Lat. 22°34-30′N). The corals of Gulf of Kutch are difficult to approach, particularly those on the banks due to the existence of vast intertidal mud flats which are difficult to negotiate by foot at low tides. The sudden influx of tidal waters also renders it risky to work on the exposed banks.

In Paga, the central pool is very shallow. The coral fauna includes, *Montipora venosa, Favites halicora, Favia* spp., *Platygyra daedalea, Symphyllia nobilis* and *Turbinaria* spp. None of the common Indo-Pacific hermatypic genera like *Acropora, Pocillopora, Stylophora* and *Seriatopora* was observed in living condition. There is total absence of true ramose corals. Visual estimate of coverage is roughly 20%. Intermittent with coral colonies there are many large sea anemones *(Discosoma)* (Fig. 5) on sandy patches. Five to ten individuals could be counted in about a sq. m. At the time of the survey in February

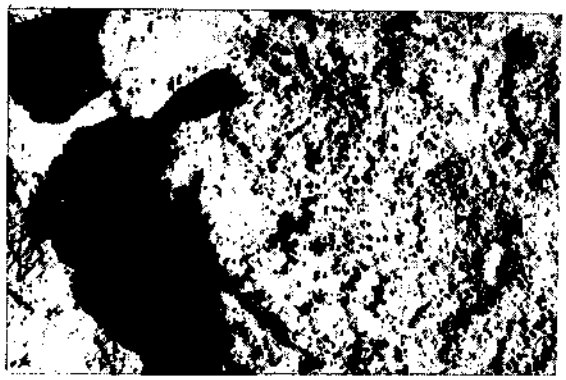


Fig. 1 Sandstones at Adatra Reef, Okha showing the barnacle zone.

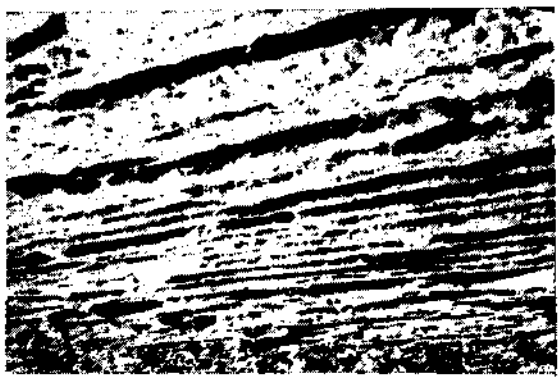


Fig. 2 Erosion of sandstones in the form of knife-edged ridges and hollows.

Fig. 3 Miniature atoll shaped growth of *Crassostrea* at Poshitra Point.

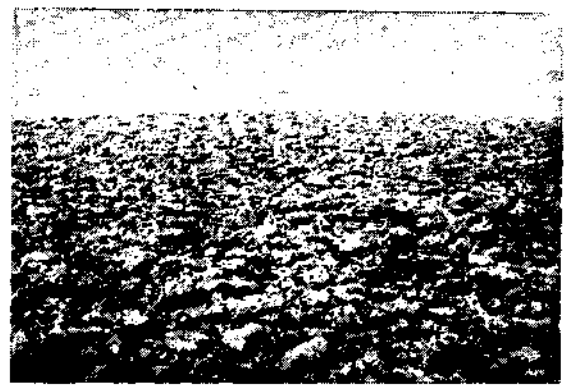


Fig. 4 The loose, dead boulders exposed at low tide at Boria.

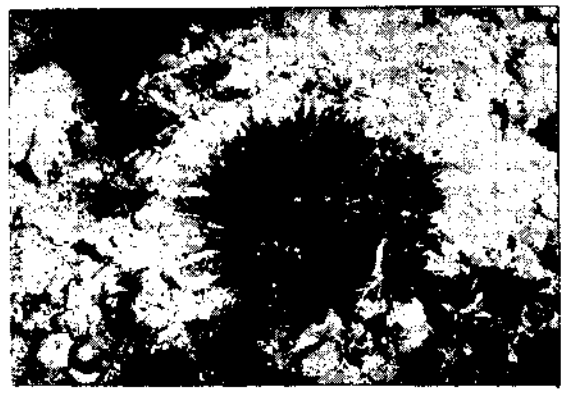


Fig. 5 The large sea anemone *(Discosoma)* at Paga Bank.

Fig. 6 Low wooded *Avicennia* at Poshitra Point. (A camel is seen feeding on the leaves).

there was a rich growth of algae, which included, *Ulva reticulata, Caulerpa recemosa, Sargassam* spp., *Padina* sp., *Gracilaria edulis* and *G. crassa.* A seasonal succession of algal growth is reported from the Gulf in literature.

Boria is similar to Paga in surface features and formation. The elevation of the highest point (sand bar) at the lowest tide is about 0.75 m. Most of the surface is level, strewn with small boulders formed as a result of erosion. When exposed (Fig. 4), they were all found coated with a thick deposit of silt. These boulders are devoid of any animal life. The lagoon-like part is confirmed to the southern tip of the bank, separated from the open sea, by the sand bar when exposed. Among the dominant species of corals, *Montipora* spp., *Favia favus, Favites halicora, Goniastrea pectinata, Platygyra daedalea, Hydnophora exesa, Cyphastrea serialia, Goniopora nigra, Porites* spp. *Coscinaraea monile* and *Turbinaria peltata* were observed. *Turbinaria peltata* was the most common, a species wide spread in the Indo-Pacific, but nowhere abundant. Here also ramose corals are totally absent. Sea anemones, alcyonarians, and sea lillies were also found intermingled with corals. A large nudibranch *(Melibe)* was fairly common. Algae were represented by *Gracilaria verrucosa, Caulerpa scapelliformis* and *Ulva reticulata.* A noteworthy nature of the corals here was the fully expanded condition of the polyps of all the colonies under bright sun light.

Pirothtan Island represents the northern limit of the coral growth in Gulf of Kutch and the island is different from Paga and Boria structurally in the sense that it is not a submergible bank. The shore is fringed by mangroves with mud flats which get exposed at low tide. The living corals are confined to a small area at the north side of the island. But the eastern side has a vast area of dead corals with most of the colonies intact, giving a clear indication of a mass mortality in the recent past. The dead coral colonies are encrusted with algae and sponges. A species of *Octopus* which is used as bait for fish is very common here. At the northern side the living corals include *Favia pallida, Goniastrea pectinata, Platygyra daedalea, Cyphastrea serialia* and *Siderastrea lilacea.* Large colonies (0.5 to 1 m in diameter) of the flabellate species of *Porites compressa* were seen though their tops are dead. Most of the corals are found partly dead or covered by sediment. Massive *Porites* was once very common in this island, but most of it had been already removed for various purposes and only rarely living colonies are seen.

The Coral fauna of Gulf of Kutch in general

As far as is known, the coral fauna of Gulf of Kutch includes 26 hermatypic species divided among 20 genera. An updated list of the species will be published elsewhere. All the species recorded are wide spread Indo-Pacific forms. A total of 26 species seems to be very low when compared to the species number of many other Indo-Pacific areas. This low number is mainly due to the absence of Pocilloporidae and *Acropora* in Gulf of Kutch fauna. A few, semifossilised, tufted branches of *Acropora* (compares *A. variabilis)* were seen among the small shingle of the sand bar in Paga clearly indicating the occurrence of *Acropora* here in the past or in very deep water. The high turbid condition of the water is the main factor that prevents the growth of *Acropora* and several other small polyped corals here. Among the non-scleractinians, *Millepora, Heliopora* and *Tubipora* could not be seen. *Porites,* the most important reef builder has dwindled. The presence of large, dead, semi-fossilised, intact colonies of massive *Porites* on the raised reef of Okha indicates that the genus was thriving very well in the past.

The mangroves

The dry climatic conditions prevailing in the region for about 8 months in a year and poor rainfall (in a place like Jamnagar the thermal amplitude is about 12°C and average annual rainfall is around 470 mm) as well as human interference have acted as limiting factors to mangrove vegetation in the region although the estimated coverage is about 52,000 ha. Mangrove vegetation has developed along protected bays, creeks and muddy flats. The formations are isolated and discontinuous and occur from Kandla, Navalakhi in the north to Jodia, Jamnagar, Sikka, Salaya and Okha in the south along the coasts of the Gulf. The mangroves of Kutch in general is of the open scrubby type with low wooded *Avicennia marina* and *Rhizophora mucronata.* In Dwaraka, Poshitra and Dohlani (Fig. 6) mostly a single species is seen, i.e. *A. marina* while from Bedi Point to Pirothtan both *Avicennia* and *Rhizophora* were found mixed. The back mangroves at higher zones are composed of *Salicornia, Suaeda* and thorny shrubs like *Acacia* and *Prosopsis.* The soil is muddy and loose and very difficult to walk through. The resident fauna include two species of *Littorina* on the trunk and undersides of trees and a species of barnacle on the roots and breathing roots. At higher levels *Uca* is very common. On the mud flats the gastropods *Cerithidia fluviatilis* and *Cerithium* sp. are very common and some times form

very thick beds, as seen in Dholani. Around Poshitra Point large number of *Periophthalmus* and *Boleophthalmus* were found "walking" on the mud flats when exposed. Here a large form of echiuroid worm was in plenty. At Dwaraka the shallow waters were found to contain young ones of mullets and prawns which are collected as seeds for culture practices. A small fishery exists in the creeks between Bedi Point and Pirothtan Island with a luxuriant mangrove formation.

The impact of ecological and human interference on the major ecosystems

An inherent low biological productivity or destruction of biogenic carbonates by high tidal range is already known from Gulf of Kutch. There is very little influx of fresh water into the Gulf and the fluctuation of salinity is minimum. The most important physical factor that at present affect the marine life of Gulf of Kutch seems to be the high degree of sedimentation. The source of sediments is mainly of terregenous material, mostly resulting from erosion by wave action. The calcareous fraction is derived from the fragments of dead molluscan shells, corals and calcareous algae, Influx of sediments through streams and rivers are of minor significance. However, transport of sediments. in and out from the muddy mangrove soil and Intertidal flats by tidal waters is a significant factor that causes the suspension of silt and sediments in the inshore waters and over the banks. A high degree of silting is a major detremental physical factor that affects the growth of corals as well as many other filter feeding marine animals adversely. Large quantities of fine silt is found all over the rubbles and boulders on Paga and Boria at exposure time which is again stirred up by the rise of tide. In Pirothtan many corals are found partly covered by silt and there is clear indication of mass mortality of corals here only due to the deleterious effect of sediments. Many corals with large polyps can combat the bad effect of sediments, while others with small polyps like *Acropora* can never live in highly turbid waters. The absence of *Acropora* in Gulf of Kutch is mainly due to high degree of silting.

Existence of extreme physical conditions such as prolonged exposure due to very high tidal amplitude is a major factor that applies constraints on the colonisation of many marine animals. In extreme condition only those highly specialised, can thrive and diversity of species will be minimized. However, in the absence of interspecific competition the intensity of population of the species that get established will be high. This is what exactly is reflected in Adatra reef where the dominant animals include only balanids, *Vermetes* and a tube dwelling polychaete, that too with a clear-cut zonation.

Human interference is a major factor that alter or damage the marine and coastal ecosystems. Because of the poor annual rain fall and arid condition, fodder for cattle and camel has been a problem and mangrove trees are regularly poached for fodder by the villagers. In many places the trees are also cut for fire wood. In Pirothtan most of the corals, particularly, the massive ones, have been already quarried and used up for various purposes which has resulted in major destruction. Living colonies are very few. Further, large quantities of calcareous sand and clay are being taken from near this island causing a severe degree of sedimentation. This has caused the recent death of many corals here. Many freshly killed colonies were found either partly or fully covered by silt. Sediments kill the coral polyps either by choking the gastrovascular cavities or by completely covering the colony leading to asphyxia. Growth is restricted by preventing the settlement of planulae on the hard substratum when the latter is coated with silt or sediments. The higher rate of sedimentation in the inshore waters of Gulf of Kutch appears to be the most deleterious physical factor that affect the marine fauna at present.

BOOKS

1. *Environmental pollution analysis.* By P.D. Goulden, Heyden & Sons Ltd., London, pp 209, 1978.

This is one of the volumes of the series 'Heyden international topics in Science' which aims at the timely dissemination of essential information about topics of current interest in science. This volume describes the methods by which environmental samples are obtained and how the levels of particular pollutants in these samples are determined. Throughout this book the emphasis is placed on the most recently developed techniques. The description of the chemical and instrumental techniques used in identification and determination of environmental pollutants is detailed to enable newcomers to the field to carryout routine analysis.

2. *Geochemical processes, water and sediment environments.* By A. Lerman, John Wiley & Sons, New York, pp 481, 1979.

This book begins with a chapter introducing the broad picture of the global geochemical cycles, and proceeds to treat in more detail the individual processes responsible for the major fluxes of materials on land, in water and, to a lesser degree, in the atmosphere. The subsequent chapters deal with the following subjects: Transport of dissolved and suspended materials, controls of the chemical composition and acidity of rain, the physical and chemical weathering of the land surface, interaction between solids and waters in rivers, lakes and oceans, regeneration of biologically formed materials, transport across the sediment water interface and chemical reactions and diagenesis in sediments.

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