PROCEEDINGS OF THE SYMPOSIUM

ON

LIVING RESOURCES *of* THE SEAS AROUND INDIA

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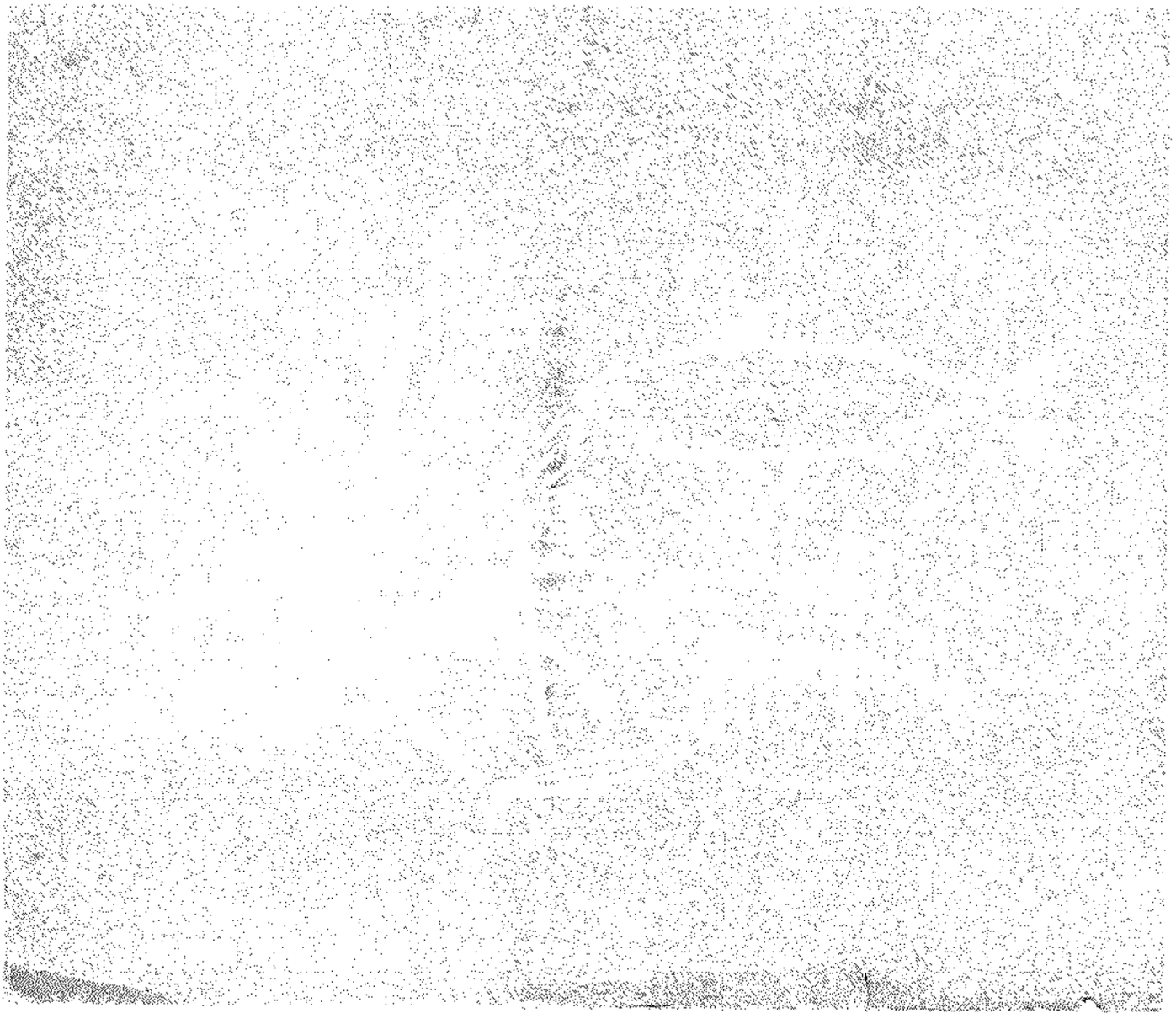

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DISTRIBUTION PATTERN OF THE MAJOR EXPLOITED MARINE FISHERY RESOURCES OF INDIA

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CONTENTS

ABSTRACT

The annual estimated total marine fish catch in India for the period 1951–65 is 0·68786 million metric tons. The marine fish production of the countries bordering the Indian Ocean in 1966 was 2·2 million metric tons, of which 40·5% was from India. In the annual average catches for 15-year period in the states, Kerala has ranked first (31·47%), followed by Maharashtra (22·4%), Madras (14·91%), Gujarat (16·9%), Mysore (8·3%) and Andhra (7·57%). The contribution to marine fisheries from West Bengal, Orissa, Goa, South Andamans and Laccadive Islands is about 1% from each or even less.

Statewise distribution pattern of the major fish groups, the component species, their life habits in relation to seasonal fluctuations in the fisheries have been discussed. A series of illustrations has been made to show the fishing craft and gear commonly used in different States, the fish species obtained and their fluctuations in the landings from quarter to quarter.

The landings by the exploratory and commercial fishing trawlers form about 1% of the total marine fish landings. The vessels operating from different bases, the common types of gear used and the catch per hour returns obtained in respect of different categories of vessels are discussed. Productive areas have been charted in the regions covered by vessels operating from Bombay, Karwar, Mangalore, Cannanore, Cochin, Tuticorin, Mandapam and Visakhapatnam. The species abundance in each region and depthwise distribution as revealed by trawler landings have been recorded.

Indian Ocean contours, currents, regional upwelling, hydrology and plankton intensities have been shown in charts from the available information, to enable understanding their relation to fluctuation in the fisheries.

I. INTRODUCTION

OF the total fish production of the Indian Ocean estimated at about 2·2 million metric tons in 1966 (FAO, 1966), about 40% is contributed by the landings from India and as in all warm tropical waters the fisheries of this region are supported by a large number of pelagic, bathypelagic and demersal groups which are exploited by varied types of gear. The fishing industry of India, as in most developing countries, is passing through an initial phase of changing over from the traditional to the modern methods of exploitation, from the use of indigenous sail craft and rather less effective gear to fishing with the help of mechanised craft and the larger powered vessels operating the more efficient types of fishing gear and other ancillary equipments as the radars, fish finders, etc. In the earlier times, the State Governments looked forward only to increasing the revenues from the fisheries but in the independent India there has been a change-over to offering financial assistance to promote expansion of the fishing and other dependent allied industries, besides incurring expenditure on exploratory fishing, fisheries research and training of scientific and technical personnel. For fisheries development substantial amounts were usefully expended by the Central and State Governments during the First Five-Year Plan (Rs. 27·8 million), the Second Five-Year Plan (Rs. 90 million) and the Third Five-Year Plan (Rs. 250 million) periods. Much information on the potential fishery resources of the inshore and offshore fishing grounds and of the life-histories and biological behaviour of the commercially important fish and prawn species has been gathered. The number of mechanised fishing craft increased from about a dozen in 1951 to about 5,000 in 1967. There has been an increase in the marine fish landings from 533,916 metric tons in 1951 to 890,100 metric tons in 1966 to meet the acute food shortage at least partially. There is a more satisfactory manner of handling and utilising the catches than before because of the increasing facilities for transporting, cold storage, quick freezing and marketing the fish.

The Indian fisheries play a large role in the national economy. Even at the modest estimate of one rupee a kilogram of fish, the marine fish catch in 1966 could be valued at over 89 crores of rupees at the production centres. There are over two lakh fishermen actively engaged in fishing and many more in the fish trade, fish curing, freezing, canning and other processing concerns who solely depend on fisheries for their livelihood. Over 60% of India's population include fish in their diet and the immediate need is to make it available to those who need it most. In the past two decades a rapidly growing export trade, especially in the frozen, canned and otherwise processesd shrimp, besides some quantities of frozen lobster tails, shark fins, frozen fish, fish maws, etc., has

been built up. This has created an incentive for more and more investments on trawlers and processing machinery from the private sector. In 1967 the fishery products earned a foreign exchange of over Rs. 170 million.* There are indications of far richer fishery resources in the seas around India than are exploited at present. A more intensive applied fisheries research, a further exploration and exploitation of the ocean depths and the as yet unattempted harvesting of the high seas will no doubt place in the near future the Indian fisheries fairly prominent in the map of the world sheries.

The object of this paper is to present a consolidated account of the recent findings on the regional and seasonal distribution pattern of the major exploited fishery resources with the help of a series of composite charts. The data are drawn almost entirely from the different divisions of the Central Marine Fisheries Research Institute dealing with Fisheries Survey, Offshore Fisheries Research, Fishery Biology, Marine Biology and Crustacean Fisheries. Clam, oyster and other molluscan shell fishery resources (except cephalopods) and the utilizable seaweeds which are no included in this account are dealt with separately by others. The writer expresses his very sincere gratitude to Dr. S. Jones, Director, Central Marine Fisheries Research Institute, for suggesting this compilation and offering very kind encouragement while the work was in progress and to Dr. R. Raghu Prasad, Deputy Director, for arranging with the Officers-in-Charge of the outstation establishments of the Research Institute to make available the necessary data. He is thankful to Dr. R. Velappan Nair, Mr. S. K. Banerji, Dr. R. Subrahmanyan, Mr. K. H. Mohamed, Dr. G. Seshappa, Mr. D. Chakraborthy, Dr. E. G. Silas and Mr. G. S. Sharma for the kind help and cooperation extended and in making available the data which form the basis of some of the illustrations included herein. He is deeply indebted to all his colleagues and particularly to Mr. T. Tholasilingam, Dr. K. V. Sekharan, Dr. M. S. Prabhu, Dr. B. Krishnamoorthy, Dr. M. V. Pai, Dr. M. D. K. Kuthalingam, Mr. K. C. George, Mr. M. G. Dayanandan, Mr. K. Venkatasubba Rao, Mr. V. Ramamohana Rao and Mr. M. E. Rajapandian for the analysis, compilation and presentation of some of the regional fisheries data included in the present work. A reanalysis of the entire data and the presentation of the same in a series of suitable illustrations were by no means easy and in this attempt the very valuable help received from Mr. C. Suseelan, Mr. K. Dorairaj, Mr. K. Prabhakaran Nair, Mr. M. Aravindakshan, Mr. A. S. Kaikini, Mr. V. Kunjukrishna Pillai and Mr. K. N. Gopalakrishnan of the Central Marine Fisheries Research Sub-Station, Bombay, is gratefully acknowledged.

The conclusions arrived at in the section dealing with the exploited fisheries of the offshore region are primarily based on the log data of the exploratory and commercial fishing vessels and for making them available and also for extending constant help and co-operation, the author is much indebted to Mr. S. Miskeith, Superintending Engineer, Government of India, Deep Sea Fishing Station, the Officers of the Offshore Fishing Stations and the authorities of the Indo-Norwegian Project, the New India Fisheries Company and the Cochin Company. He is also thankful to Dr. (Mrs.) P. V. Kagwade and Mr. D. M. Punwani for going through the manuscript.

II. Fish Landings in India

The All-India Annual Landings for 1951–65

In 1956 for the first time, India's total fish catch reached the level of one million metric tons. In the 15-year period of 1951-65 the total annual fish catches ranged from 0·744 to 1·320 million metric tons with an average of 0·979 million metric tons. The annual marine fish catch during the period ranged from 0·528 million metric tons to 0·8796 million metric tons with an average of 0·68786 million metric tons. The world fish production in 1966 was 56·8 million metric tons and India's total catch in that year was 1·367 million metric tons. She ranked seventh in the world's fish-producing countries, the first six countries being Peru—8·789, Japan—7·077, USSR—5·3488, Norway—2·849, USA—2·5146 and Chile—1·383 million metric tons. The marine fish production of all the countries bordering the Indian ocean was 2·2 million metric tons in 1966, of which India's catch was 0·8901 million metric tons forming 40·5%.

* The export value for 1968 is over Rs. 220 million.

State-wise Marine Fish Landings

The average annual all-India landings of the marine fish for the 15-year period worked out to 687,860 metric tons. Among the maritime states of India, Kerala has ranked first with a catch of 217,392 metric tons (31·47%), Maharashtra second with 154,722 metric tons (22·40%), Madras third with 102,981 metric tons (14·91%), Gujarat fourth with 89,106 metric tons (12·90%), Mysore fifth with 56,851 metric tons (8·23%) and Andhra sixth with 52,293 metric tons (7·57%). The rest, *viz.*, West Bengal and Orissa, Goa, South Andamans and Laccadive Islands, have each contributed to about 1% or even less of the total marine fish landings (Fig. 1).

III. Fishing Villages, Fishermen Population, Fishing Craft and Gear

Based on the survey census of 1961–62 carried out by the Central Marine Fisheries Research Institute in the eight maritime states of West Bengal, Orissa, Andhra, Madras, Kerala, Mysore, Maharashtra and Gujarat the total number of fishing villages is estimated to be 1,797, the marine fishermen population 958,937 (active fishermen 229,354) and the number of fishing craft 90,424. Madras State has the highest number of fishing villages and ranking next in the order are Andhra, Kerala, Maharashtra, Gujarat, Orissa and West Bengal. The active fishermen population is the highest from Kerala (74,241) followed by Madras (56,586), Andhra (47,700), Maharashtra (20,698), Gujarat (11,732), Mysore (8,963), Orissa (8,828) and West Bengal (606). Madras has also the highest number of fishing craft (29,661) and ranking next in the order are Kerala (20,667), Andhra (19,772), Maharashtra (7,894), Mysore (6,357), Gujarat (3,179), Orissa (2,786) and West Bengal (108). There are over 5,000 mechanised fishing craft fishing on the Indian coasts in different states. The powered fishing vessels of the medium and the larger types used in the exploratory fishing by the Government of India, the Indo-Norwegian Project and some of the State Governments are about 50. A small number of trawlers are also in use by the private sector for commercial fishing on the continental shelf.

The fishing craft and gear are varied and are designed to suit the local conditions. On the east coast the sea being rough, the craft is non-rigid like the catamarans and the Masula boats; and on the west coast where the sea is comparatively calm, the more rigid types of craft like the canoes and the bigger types of boats are common. The gear is varied to suit the types of fishes caught, like long lines and hand lines for hooking seerfishes, sharks, etc., and seines of various types for shoaling fishes like mackerel and sardines. Where the fishing grounds are fairly even with wide sandy beaches bordering them, shore-seines are widely employed for netting collectively all groups of fishes available in the region. Bottom-set gill-nets and drift-nets are effectively operated for gilling the fishes at a wide range in depths of water columns. Fixed stake-nets are best used where the grounds are uneven or where the tidal flow is particularly good. Baited basket-traps for small percoid fishes in rocky coastal lagoons and cast-nets and drag-nets in very shallower waters are widely used in small-scale fishing. In the exploratory and commercial fishing operations by small, medium and large vessels the gear commonly employed are the otter-trawls for fish and shrimps; and some of the larger vessels have regularly used the bull-trawls. Figures 2 to 6 show state-wise usage of the types of craft and gear commonly employed (for details *see* Hornell, 1924, 1938, 1950; Chopra, 1951; Jayaraman *et al.*, 1959; Shariff, 1961; CMFRI, 1967; Rao *et al.*, 1968).

IV. Exploited Marine Fishery Resources of the Inshore Region

Species-wise Abundance of Marine Fishes

Figures 7 to 13 show details of the species-wise or group-wise landings from the inshore fisheries of the several coastal states for the period 1956–65. Before these are explained it is felt necessary that some particulars of species-wise or group-wise fish landings on an all-India basis should be given. Landings of fish for the period 1957–65 are available in the *CMFRI Souvenir* (1967), from

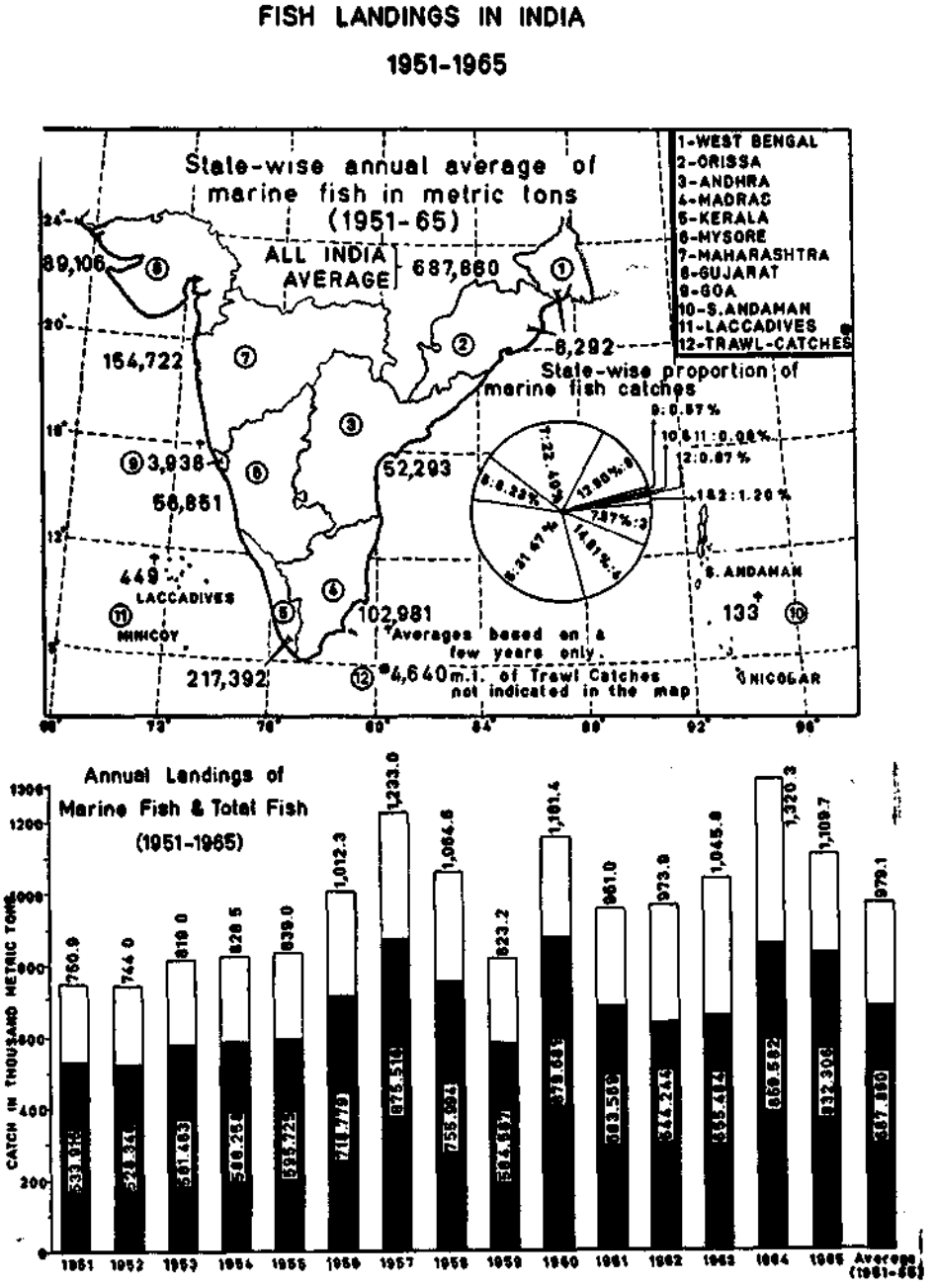


FIG. 1. Annual landings of marine fish and total fish in India and average state-wise marine fish production for the period 1951–65.

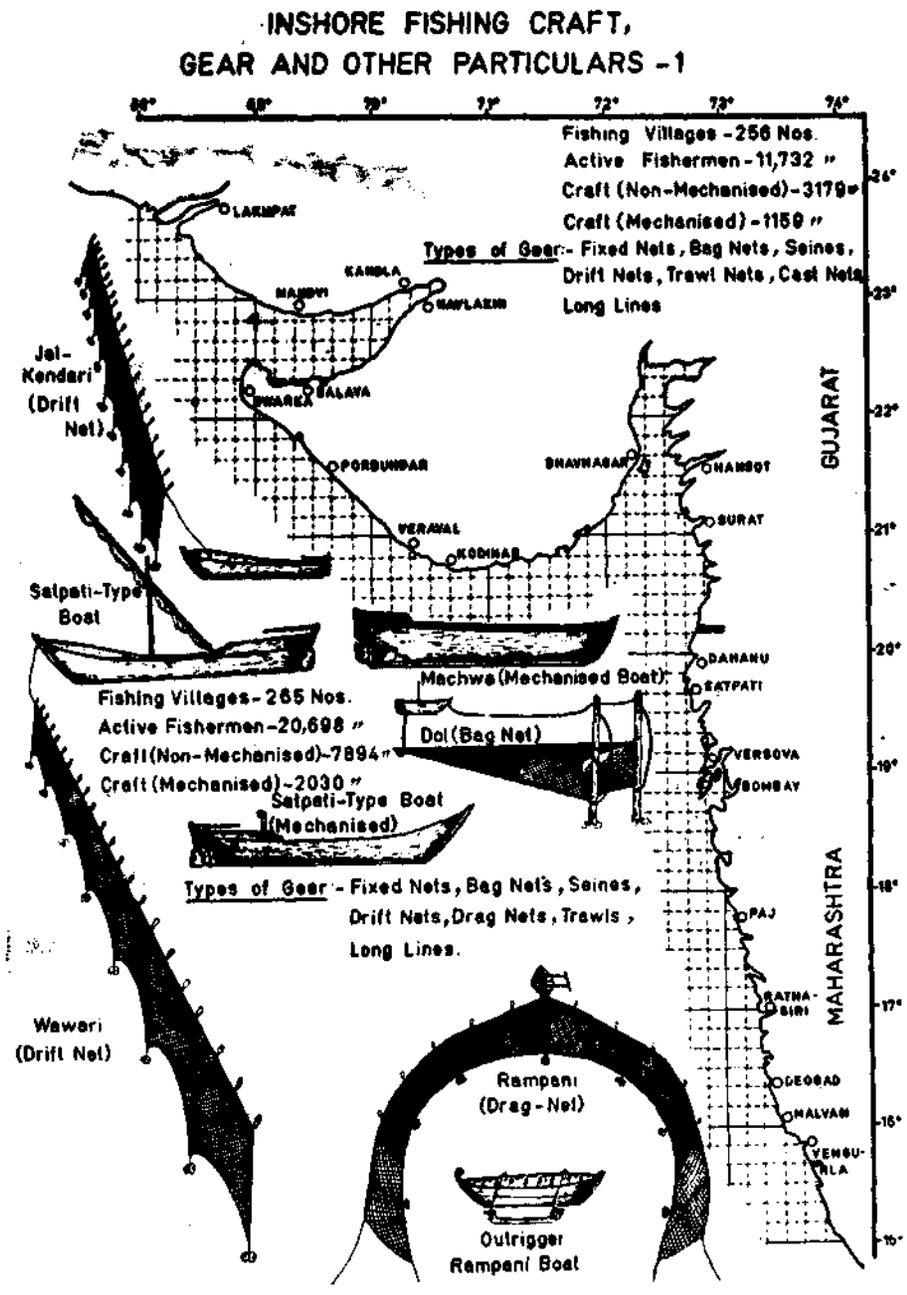


FIG. 2. Census of fishing villages, active fishermen, non-mechanised and mechanised fishing craft and types of fishing gear operated in Gujarat and Maharashtra States (Based on 1961–62 census as given in *CMFRI Souvenir*, 1967).

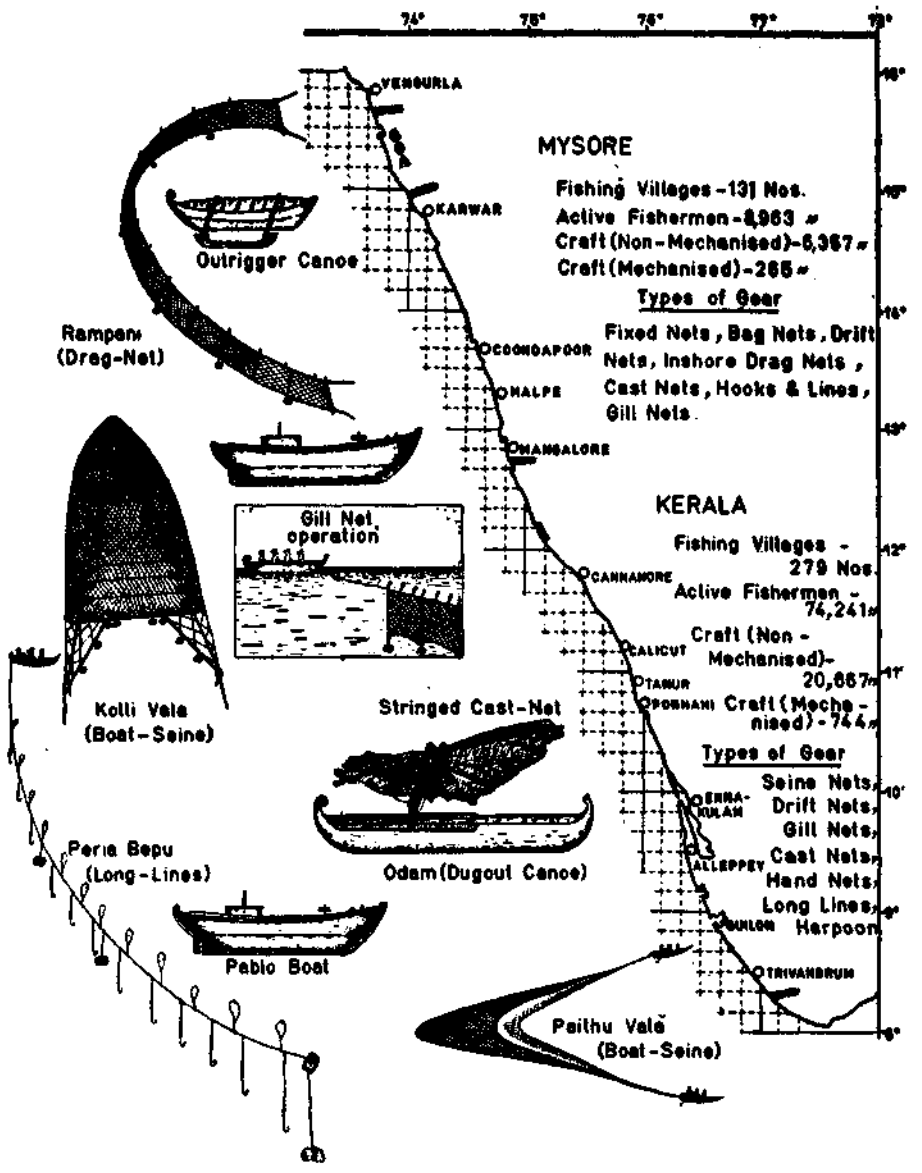


FIG. 3. Census of fishing villages, active fishermen, non-mechanised and mechanised fishing craft and types of fishing gear operated in Mysore and Kerala (Based on 1961–62 census as given in *CMFRI Souvenir*, 1967)

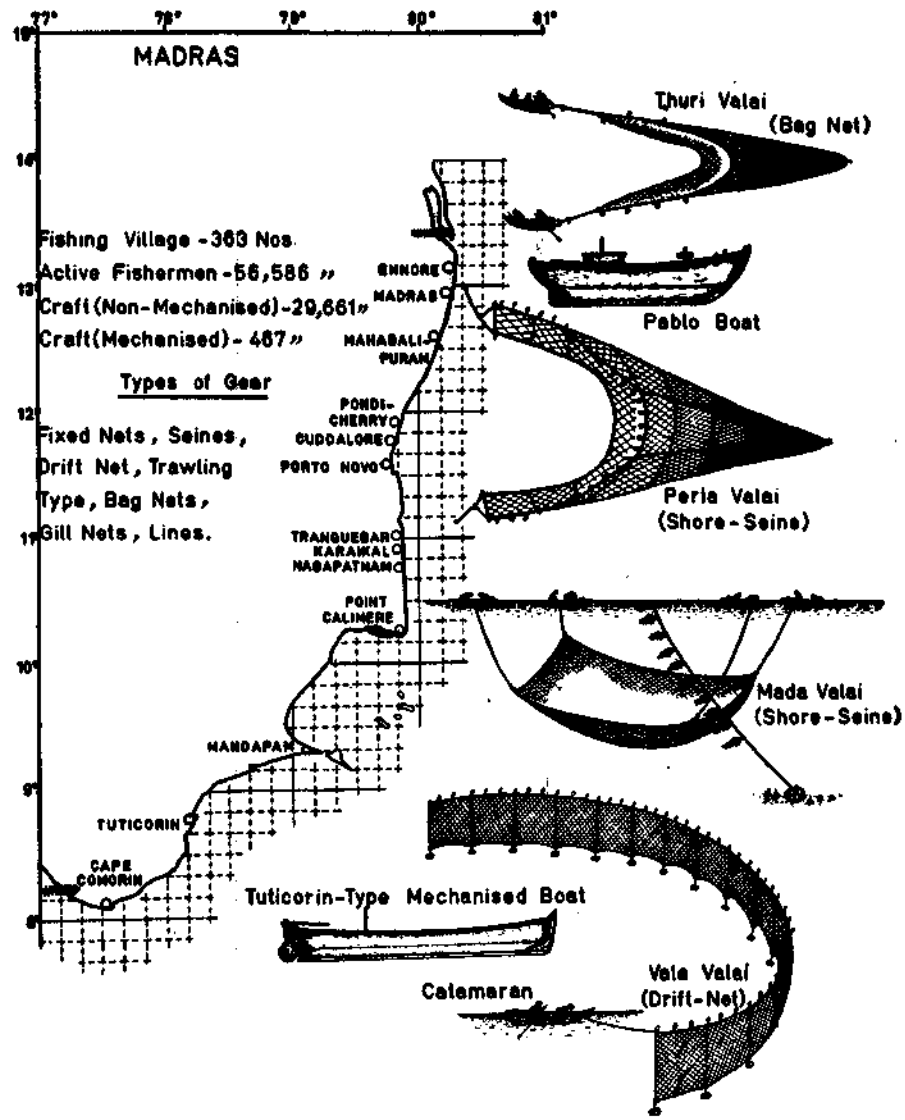


FIG. 4. Census of fishing villages, active fishermen, non-mechanised and mechanised fishing craft and types of fishing gear operated in Madras (Based on 1961–62 census as given in *CMFRI Souvenir*, 1967).

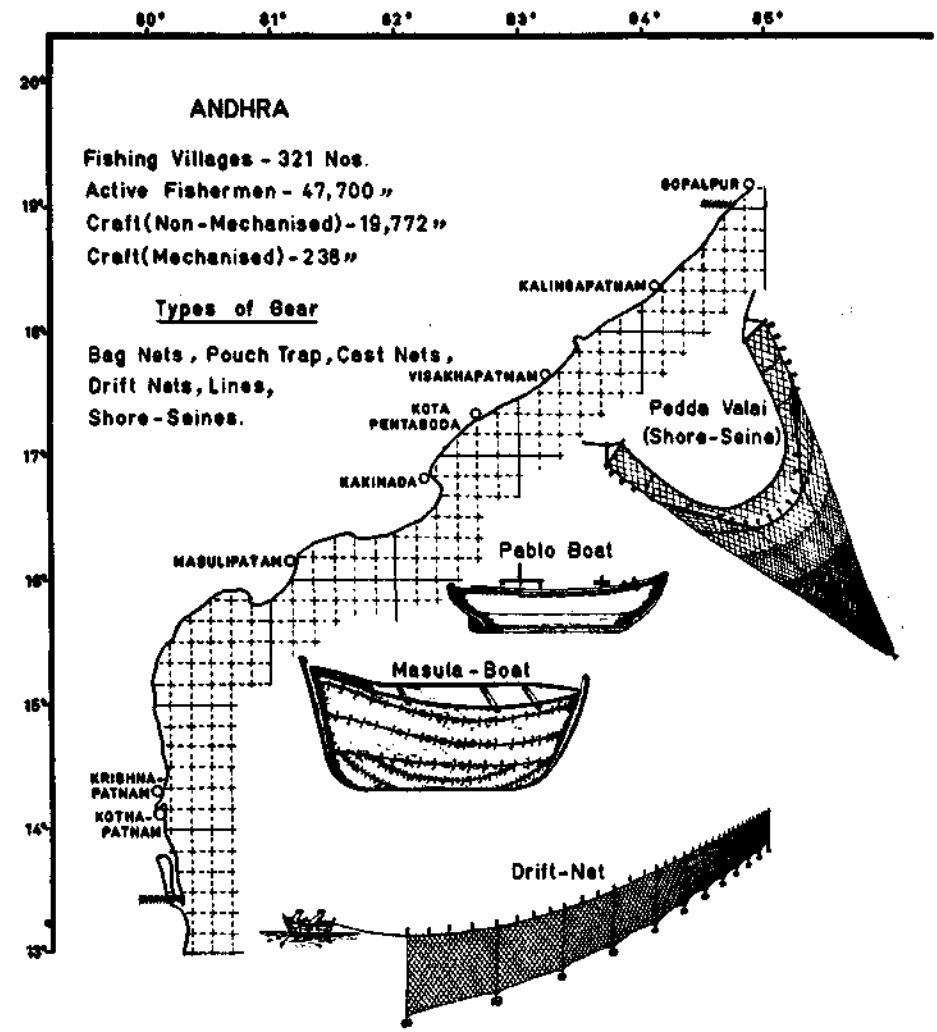


FIG. 5. Census of fishing villages, active fishermen, non-mechanised and mechanised fishing craft and types of fishing gear operated in Andhra (Based on 1961–62 census as given in *CMFRI Souvenir*, 1967.)

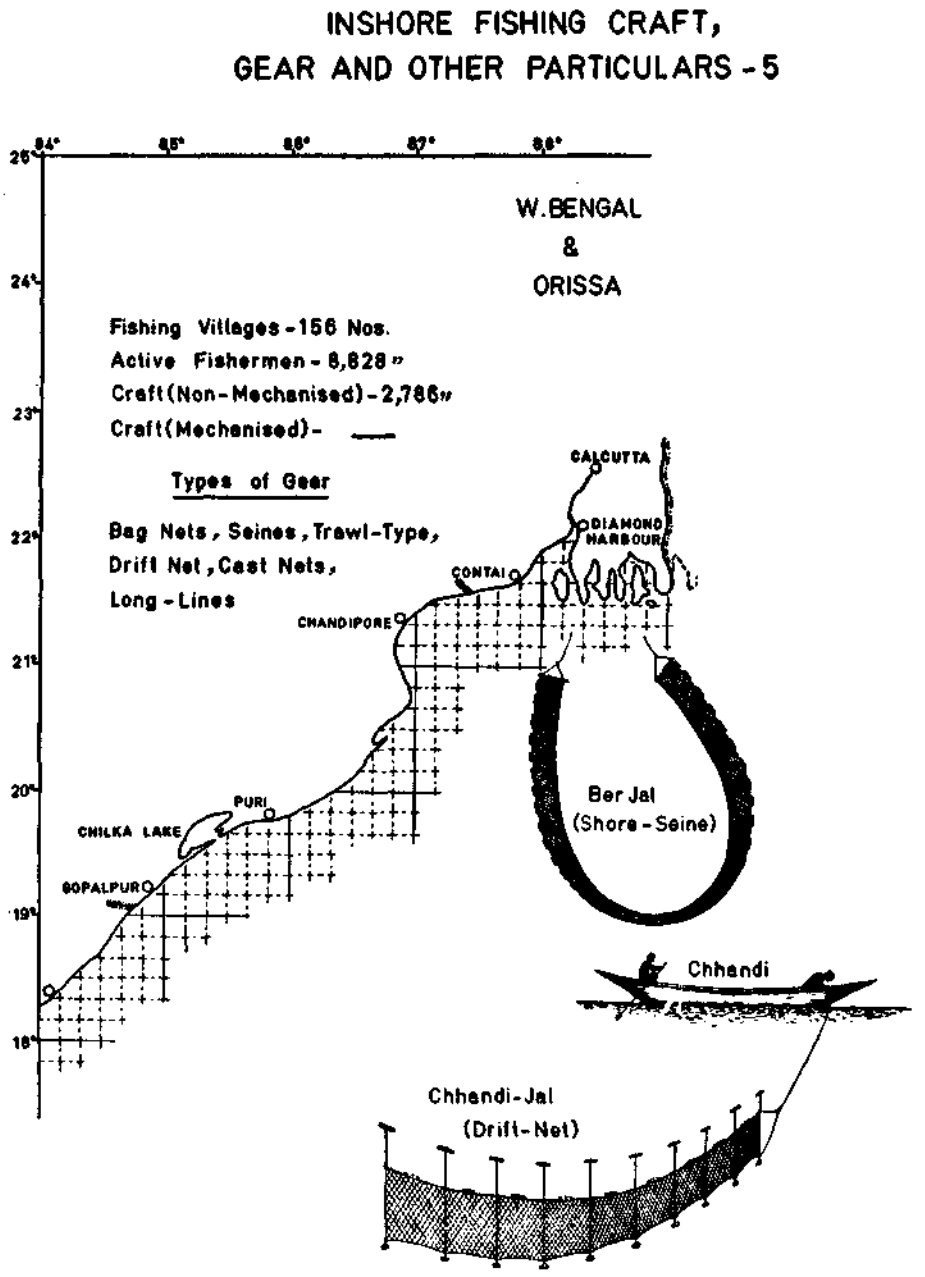
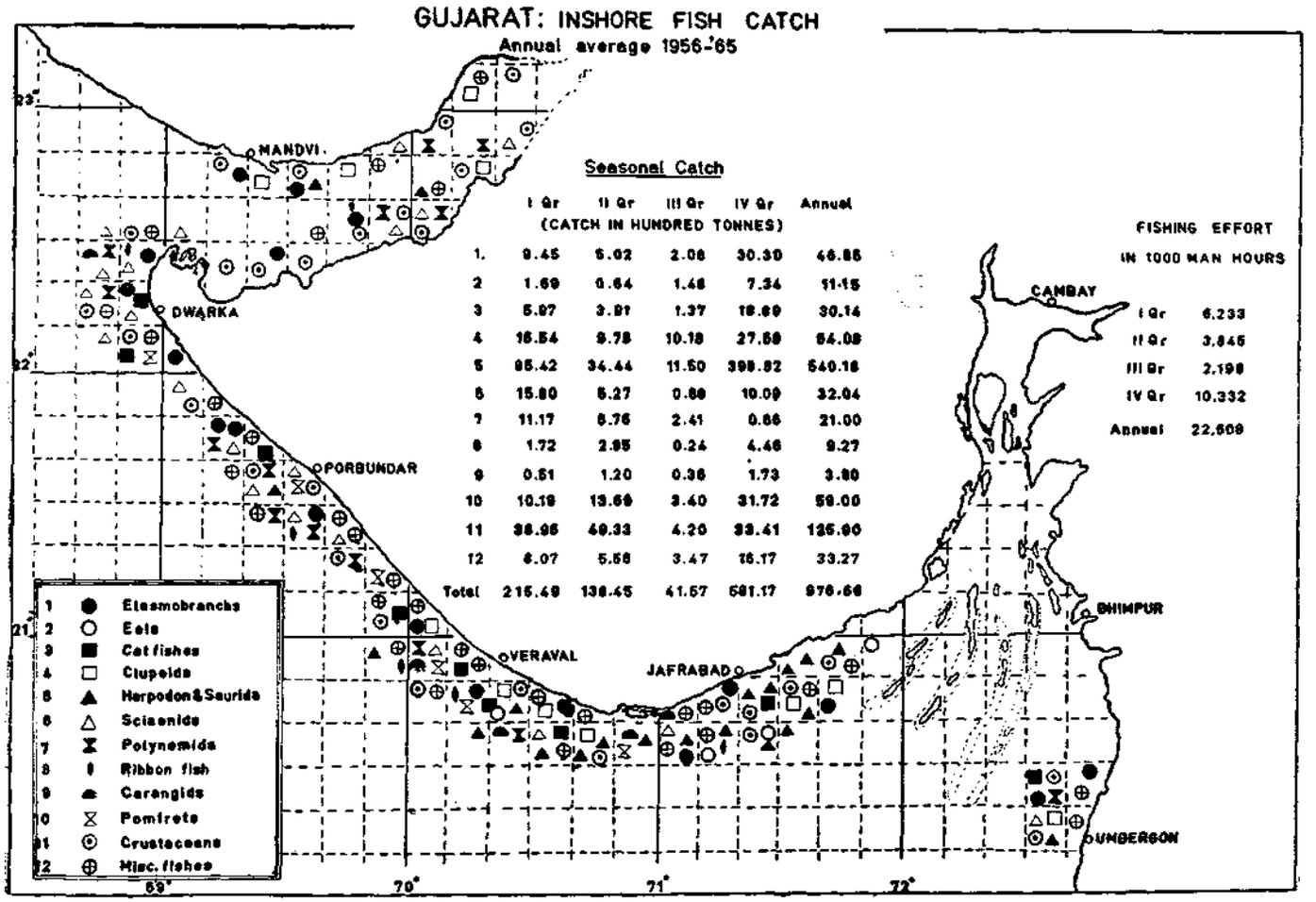
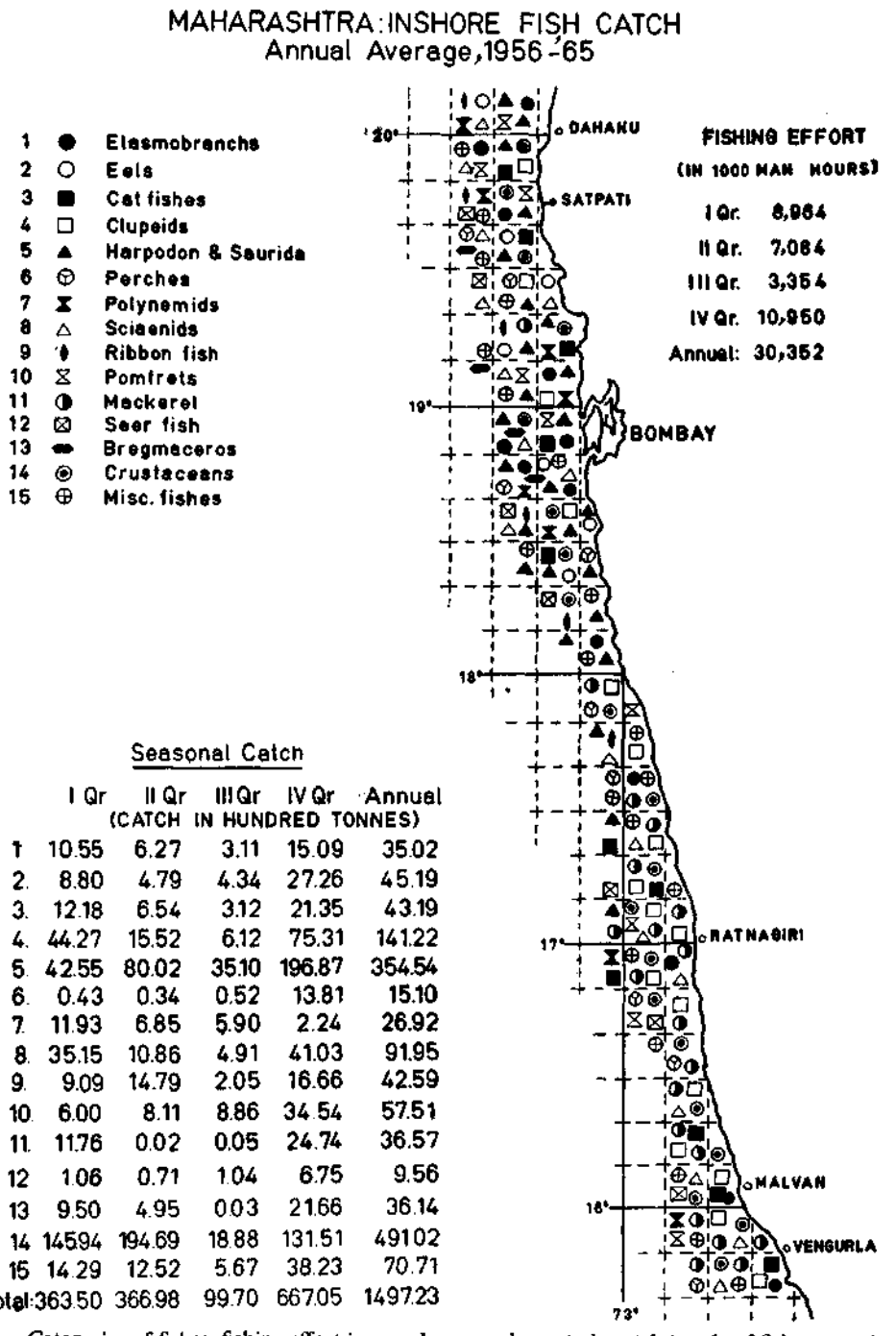


FIG. 6. Census of fishing villages, active fishermen, non-mechanised and mechanised fishing craft and types of fishing gear operated in West Bengal and Orissa (Based on 1961–62 census as given in *CMFRI Souvenir*, 1967).

FIG. 7. Categories of fishes, fishing effort in man-hours and quarterly catch trends of fish groups in the inshore catches of Gujarat State. The distribution pattern is not strictly square-wise but approximate within about 20 miles from the coastline.





Seasonal Catch

	I Qr	II Qr	III Qr	IV Qr	Annual
	(CATCH IN HUNDRED TONNES)				
1	10.55	6.27	3.11	15.09	35.02
2	8.80	4.79	4.34	27.26	45.19
3	12.18	6.54	3.12	21.35	43.19
4	44.27	15.52	6.12	75.31	141.22
5	42.55	80.02	35.10	196.87	354.54
6	0.43	0.34	0.52	13.81	15.10
7	11.93	6.85	5.90	2.24	26.92
8	35.15	10.86	4.91	41.03	91.95
9	9.09	14.79	2.05	16.66	42.59
10	6.00	8.11	8.86	34.54	57.51
11	11.76	0.02	0.05	24.74	36.57
12	1.06	0.71	1.04	6.75	9.56
13	9.50	4.95	0.03	21.66	36.14
14	145.94	194.69	18.88	131.51	491.02
15	14.29	12.52	5.67	38.23	70.71
Total:	363.50	366.98	99.70	667.05	1497.23

FIG. 8. Categories of fishes, fishing effort in man-hours and quarterly catch trends of fish groups in the inshore catches of Maharashtra State. The distribution pattern is not strictly square-wise but approximate within about 20 miles from the coastline.

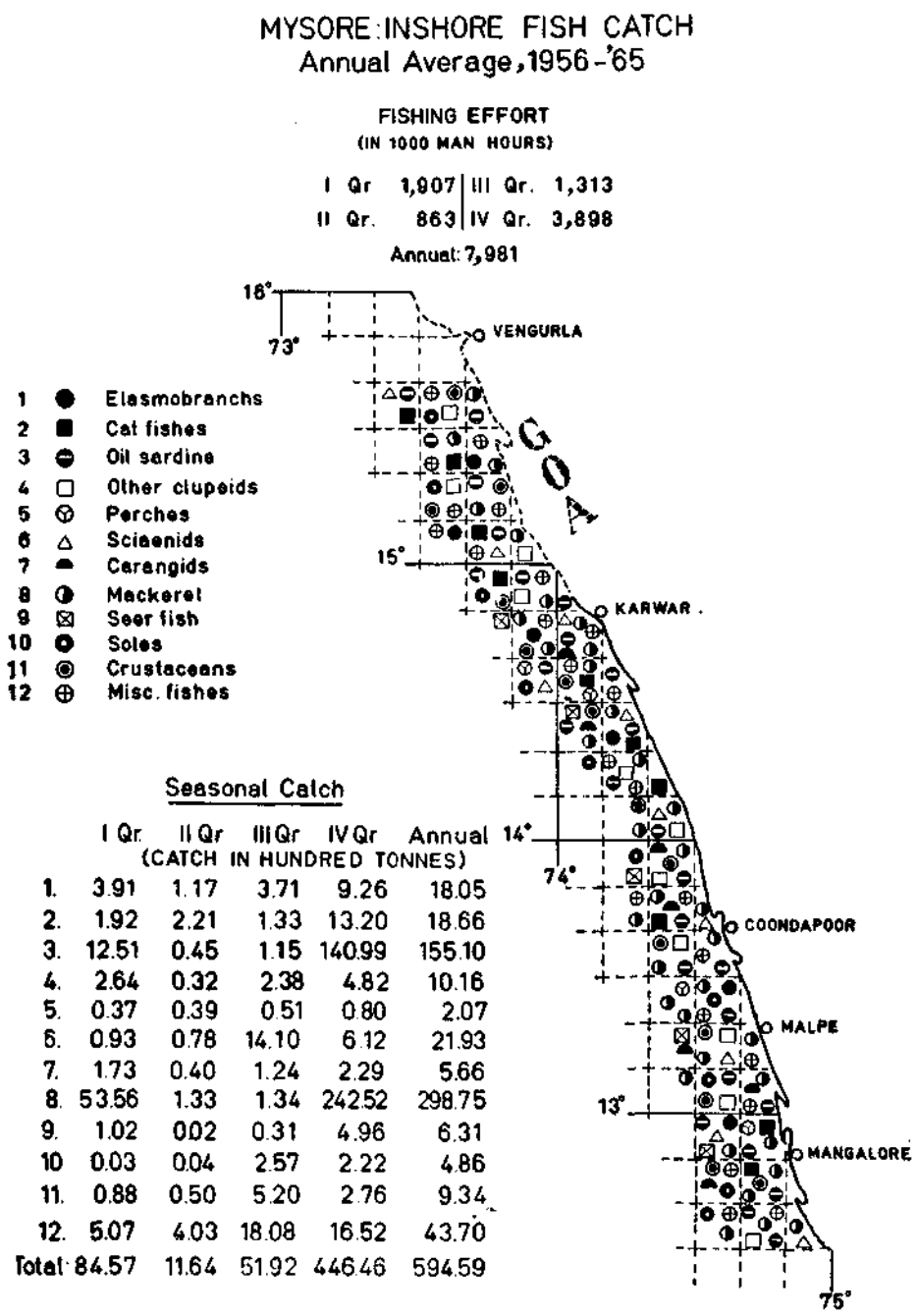


FIG. 9. Categories of fishes, fishing effort in man-hours and quarterly catch trends of fish groups in the inshore catches of Mysore State. The distribution pattern is not strictly square-wise but approximate within about 20 miles from the coastline.

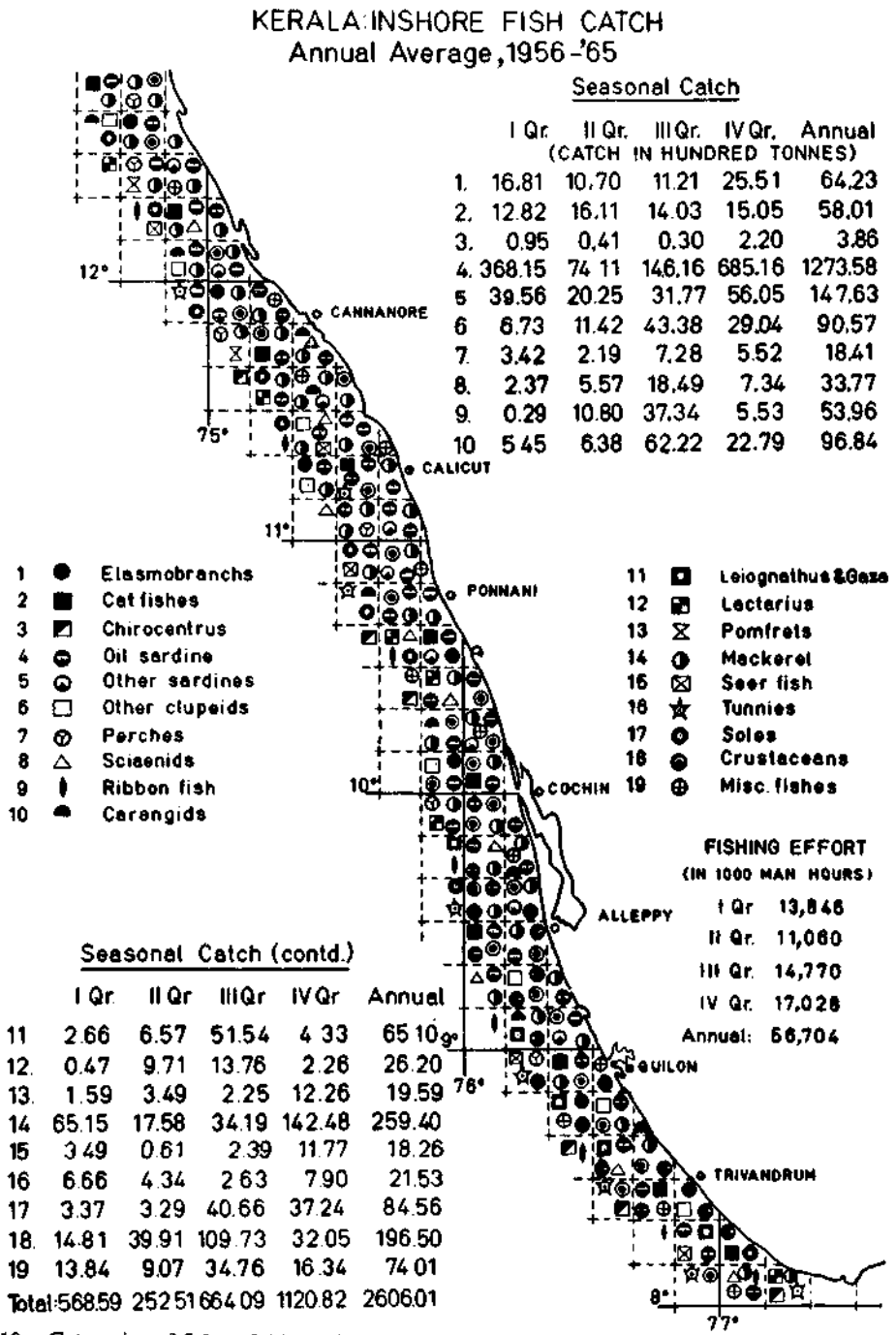
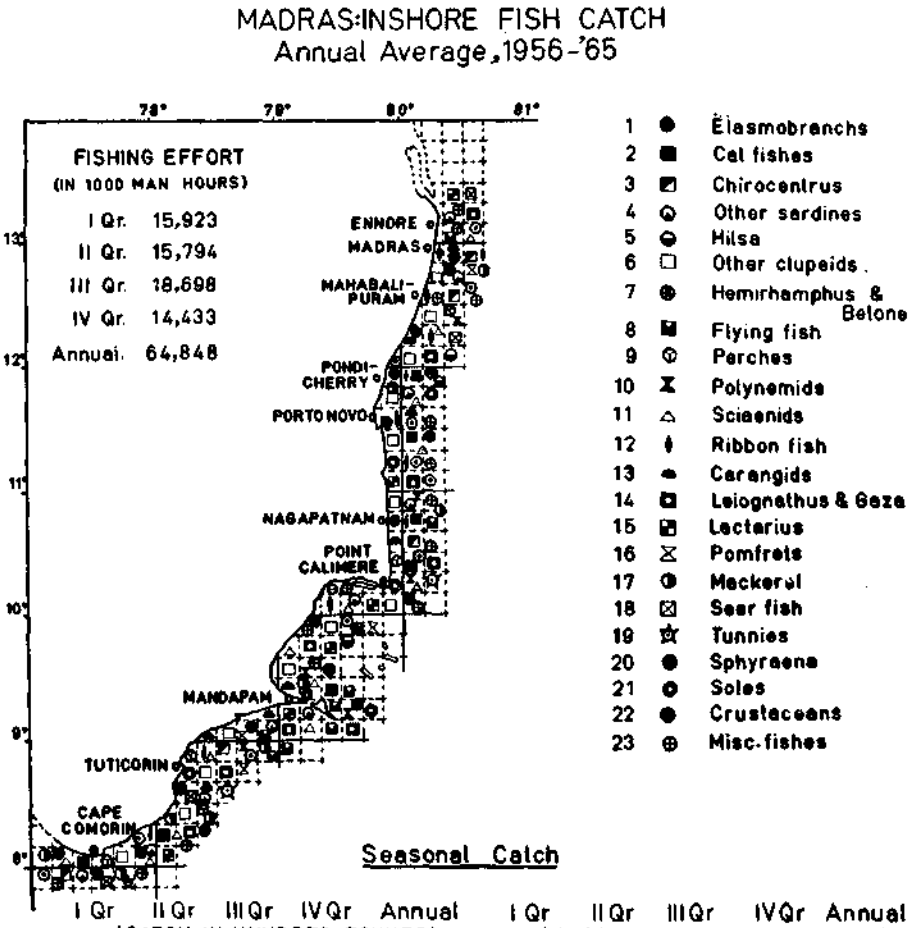


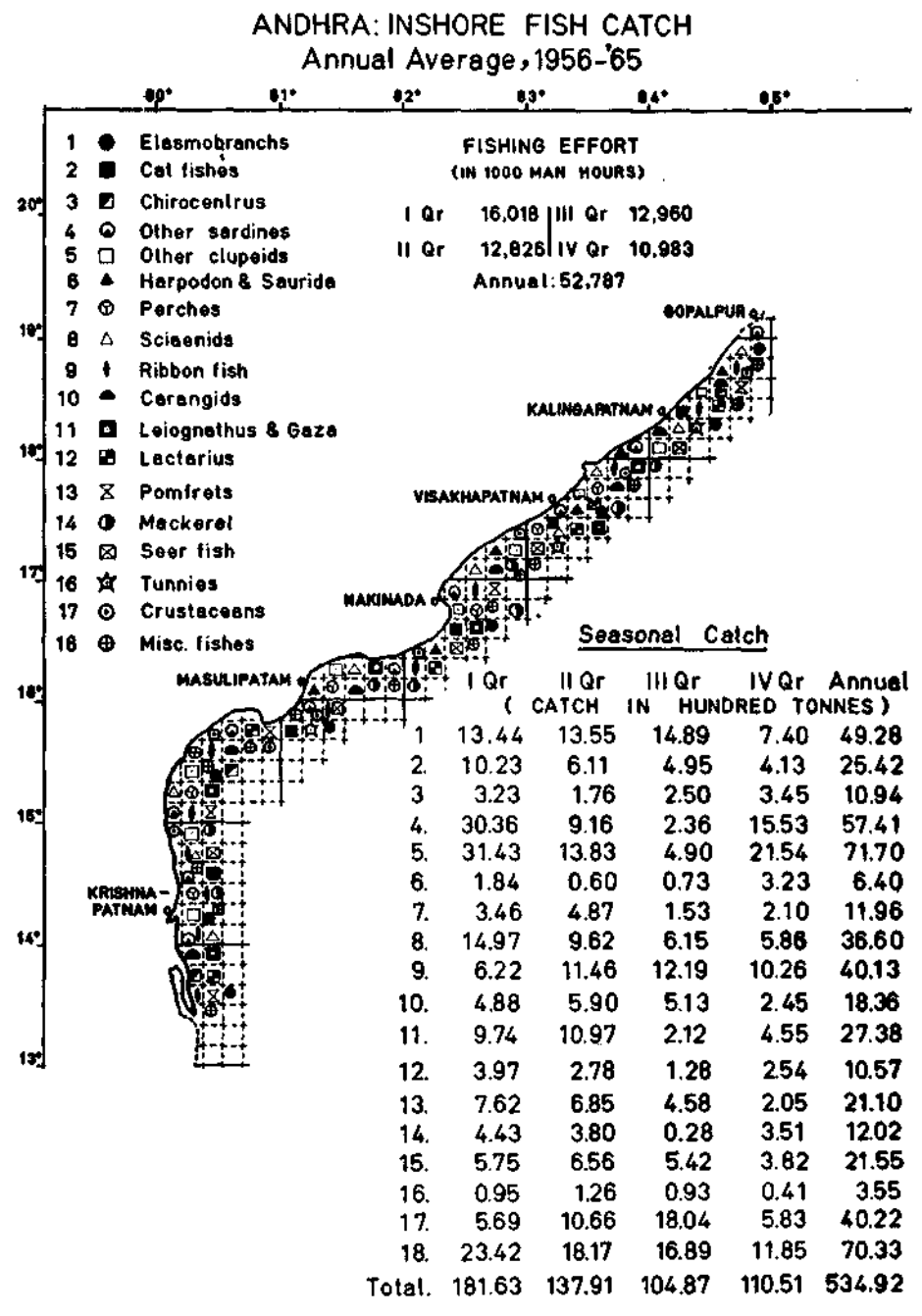
FIG. 10. Categories of fishes, fishing effort in man-hours and quarterly catch trends of fish groups in the inshore catches of Kerala State. The distribution pattern is not strictly square-wise but approximate within about 20 miles from the coastline.



Seasonal Catch

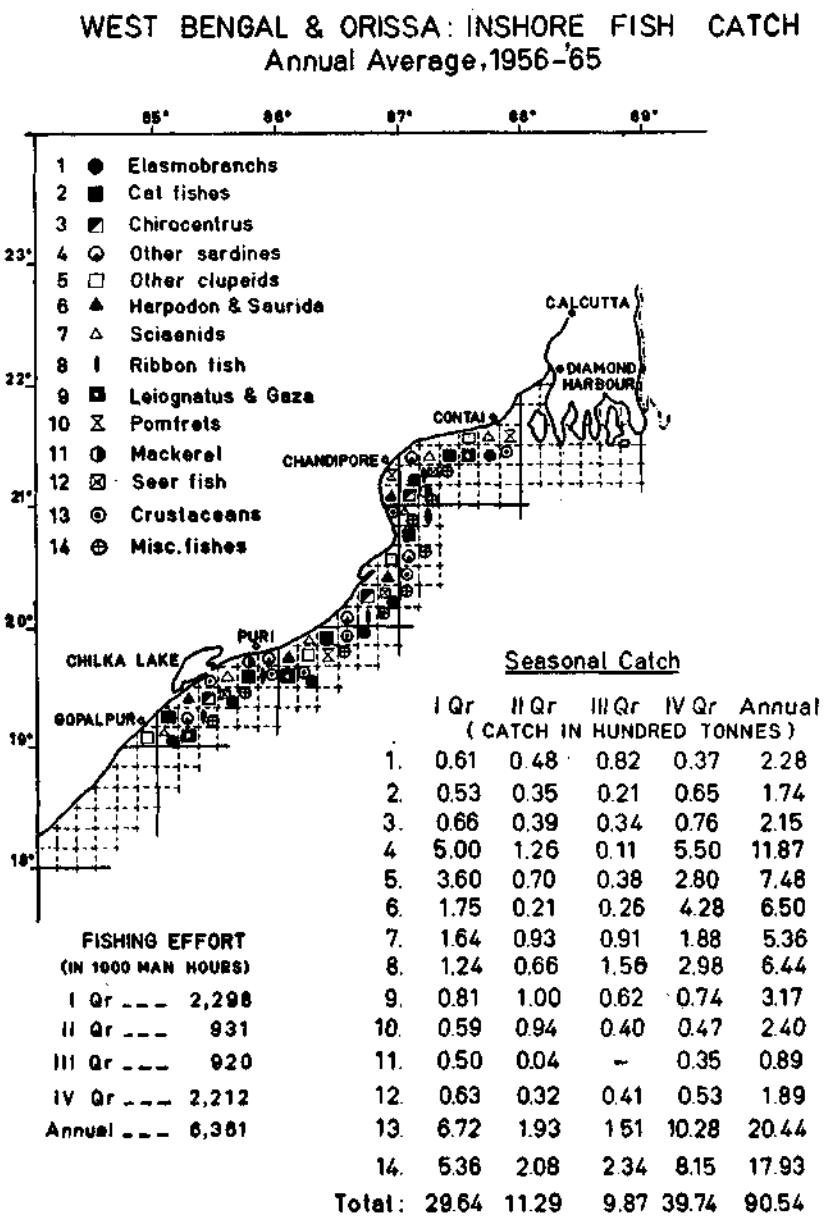
	I Qr	II Qr	III Qr	IV Qr	Annual		I Qr	II Qr	III Qr	IV Qr	Annual
	(CATCH IN HUNDRED TONNES)						(CATCH IN HUNDRED TONNES)				
1	21.00	20 91	32.37	14.51	88.79	13.	17.06	27.30	47.54	16.70	108.60
2.	9.35	6.35	12.57	5.69	33.96	14.	12.51	17.43	26.63	18.55	75.12
3.	10.66	7.90	6.30	8.81	33.67	15.	4.22	10.47	22.54	20.56	57.79
4.	23.27	20.77	22.42	27.11	93.57	16.	4.14	5.11	6.63	3.46	19.34
5.	6.79	1.40	2.66	1.52	12.37	17.	5.67	4.45	8.45	1.92	20.49
6.	21.60	24.62	40.79	26.66	113.67	18.	8.79	5.50	9.14	9.40	32.83
7	1.42	2.36	0 40	1.72	5.90	19.	1.95	1.81	2.13	4.36	10.25
8.	0.04	16.56	2.45		19.05	20.	2.19	1.01	3.60	1.40	8.20
9.	11.92	8.44	16.72	8.81	45.89	21.	1 18	1.20	2.07	1.20	5.65
10.	1.59	1.90	1.43	1.31	6.23	22.	10.37	11.13	13.30	9.00	43.80
11.	14.39	12.31	20.18	13.21	60.09	23	27.57	11.52	25.90	21.46	86.45
12.	6.81	10.99	76.37	29.55	123.72	Total:	224.49	231.44	402.59	246.91	1105.43

FIG. 11. Categories of fishes, fishing effort in man hours and quarterly catch trends of fish groups in the inshore catches of Madras State. The distribution pattern is not strictly square-wise but approximate within about 20 miles from the coastline,



	I Qr	II Qr	III Qr	IV Qr	Annual
1	13.44	13.55	14.89	7.40	49.28
2.	10.23	6.11	4.95	4.13	25.42
3	3.23	1.76	2.50	3.45	10.94
4.	30.36	9.16	2.36	15.53	57.41
5.	31.43	13.83	4.90	21.54	71.70
6.	1.84	0.60	0.73	3.23	6.40
7.	3.46	4.87	1.53	2.10	11.96
8.	14.97	9.62	6.15	5.86	36.60
9.	6.22	11.46	12.19	10.26	40.13
10.	4.88	5.90	5.13	2.45	18.36
11.	9.74	10.97	2.12	4.55	27.38
12.	3.97	2.78	1.28	2.54	10.57
13.	7.62	6.85	4.58	2.05	21.10
14.	4.43	3.80	0.28	3.51	12.02
15.	5.75	6.56	5.42	3.82	21.55
16.	0.95	1.26	0.93	0.41	3.55
17.	5.69	10.66	18.04	5.83	40.22
18.	23.42	18.17	16.89	11.85	70.33
Total.	181.63	137.91	104.87	110.51	534.92

FIG. 12. Categories of fishes, fishing effort in man-hours and quarterly catch trends of fish groups in the inshore catches of Andhra State. The distribution pattern is not strictly square-wise but approximate within about 20 miles from the coastline.



	I Qr	II Qr	III Qr	IV Qr	Annual
1.	0.61	0.48	0.82	0.37	2.28
2.	0.53	0.35	0.21	0.65	1.74
3.	0.66	0.39	0.34	0.76	2.15
4	5.00	1.26	0.11	5.50	11.87
5.	3.60	0.70	0.38	2.80	7.48
6.	1.75	0.21	0.26	4.28	6.50
7.	1.64	0.93	0.91	1.88	5.36
8.	1.24	0.66	1.56	2.98	6.44
9.	0.81	1.00	0.62	0.74	3.17
10.	0.59	0.94	0.40	0.47	2.40
11.	0.50	0.04	–	0.35	0.89
12.	0.63	0.32	0.41	0.53	1.89
13.	6.72	1.93	1.51	10.28	20.44
14.	5.36	2.08	2.34	8.15	17.93
Total:	29.64	11.29	9.87	39.74	90.54

FIG. 13. Categories of fishes, fishing effort in man-hours and quarterly catch trends of fish groups in the inshore catches of West Bengal and Orissa States. The distribution pattern is not strictly square-wise but approximate within about 20 miles from the coastline.

which the average annual species-wise landings for the 5-year period of 1961–65 given in Table I are derived:

TABLE I

Composition of fish landings—average for 1961–65

Elasmobranchs	36,851	(*c*) *Trachynotus*	34
Clupeiform fishes:		(*d*) Other carangids	147
(*a*) Oil sardines	175,605	(*e*) *Coryphaena* and *Elacate*	299
(*b*) Other sardines	29,931	Silver-bellies:	
(*c*) *Hilsa ilisha*	2,096	(*a*) *Leiognathus*	21,413
(*d*) Other *Hilsa*	7,278	(*b*) *Gazza*	110
(*e*) *Anchoviella*	23,904	*Lactarius*	7,539
(*f*) *Thrissocles*	5,594	Pomfrets	19,379
(*g*) *Chirocentrus*	7,641	Mackerel	41,505
(*h*) Other clupeid fishes	15,463	Seerfish	10,420
Bombay duck and Saurida:		Tunnies	4,651
(*a*) *Harpodon nehereus*	84,977	Barracudas and grey mullets:	
(*b*) *Saurida* and *Saurus*	983	(*a*) *Sphyraena*	1,471
Catfishes	17,893	(*b*) *Mugil*	1,515
Eels	6,727	*Bregmaceros*	4,338
Belone and *Hemirhamphus*	1,360	Soles	10,027
Flying fish	1,536	Crustaceans:	
Perches	10,808	(*a*) Penaeid prawns	45,976
Red mullets	2,369	(*b*) Non-penaeid prawns	34,422
Polynemids	3,403	(*c*) Other crustaceans	2,417
Sciaenids	26,759	Cephalopods	236
Ribbon-fishes	24,873	Miscellaneous fishes	21,358
Carangids:			
(*a*) *Caranx*	18,403	Total	735,131
(*b*) *Chorinemus*	3,154		

It may be seen from Table I that the first five groups of fish categories whose landings are over 35,000 metric tons are the oil sardine (*Sardinella longiceps*), Bombay duck (*Harpodon nehereus*) crustaceans (chiefly the penaeid and non-penaeid prawns), the mackerel (*Rastrelliger kanagurta*) and the elasmobranchs (sharks, skates and rays). Among the fishes whose landings are between 15 and 35 thousand metric tons are the other sardines, sciaenids, ribbon-fishes, *Anchoviella* spp., *Caranx* and other carangids, catfishes, other clupeiform fishes, *Leiognathus* and pomfrets; those between 10 and 15 thousand metric tons are the perches, seerfish and the soles. Fish which are landed below 10 thousand metric tons are the rest excepting the miscellaneous fishes which formed a fairly high proportion. In the following account the regional and the seasonal availability of the individual categories of fishes is dealt with.

Elasmobranchs

In the all-India annual average marine fish landings for the 1961–65 period the elasmobranchs, *viz.*, sharks, skates and rays rank fifth in abundance forming 5%. In the major state-wise landings the annual average for the period 1956–65 was the highest in Madras State (8,879 metric tons) and ranking next in the order are Kerala (6,423 metric tons), Andhra (4,928 metric tons), Gujarat (4,685 metric tons), Maharashtra (3,502 metric tons), Mysore (1,805 metric tons) and West Bengal and Orissa (228 metric tons). In Madras State, where they are most abundant, the third quarter landings are the highest in the year, the first and second quarter's catches are fairly high and the fourth quarter's catches are the lowest. In other states on the east coast, *i.e.*, Andhra and West Bengal and Orissa the seasonal trends of catches are very much the same as in Madras. Contrasted with this, in all the states on the west coast the fourth quarter's catch is the highest and ranking next is that of the first quarter. The lowest catch in Gujarat and Maharashtra is in the third quarter, whereas in Mysore and Kerala it is in the second quarter. Of the elasmobranch catches from eight states, those on the east coast formed about 46% during the 10-year period (Figs. 7–13).

The genera and species constituting the catches on both the coasts are the same, the more common among them being *Chiloscyllium griseum* M.H., *Stegostoma varius* (Seba), *Scoliodon palasorrah* (C.), *Scoliodon sorrakowah* (C.), *S. walbeehmi* Blkr., *Hypoprion hemiodon* M.H., *Carcharinus bleekeri* Dumeril, *C. dussumieri* (M.H.), *C. gangeticus* (M.H.), *C. limbatus* (M.H.), *C. melanopterus* (Q.G.), *C. menisorrah* (M.H.), *Galeocerdo arcticus* (Faber), *Sphyrna blochii* (C.), *S. zygaena* (L.), *Rhinobatus granulatus* (C.), *Rhynchobatus djiddensis* (Forsk.), *Pristis cuspidatus* Latham, *P. microdon* Latham, *Dasyatis* (*Himantura*) *bleekeri* (Blyth), *D.* (*H.*) *uarnak* (Forsk.), *Aetobatus flagellum* (Schn.), *Rhinoptera javanica* (M.H.), and *Manta ehrenbergii* (M.H.).

Some of the elasmobranchs attain gigantic sizes. *Rhincodon typus* (Smith), the whale shark, is the largest of this group growing to over 15 metres in length. Among the man-eating sharks *Alopias vulpinus* (Bonn.) and *Galeocerdo arcticus* are about 4·5 metres in length. Among the rays *Aetobatus flagellum* attains 3·3 metres across the disc. All the saw-fishes (*Pristis* spp.) also grow to very large size of over 4·5–7 metres in length.

Elasmobranchs are caught by different types of gear used for capturing other fishes. For the larger species of oil-yielding sharks a special type of gear, the revolving chain hooks, is widely used. While the elasmobranchs occur in all the regions, the chief fishing centres are Kodinar, Veraval, Bombay, Karwar, Mangalore, Tellicherry, Kozhikode and Trivandrum on the west coast and Tuticorin, Adirampattinam, Point Calimere, Nagapattinam, Kakinada, Masulipatnam, Visakhapatnam and Contai on the east coast.

Although not very good eating, the elasmobranchs are widely used as food either in fresh or cured (salted and dried) condition. They are besides used for making fish-meal and fish-manure. During the Second World War, when cod liver oil was scarce in this country, a new industry had sprung up for processing shark liver oil for medicinal purpose because of its very rich vitamin A content of a potency of 10,000 to 24,000 International Units per Gram Weight of the oil. The species found rich in vitamin content are *Galeocerdo arcticus, Carcharhinus melanopterus, C. gangeticus, C. limbatus, C. menisorrah, Sphyrna blochii, S. zygaena, Pristis cuspidatus, Scoliodon palasorrah* and *S. walbeehmi.* Some of the rays and sharks yield huge quantities of oil which, though not utilized for medicinal purpose, is used to a large extent in the leather industry for tanning, etc. There is an export trade in dried fins of sharks to some of the Far Eastern countries, the exporting centres being located at Bombay, Madras and Nagapattinam. Tanned shark skin is utilized as leather in various places in the world, but it has not been used in India.

Oil Sardine (*Sardinella longiceps Val.*)

The annual average catch of the oil sardine of the family Clupeidae for 1961–65 has been 175,605 metric tons forming 23·88% of the total marine fish catch. The annual fluctuations in the catches of no other species of commercial fish are so marked as those of the oil sardine. In the 15-year period of 1951–65 (Prabhu, 1967) the lowest catch of the oil sardine was 7,412 metric tons in 1956 forming 1·0% and the highest catch was 274,333 metric tons in 1964 forming 31·9%. Thus when the fishery is good it forms a third of the marine fish catch of the country. As may be seen from Figs. 7 to 13, the fisheries are important in two maritime states, Kerala and Mysore. Based on the 10-year average it is seen that Kerala's oil sardine catch is about half of the marine fish catch of the state; it is about eight times the catch of the oil sardine in the Mysore State. These figures clearly indicate the unique position Kerala enjoys in the oil sardine fishery of India.

Oil sardines occur along the coasts of Arabia, Iran, Pakistan, Ceylon, Andamans and in Java and Bali Straits. In India this species occurs in abundance supporting good fishery from Quilon in the south to Ratnagiri in the north. Beyond the northern border of the Mysore State the catches dwindle. In Madras, Andhra and Andamans only stray catches are met with.

In Kerala boat-seines (*Mathikolli vala, Patten-kolli vala, Thattum vala, Paithu vala, Nona vala*) gill-nets (*Mathichala vala* and *Nethel vala*) and cast-nets (*Veechu vala*) and in Mysore shore-seines

(*Rampani, Kairampani* and *Yendi*), gill-nets (*Ida bale*, etc.) and cast-nets (*Koori bale*) are the common types of gear in use in the oil sardine fishery.

In both the states, Kerala and Mysore, the landings in the fourth quarter are the highest, in the first quarter moderate and in the third and second quarters poor (Figs. 9 and 10). The fishery commences on the west coast after the outbreak of the south-west monsoon. Big-sized fishes in advanced stages of maturity along with many small-sized sardines appear in August–October. In the peak season of September to January the catches are made up chiefly of juveniles ranging from 12 to 15 cm.; thereafter the fishery dwindles and is closed by about April–May. The species attains sexual maturity at about 15 cm.; and appears to have protracted spawning from July to about November. Where the oil sardines spawn, wherefrom they arrive in the inshore waters to support fisheries and to where they go after the fishing season are little known.

Oil sardines are used as food both in the fresh and cured conditions. The body oil content being pretty high, it is extracted and put to use in the jute, leather and soap industries. The fish manure is used as a fertilizer in the cocoanut, coffee and tea plantations. The oil extracted by crude methods is applied to the fishing craft as a repellant to prevent the attack of the wood by the marine borers. There are a few establishments on the west coast for canning the oil sardines in the medium of edible oils. This being an easily perishable fish, proper cold storage facilities are essential to deal with the catches at the landing centres.

The fisheries, both annual and seasonal, are unpredictable. One of the factors governing the fluctuations in the fishery in the coastal waters is the availability of the diatom, *Fragilaria oceanica* Cleve which seems to be the favourite food of the oil sardine (Nair and Subrahmanyan, 1955; Nair, 1958).

Other Clupeiform Fishes

Besides the oil sardine, there are the other clupeiform fishes belonging to a few families which together constitute a fairly good proportion of the marine fish catches all along the coasts (12·5% annual average, 1961–65). Of these the other sardines and the related fishes (family Clupeidae) are the most important (4·07%). They are represented by the more common species, *viz.*, the white sardine *Kowala coval* (C.), the short-bodied sardine *Sardinella albella* (Val.), the gibbose sardine *S. jussieu* (Lac.), the fringe scale sardine *S. fimbriata* (Val.), the spotted sardine *Ambligaster sirm* (Walbaum), the toothed shad *Pellona ditchela* Val., the Indian shad *Euplatygaster indica* (Swainson), the slender shad *Ilisha elongata* (Bennett), the jewelled shad *Ilisha filigera* (Val.), the true Hilsa *Hilsa ilisha* (Ham.), the Chinese herring *Hilsa toli* (Val.), the long-finned herring *Opisthopterus tardoore* (Cuv.), and the Russel's herring *Raconda russelliana* Gray. The white sardine fishery is important only on the south-west coast. *S. fimbriata* is the most abundant of the other sardines on all coasts. *S. albella* and *S. jussieu* are caught in particular abundance on the south-east coast of India near Mandapam (Sekharan, 1967). *Hilsa ilisha* is a migratory fish ascending all the major river systems, where it is caught in considerable quantities. In coastal waters it occurs in the vicinities of the river mouths especially Narmada, Tapti, Cauvery, Pennar, Godavari, Krishna and Mahanadi. *Hilsa* fisheries in the estuaries of West Bengal are of particular importance because of the high magnitude of the landings.

Of the clupeiform fishes, the common members of the family Dorosomidae are *Nematalosa nasus* (Bloch) and *Anodontostoma chacunda* (Ham.-Buch.). These are small fishes obtained in small quantities on all coasts. The rainbow sardines *Dussumieria acuta* Val. and *D. hasseltii* Blkr. are common on all coasts but not abundant. The anchovies (family Engraulidae) include *Coilia dussumieri* Val., *Anchoviella commersoni* (Lac.), *A. indica* (V. Hass.), *A. heterolobus* (Ruppell), *A. baganensis* (Hardenberg), *Thrissocles malabaricus* (Bl.), *T. mystax* (Schn.), *T. setirostris* (Brouss.) and *T. dussumieri* (Val.) occurring in large quantities (about 4% of the marine fish catch) and are of considerable importance in Madras, Kerala and Andhra.

In Gujarat and Maharashtra miscellaneous clupeoids are in abundance in the fourth and the first quarters of the year with the peak catches in the fourth quarter. In Mysore the catches of the other clupeoids are high in the fourth quarter. In Kerala the other sardines are in abundance in the first, third and fourth quarters with the peak landings in the fourth quarter; the other clupeoids are best obtained in the third quarter. In Madras the other sardine catches are good all round the year. *Hilsa* is best obtained in the first quarter and the miscellaneous clupeoids in the third quarter. In Andhra the other sardines and miscellaneous clupeoids are the highest in the first quarter and are in fair quantities in the fourth quarter. In West Bengal and Orissa the other sardines and the miscellaneous clupeoids are abundant in the first and the fourth quarters (Figs. 7 to 13).

The major divisions of the order Clupeiformes include in addition to the aforesaid families a few others, *viz.*, Albulidae, Elopidae, Megalopidae, Chanidae and Chirocentridae represented by *Albula vulpes* (Linn.), *Elops saurus* (Linn.), *Megalops cyprinoides* (Brouss.), *Chanos chanos* (Forsk.) and *Chirocentrus dorab* (Forsk.) all of which grow to a large size. The first three are carnivorous 60 to 90 cm. when full grown and common but not abundant in all the coastal waters. The milk fish *Chanos chanos* is solely a plankton feeder attaining a maximum size of nearly 1·8 metres, occurring both in the inshore and offshore waters. Its minute fry in enormous numbers enter the shallow coastal lagoons and creeks in summer months. *Chanos* culture is widely practised in Java, Indonesia and Philippines in brackishwater farms known as "Tumbaks". In India *Chanos* culture is attempted with much success in marine and brackishwater fish farms and in freshwater tanks, ponds, etc., in Kerala and Madras. The growth of *Chanos* in freshwaters is more rapid than in the salt waters; but in the former environment the fish do not attain sexual maturity. The genus *Chirocentrus* is dealt with separately in the following account.

The dorab or the wolf herring, *Chirocentrus dorab* (Forsk.), a carnivorous fish, although distributed on all coasts, is comparatively more abundant on the east coast, especially in Madras State where its catches are the highest among all the maritime states. Its reported maximum length is 3·5 metres, but fish measuring about 1 metre are not uncommon in the commercial catches. The fish seems to breed in the offshore waters. The major catches are landed by shore-seines and gill-nets. In Madras, Andhra, West Bengal and Orissa and Kerala the catches are high in the first and the fourth quarters. In general the peak catches are in the fourth quarter. In Gujarat, Mysore and Maharashtra the catches are insignificant and are included in the miscellaneous fishes (Figs. 7 to 13). In 1961–65 period the annual average of this fish is 1·04% in the total marine fishes landed in India. There is a second species, *C. nudus* Swainson, growing to about 100 cm. in length reported to be occurring commonly in the inshore fish catches of the Palk Bay and the Gulf of Mannar.

Bombay Duck and Saurida

The Bombay duck, *Harpodon nehereus* (Ham.) of the family Synodidae supports a very important fishery, especially on the north-western coast of India. Outside India it is known to occur on the east coast of Africa, Malaya, Indonesia and China. In the all-India landings of marine fish for 1961–65 the annual average of the Bombay duck was 84,977 metric tons and *Saurida* and allied genera, 983 metric tons. All these members are treated together as one group because of their taxonomic affinities. This group ranks second forming about 12% in the total marine fish landings. Within this group Bombay duck forms 98·86% and *Saurida* and others 1·14%. Among the eight main coastal states Gujarat has given the highest landings (54,018 metric tons) on an annual average for the period 1956–65 and Maharashtra ranking second (35,454 metric tons). Mysore, Kerala and Madras show no landings and Andhra has given an annual average of 640 metric tons and West Bengal and Orissa 650 metric tons. There is thus a discontinuous pattern of distribution. Of the total landings of Bombay duck, 98·58% come from Gujarat and Maharashtra and 1·43% from Andhra, Orissa and West Bengal in the said 10-year period.

It may be seen from Figs. 7, 8, 12 and 13 that in all the states where they are caught hte landings are the highest in the fourth quarter. In Gujarat and Maharashtra the landings are the

lowest in the third quarter; in the two states respectively, the first and the second quarters catches are moderate. In the landings from the east coast states the catches are moderate in the first quarter and rank second in those of the fourth quarter; they are poor in the third quarter and poorest in the second quarter. In brief, it appears that the fishery is good from October to March in Gujarat, Andhra and West Bengal and Orissa and October to May or June in Maharashtra.

In the 15-year period of 1951–65, the fluctuations in the annual landings have been very marked. In 1951 the landings amounted to 7,261 metric tons (1·36%) and they increased fairly gradually to 128,880 metric tons (17·93%) in 1956. In the years that followed there has been a decrease upto 73,894 metric tons (9·06%) in 1965. On the west coast fishing is mainly by fixed bag-nets ("Dol"), which are operated 9–20 km. from the coast at depths of 20–30 metres. The types of gear used on the Andhra coast are the boat-seines; on the Orissa coast and in the estuaries of West Bengal fixed bag-nets of different kinds are operated.

H. nehereus is the only species supporting the Bombay duck fishery on the Indian coasts. It is known to attain a total length of 381 mm. At 210 mm. length the fish attains sexual maturity. The size range of the fish in the commercial catches is 60–270 mm. About 80% of the individuals in the catches are juveniles. Although individual fishes appear to breed only once a year, the species as a whole breed almost throughout the year. The morphometric studies have shown that the fisheries at various places on the Maharashtra coast are supported by a single stock, whereas those of Gujarat and Andhra coasts are supported by independent stocks (Bapat, 1967). The wanderings of the Bombay duck (Hora, 1934) which bring about fisheries of much regional importance along certain coasts seem to be influenced by two main factors, *i.e.*, the availability of the food and the favourable salinity medium of the waters.

A portion of the catch is used as food when fresh but the bulk of it is sun-dried. Being a very soft fish it is easily spoiled. When the landings arrive late the catch is very often not in a fit condition for human consumption and is perforce converted into manure. The fish is sun-dried on specially erected bamboo scaffoldings.

The closely related forms, *viz.*, *Saurida tumbil* (Bl.), *S. undosquamis* (Richardson) and *Trachinocephalus myops* (Schn.) are obtained in occasional catches all along the coast. When these are in insignificant quantities, they are recorded along with miscellaneous fishes in the fishery survey data.

Cat-fishes

The marine cat-fishes belong to two families, Plotosidae and Tachysuridae. The former includes a few species under the genus *Plotosus*. The common species are *P. canius* Ham. and *P. anguillaris* (Bl.) which grow to over 75 cm. in length. They inhabit the coastal waters and often enter the backwaters and estuaries. Family Tachysuridae includes a very large number of commercial species of which *Osteogeniosus militaris* (Linn.), *Tachysurus sona* (Ham.), *T. maculatus* (Thunberg), *T. caelatus* (Val.), *T. thalassinus* (Rupp.), *T. dussumieri* (Val.) and *T. jella* (Day) are common. A few of them attain a large size; *T. sona*, for example, grows to about 1 metre in length. Although all the species are found on all coasts in this country, *T. thalassinus* and *T. dussumieri* are best obtained from Kerala. *T. jella* is comparatively more abundant on the east coast. All being predacious and carnivorous, the cat-fishes are very destructive to other fishes. They are caught in all types of gear, particularly hooks and lines, and are consumed in fresh or cured conditions. The air-bladders are used for the manufacture of isinglass.

In the annual average for 1961–65 the cat-fishes have formed 2·43% of the total marine fish catch. Their landings are the highest in Kerala; Maharashtra, Madras, Gujarat, Andhra, Mysore and West Bengal and Orissa follow in the order of decreasing abundance. In Kerala the catches are the highest in the second quarter, but there is practically little difference in the relative abundance from quarter to quarter. In Gujarat, Maharashtra, Mysore and West Bengal and Orissa the highest

seasonal catches are in the fourth quarter and in Madras and Andhra they are in the third and first quarters respectively (Figs. 7 to 13).

Eels

A large number of eels occur in the coastal and offshore waters. *Anguilla bengalensis* (Gray and Hardw.) of the family Anguillidae, *Muraenesox talabonoides* (Blkr.) and *Muraenesox cinereus* (Forsk.) of the family Muraenesocidae are the common commercial species. The former is fairly abundant on the east coast while the latter two species in the north-western coast of India. *M. talabonoides* grows to a large size, upto about 2 metres in length. All eels are predacious and carnivorous. In the annual average catch of marine fishes for the period 1961–65 eels formed 0·9%. In the 1956–65 period Maharashtra's annual average catch of eel was 4,519 metric tons forming 3·02% of the state's total marine fish catch and this was the highest among the eel catches of all States. Gujarat ranked next with 1,115 metric tons of eels forming 1·14% of the total marine fish catch of that state.

Garfishes and Half-Beaks

The common garfishes of the family Belonidae are *Tylosurus strongylurus* (V. Hass.), *T. crocodilus* (Le Sueur) and *Xenentodon cancila* (Ham.-Buch.). The half-beaks of the family Hemirhamphidae are represented by *Zenarchopterus dispar* (Val.), *Hyporhamphus gaimardi* (Val.), *H. unifasciatus* (Ranzani), *Hemirhamphus georgii* (Val.) and *H. marginatvs* (Forsk.). The half-beaks grow to about 15 to 30 cm. The garfishes grow to bigger size, as *T. crocodilus* which is over a metre in length when full grown. These fishes in the 5-year period 1961–65 have given an annual average of 0·18%. In Madras State, where they are in comparatively greater abundance, the catches are the highest in the second quarter (Fig. 11).

Flying Fishes

These are represented in India by *Parexocoetus brachypterus* (Rich.), *Exocoetus volitans* Linn., *Cypselurus bahiensis* (Ranz.), *C. poecelopterus* (Cuv. & Val.), *C. altipennis* (Val.) and *C. coromandalensis* Hornell and are obtained with other fish catches in small quantities all along the coast. However, in Madras State they support an important fishery along the Coromandal Coast from Point Calimere to Madras. Specially built large-sized sail-catamarans called *Kolamarams* are used in the fishery which commences by about May and lasts till July or August. These fish inhabit offshore waters 30 to 40 kilometres away from the shore and have the habit of depositing their eggs on floating weeds like *Sargassum* spp. The fishermen carry bundles of *Pandanus* leaves or twigs of *Tephrosia* which are tied to long ropes and suspended in the sea to lure the fish. As they are attracted by these lures to deposit their eggs, they are scooped by nets which are emptied into the catamaran. Much of the fishing is done from Nagapattinam, Cuddalore and Madras. Almost the entire catch is salted and sun-dried. As may be seen from Fig. 11, the bulk of the landings is in the second quarter of the year. In Madras State the flying fishes constitute as much as 1·72% of the marine fish catch. In the all-India annual average catch for 1961–65 flying fishes formed 0·21% of the total landings.

Perches

Perches and perch-like fishes belong to a large number of families with great many species under them. The following genera are common: *Lates* and *Psammoperca* (Latidae); *Ambassin* (Ambassidae); *Holocentrus, Serranus, Epinephelus* (Serranidae): *Pelates, Eutherapon, Therapon* (Theraponidae); *Priacanthus* (Priacanthidae); *Apogon, Apogonichthys* (Apogonidae); *Sillago* (Sillaginidae); *Aprion, Pristipomoides, Lutianus* (Lutianidae); *Nemipterus* (Nemipteridae); *Lobotes* (Lobotidae); *Pentaprion, Gerres, Pertica* (Gerridae); *Pomadasys* (Pomadasyidae); *Scolopsis* (Scolopsidae); *Gaterin* (*Diagramma*) (Plectorhynchidae); *Lethrinella, Lethrinus* (Lethrinidae); *Argyrops*; *Acanthopagrus* (Sparidae); *Ephippus* (Ephippidae); *Platax* (Platacidae); *Drepane* (Drepanidae)

Pomacentrus, *Amphiprion*, *Abudefduf* (Pomacentridae); *Siganus* (Siganidae); *Acanthurus* (Acanthuridae); *Kurtus* (Kurtidae), etc. These fishes are abundant in coastal waters and more particularly around the coral reefs and in the rocky bottom of the sea even at considerable depths. The size varies much; some species like *Epinephelus tauvina* (Forsk.) grow to about 2·1 metres and a few of the *Apogon* species do not exceed 8 to 10 cm. in length. Perches are caught by hook and line, gill-nets, seines and baited basket-traps.

Lates calcarifer (Bloch) called 'Bekti' is a coastal fish which enters and survives well in estuaries, backwaters and also in freshwater. In ponds and tanks it lends itself to culture and grows rapidly, feeding on a variety of organisms. Being predatory, it is rather harmful to other fishes in mixed fish-pond culture. The maximum size known is 152 cm. but the usual size in the commercial landings is about 45 to 60 cm.

Perches have formed 1·47% of the marine fishes in the annual average catch for 1961–65 period As seen from Figs. 8 to 12 these fishes are most abundant in Madras State where they form 4·1% of the marine fish catch, Kerala, Maharashtra and Andhra ranking next in the order given. The highest catches of perches in Maharashtra and Mysore are in the fourth quarter; in Kerala and Madras in the third quarter and in Andhra in the second quarter.

Some of the perch-like fishes, as the carangids, sciaenids, red mullets, etc., which form regular fisheries, have been dealt with separately.

Red Mullets

The red mullets or goat-fishes of the family Mullidae are small-sized fish often brightly coloured and represented by a large number of species of which *Upeneus sulphureus* Cuv., *U. vittatus* (Forsk.) and *Parupeneus indicus* (Lac.) are common on both the east and west coasts. In the all-India annual average for 1961–65 the red mullets amounted to 2,639 metric tons forming 0·36% of the marine fishes.

Polynemids

The thread-fins of the family Polynemidae, of which 9 species are so far known from India, *viz.*, *Eleutheronema tetradactylum* (Shaw), *Polydactylus indicus* (Shaw), *Polynemus heptadactylus* Cuv., *P. sextarius* Bl., *P. plebeius* (Brouss.), *P. sexifilis* Val., *P. paradiseus* Linn., *P. xanthonemu* Val. and *P. microstoma* Blkr. occur in all coastal waters on the continental shelf and frequent th backwaters and estuaries some of them even ascending up the rivers a few miles from the river mouths *E. tetradactylum* grows to 180 cm. and *P. indicus* to 140 cm. and the rest are small usually not exceeding 30 cm. in length. They are all carnivorous fishes. *E. tetradactylum* (the Indian Salmon—*Rawas*). *P. indicus* (*Dara*), *P. heptadactylus* (*Shende*), *P. paradiseus* (Mango fish) and *P. sextarius* support fisheries in this country. The most important polynemid fishery is located in the north-western part of India in Bombay-Saurashtra waters, the chief commercial species there being *Dara*, *Rawas* and *Shende* (Kagwade, 1968).

The annual average of the polynemids for the 1961–65 period was 3,403 metric tons forming 0·46% of the total marine fish catch. In the major state-wise landings of polynemids for the 10-year period 1956–65 the annual average for Gujarat State was 2,100 metric tons, Maharashtra 2,692 metric tons and Madras 623 metric tons. In Gujarat and Maharashtra the catches are high in the first two quarters. In Madras State the landings are more or less equal, although low, in all the quarters (Figs. 7, 8 and 11).

Sciaenids

The members of the family Sciaenidae are well represented by a large number of species popularly known as the Jewfishes, occurring in abundance on all the coasts. Some of the larger species

Pseudosciaena diacanthus (Lac.) (*Ghol*) and *Otolithoides brunneus* (Day) (*Koth*) support important fisheries and are highly priced. A number of smaller species are low-priced and are known collectively as *Dhoma* in Gujarat and Maharashtra. The sciaenids in the all-India marine fish catches formed 3·64% in the annual average for the 5-year period of 1961–65 amounting to a total of 26,759 metric tons. In the 10-year period of 1956–65 among the maritime states Maharashtra ranked first, where the sciaenid catches formed 6·14% of the total marine fish catch of the state; Madras second with 5·43%, Andhra and Gujarat ranking next with 6·84% and 3·28% respectively. In Gujarat and Andhra the peak catches are obtained in the first quarter; in Maharashtra and West Bengal and Orissa in the fourth quarter and in Mysore, Kerala and Madras in the third quarter (Figs. 7 to 13).

Pseudosciaena diacanthus (Lac.), *Otolithoides brunneus* (Day), *Johnius coibar* (Ham.), *Otolithus ruber* (Schn.) and *O. argenteus* Cuv. grow to a large size of 60 to 120 cm. in length. *Sciaena dussumieri* (Val.), *S. russelli* (Cuv.), *J. aneus* Bl., *J. maculatus* Schn., *J. sina* (Cuv.) and *J. axillaris* (Cuv.) grow to 20 to 30 cm. in length. As a by-product of the fishery, their air-bladders are collected, sun-dried and exported in quantities for the manufacture of isinglass. The air-bladders of sciaenid fishes are priced higher than those of the polynemid fishes.

Ribbon-Fishes

Ribbon-fishes or hair-tails of the family Trichiuridae, represented in the Indian waters by *Trichiurus lepturus* Linn., *Lepturacanthus savala* (Cuv.), *Eupleurogrammus intermedius* (Gray) and *E. muticus* (Gray) are important, low-priced food fishes landed in quantities at all the fishing centres on the east and the west coasts, but in particular abundance in Kerala, Madras and Andhra. The all-India annual average landings of the ribbon-fishes in the 1961–65 period have been 24,873 metric tons which formed 3·38% of the marine fishes. The catches have been found to vary widely from year to year. In the 5-year period the lowest catch was 16,452 metric tons in 1963 forming 2·50% and the highest was 41,921 metric tons in 1965 forming 5·03% of the marine fishes of the country.

In the average landings of marine fishes for 1956-65 within the maritime states, it is found that ribbon-fishes formed 0·95% in Gujarat, 2·84% in Maharashtra, 2·07% in Kerala, 11·19% in Madras, 7·5% in Andhra and 7·11% in West Bengal and Orissa. Nearly 50% of the all-India ribbon-fish catch is contributed by the Madras State.

T. lepturus is the most important ribbon-fish of our coast and the commercial catches have individuals usually in the size range from 16 to 18 cm. Individuals of over 1 metre in length are not uncommon. The dominant groups differ from place to place, but in general all the age groups are met with. The commercial size of *E. intermedius* is from 14 to 35 cm. and of *L. savala* and *E. muticus* from 25 to 75 cm. The latter two species are comparatively in greater abundance in the northern latitudes (James, 1967).

The breeding grounds of ribbon-fishes appear to be in the far-off deeper water. *T. lepturus* is known to spawn once a year and the other species more than once. The entry of shoals into the inshore waters seems to be immediately after spawning, as the larger individuals show spent gonads. Ribbon-fishes are all predacious, carnivorous and sometimes cannibalistic. Each shoal consists of one species only. They are caught in various types of fishing gear, but chiefly in seines and to some extent in gill-nets and otter trawls and sometimes by hook and line. In Gujarat and Maharashtra landings are the highest in the fourth quarter and lowest in the third quarter; in Kerala, Madras and Andhra they are the highest in the third quarter and lowest in the first quarter and in West Bengal and Orissa they are the highest in the fourth quarer and lowest in the second quarter (Figs. 7 to 13). The fish is marketed fresh or in cured condition (dry-cured and wet-cured).

Carangids and Allied Fishes

The trevallies, the horse-mackerels, the queenfishes, etc., of the family Carangidae, the dolphin fishes of Coryphaenidae and the kingfishes of Rachycentridae are a mixed assemblage of pelagic

warm water fishes which form a fairly high proportion of the catches both on the east and west coasts of India. Of the above fishes, the horse-mackerels are the most abundant. In the annual average landings for 1961–65 these fishes formed about 3% of the total marine fish catches. *Megalapsis cordyla* Linn., *Decapterus russelli* (Rupp.), *Alectis* spp., *Selaroides leptolepis* (Cuv.), *Selar kalla* (Cuv.), *S. mate* (Cuv.), *S. crumenophthalmus* (Bl.), *Carangoides malabaricus* (Bl.), *C. armatus* (Forsk.), *Chorinemus lysan* (Forsk.), *C. tol* Cuv., *C. sancti-petri* Cuv. and *Trachinotus blochii* Lac. are fairly common members of the family Carangidae. Families Rachycentridae and Coryphaenidae are represented by *Rachycentron canadus* (Linn.) and *Coryphaena hippurus* (Linn.) respectively. Some of the species of *Chorinemus, Trachinotus, Caranx ignobilis, C. stellatus* Eydoux and Souleyet and *C. sexfasciatus* (Q.G.) grow to over 60 cm. while a large number of other carangids hardly exceed 30 cm. in length.

In the annual averages for 1956–65, as may be seen from Figs. 7 to 13, the highest yields of carangids are from Madras where they form 9·82% of the marine fishes of the state; ranking next is Kerala with 3·71%. In Gujarat and Mysore the highest yields are in the fourth quarter, in Kerala and Madras in the third quarter and in Andhra in the second quarter of the year. In Maharashtra and West Bengal and Orissa carangid catches are poor. In general it may be stated that these fishes occur all round the year.

Silver Bellies

Silver bellies or pony fishes of the family Leiognathidae, which occur in the commercial catches along the east and west coasts, are laterally much compressed, slimy fishes with minute scales. They move in shoals in the inshore waters whence they enter the estuaries and even the rivers for some distance from the sea. They are represented by three genera, *viz., Secutor, Leiognathus* and *Gazza. S. ruconius* (Ham.-Buch.), *S. insidiator* (Bl.), *L. dussumieri* (Val.), *L. fasciatus* (Lac.), *L. equulus* (Forsk.), *L. bindus* (Val.), *L. lineolatus* (Val.) and *G. minuta* (Val.) are fairly common, but *L. splendens* Cuv. is the most abundant. Most of them are small fish about 10 to 13 cm. in length and a few like *L. equulus* are known to grow up to 30 cm. They are low-priced fish caught in quantities by shore-seines, boat-seines and trawl-nets and cured by sun-drying.

In Gujarat, Maharashtra and Mysore States the catches of silver bellies are insignificant. The bulk of landings are from Madras, Kerala and Andhra States. Heavy landings of silver bellies are obtained on the south-eastern coast in the vicinities of Mandapam, Rameswaram, Pamban and Thangachimadam and on the south-western coast in the vicinities of Kerala backwaters. Off Visakhapatnam and Kalingapatnam on the east coast silver bellies are caught in fair abundance.

The annual average catch of silver bellies (1961–65) is 21,523 metric tons forming 2·93% of the total marine fish catch of India. Within Madras State they form 6·79%, in Kerala 2·5%, in Andhra 5·12% and in West Bengal and Orissa 3·5% of the marine fish catches. The fishery in Kerala commences in the second quarter, reaches the peak in the third quarter and dwindles by the fourth quarter. In Madras the fishery is fairly good in the second, third and fourth quarters with the peak catches in the third quarter; in Andhra and West Bengal and Orissa very good catches are obtained in the first and second quarters (Figs. 10 to 13).

Lactarius

The white fish, *Lactarius lactarius* (Schn.) of the family Lactariidae is a small-sized, carnivorous fish growing up to 28 cm. in length. The size range in commercial catches is between 13 and 25 cm. *Lactarius* moves in shoals in inshore waters; it is more abundant in the east coast than on the west coast. In the marine fishes of the states, *Lactarius* forms 5·2% in Madras, 1·97% in Andhra and about 1% in Kerala (based on annual average catches for 1956–65). The landing centres on the east coast are Mukkur, Pamban, Sippikulam, Idinthakarai, Tranquebar and Madras City in Madras State, Uppada in Andhra and Gopalpur in Orissa. The major landing centres on the west coast

are Kozhikode, Thanur and Ponnani in Kerala. In the Kutch region *Lactarius* forms a good proportion of the trawler catches.

In the all-India catches for 1961–65, *Lactarius* amounted to 7,539 metric tons forming 1·02% of the marine fishes. The landings are extremely good in the second and third quarters in Kerala, third and fourth quarters in Madras and first, second and fourth quarters in Andhra. *Lectarius* is consumed either fresh or in cured state.

Pomfrets

The Pomfrets (family Stromatidae) are among the best of the table fishes having ovate, compressed bodies, occurring in shoals usually away from the shore comparatively in deeper waters. The brown pomfret *Parastromateus niger* (Bl.), the silver pomfret *Pampus argenteus* (Euphr.) and the Chinese pomfret *Pampus chinensis* (Euphr.) represent this group which forms about 2·64% of the marine fishes (annual average for 1961–65). As seen from Figs. 7 to 13, pomfrets are best obtained in the fourth quarter of the year in Gujarat, Maharashtra and Kerala. In Andhra there is a gradual decline of the catch from the first to last quarters. In West Bengal and Orissa the variation in catches is not marked from quarter to quarter. In the annual state-wise averages for 1956–65 the catches decreased from Gujarat to Maharashtra, Andhra, Kerala, Madras and West Bengal and Orissa in the order of abundance (Figs. 7 to 9 and 11 to 13).

Mackerel

The Indian mackerel, *Rastrelliger kanagurta* Cuv. of the family Scombridae, is a much esteemed table fish which is widely distributed in the Indian and the Pacific Oceans, from the east coast of Africa to Northern Australia and Micronesian and Polynesian groups of Islands, contributing to fisheries of some magnitude in some countries in the region. In the 1961–65 period, the annual average of the mackerel landings in India has been 41,505 metric tons forming 5·6% of the marine fish catch. In the 10-year period of 1956-65 the annual average has been 62,193 metric tons, with the lowest catch of 16,426 metric tons in 1956 forming 2·29% and the highest catch of 133,655 metric tons in 1960 forming 15·22%. The highest percentage of mackerel catch was 19·65 in 1951, In that year, in 1958 and 1960 the mackerel catches have exceeded 1 lakh metric tons.

Unlike the oil sardine the fishery of which is confined to the west coast, the mackerel supports fisheries on both the coasts, although the bulk of the landings to the extent of about 80% comes from the west coast centres, the chief among them being Quilon, Alleppey, Cochin, Calicut, Tellicherry, Malpe, Karwar and Malwan. The fishery in general extends on the west coast from Cape Comorin to Ratnagiri. On the east coast sporadic catches occur near Mandapam, Nagapattinam. Madras, Kakinada, Visakhapatnam and some parts of Orissa (Pradhan and Rao, 1958; Venkataraman, 1967). For the 10-year period, the annual average landings have been the highest from Mysore (29,875 metric tons), Kerala ranking next (25,940 metric tons) followed by Maharashtra (3,657 metric tons). Mackerel landings in Madras State (2,049 metric tons) are higher than those in Andhra (1,202 metric tons). Those from Orissa and West Bengal are insignificant (89 metric tons).

In Konkan, North Kanara and South Kanara, the chief gears in operation are the shore-seines (*Rampani*), gill-nets (*Patta bale*) and cast-nets (*Pag*). The types of fishing boats are *Pandi*, *Hodi* and *Dhoni* with or without out-riggers. In Kerala boat-seines (*Odam vala*, *Paithu vala*, *Ayila kolli vala*, *Thattum vala*, *Nona vala*), shore-seines (*Kara vala*) and gill-nets (*Ayila chala vala*) are operated with the help of dug-out canoes. In Madras State Masula boats, Tuticorin type of boats, canoes and catamarans are chiefly used for operating different types of shore-seines, boat-seines, bag-nets and gill-nets. In Andhra and Orissa more or less similar types of gear are used as in Madras, with Masula boats, plank-built boats and catamarans.

The fishing season starts very early in about August in the southern zone from Cape Comorin to Ponnani and lasts till February. In the Central zone from Ponnani to Mangalore also the season starts at about the same time and lasts till March–April. In the northern zone from Mangalore to Ratnagiri the fishery starts late by about October-November and lasts till about March. Peak catches occur in October-November. In Karwar and South Kanara two peaks are noticed, one at the beginning and the other at the end of the fishing season. As may be seen from Figs. 8 to 10, mackerel landings are the highest in the fourth quarter and moderate in the first quarter and poor in the second and third quarters of the year in Maharashtra, Mysore and Kerala States. In Madras the third quarter's catches are the highest and the fourth quarter's the lowest (Fig. 11). In Andhra the catches are uniformly moderate in all the quarters except in the third quarter when they are the lowest (Fig. 12). In West Bengal and Orissa the catches are poor in all quarters (Fig. 13).

The fishery is supported mostly by juveniles between 16–18 cm. Regarding the rate of growth different views are held. Recent investigations at the Central Marine Fisheries Research Institute show that the fish attains a length of 22 cm. at the end of the first year and about 24 cm. at the end of the second year of its life. The 18 cm. size common in the mackerel fishery is supposed to be reached in about 5 to 6 months. Sexual maturity is attained when the fish is about 22 cm. in length. The spawning season on the west coast appears to be prolonged with the possibility of two spawning periods, *i.e.*, about May–August and November–March. On the east coast October–November and May–June appear to be the periods when the fish spawn in different regions. There appear to be good spawning grounds off Vizhingam and Madras.

Mackerel is pelagic and the fishery is confined to the inshore region, but small numbers are occasionally obtained from deeper waters as reported from Bombay-Saurashtra coast (Narayanan Kutty, 1962). An inverse relationship between oil sardine landings and mackerel landings has been observed (Nair and Chidambaram, 1951). There are, however, some years during which both the mackerel and oil sardine catches have been recorded to be very high. For instance, in 1960 the oil sardine catch was 189,016 metric tons (21·5%) and the mackerel catch was 133,65 metric tons (15·22%); similarly, in 1958 the oil sardine catch was 123,730 metric tons (16·4%) and mackerel catch 12382 metric tons (16·31%).

The mackerel is a plankton feeder, though occasionally carnivorous tendencies have been observed. Possibly the shoreward movement of the mackerel shoals in the period of the fishery is determined by the abundance of planktonic food items in any particular region. There appears to be some relationship between the rainfall in the region and the landings of mackerel. In respect of the wind force in monsoon and the fluctuations in the fishery, it is observed that good fisheries have resulted when the wind force had mean values.

Mackerel is consumed fresh or in cured condition. About 50% of the catch is salt-dried, wet-cured or pickled by Colombo method using salt and tamarind. When catches are big, they are impounded for a short period in shallow waters by *Rampani* nets before they could be disposed of in a satisfactory manner.

Seerfishes

Seerfishes of the family Scombridae are represented by a few species under two genera, *Scomberomorus* Lacepede and *Acanthocybium* Gill. They are in general high-priced quality fishes. Some of the species grow to over a metre in length. The barred Spanish mackerel *Scomberomorus commerson* Lac., the streaked Spanish mackerel *S. lineolatus* (Cuv.), the spotted Spanish mackerel *S. guttatus* (Sch.) and the wahoo, *Acanthocybium solandri* (Cuv.) are the common species under this group.

The all-India annual average catch of seerfishes for 1961–65 is 10,420 metric tons forming 1·41% of the marine fish catch. As is seen from Figs. 8 to 13 the major portion of the catch comes

from Madras, Andhra and Kerala, although fair quantities are landed in Maharashtra and Mysore. In the remaining maritime states they are landed in small quantities only. In the 10-year period of 1956–65 in the annual average catch the seerfishes formed 4·03% in Andhra and 2·97% in Madras State. In West Bengal and Orissa also the percentage proportion of the seerfishes is fairly high (2·08%). In Maharashtra, Mysore, Kerala and Madras the peak catches are in the fourth quarter of the year and the lowest catches in the second quarter. In Andhra and West Bengal and Orissa there is no significant variation in the catches from quarter to quarter.

Seerfishes are caught in types of gear used for other fishes, but they form a high proportion in the landings by gill-nets and hooks and lines. They are consumed fresh or cured (salted and dried or wet-cured) and the demand for them is very high wherever they occur, as they are considered the tastiest among the marine fishes.

Tunnies and Allied Fishes

Among the scombroid fishes the tunnies and their like under the subfamily Thunninae (family Scombridae), the spearfishes and the sailfishes (family Istiophoridae) and the swordfishes (family Xiphiiae) are economically important food fishes, widely distributed in the tropical and temperate waters. In the past two decades the biological and taxonomic studies of this group of fishes have received much attention in this country. In recent years a large number of new records from the Peninsular India, the Andaman-Nicobar waters and the Laccadive Sea has been reported. Of the tuna and tuna-like fishes, the frigate mackerels *Auxis thazard* (Lac.), *A. thynnoides* Blkr., the oriental bonito *Sarda orientalis* (Tem. Schl.), the dogtooth tuna *Gymnosarda unicolor* (Rupp.), the oriental bluefin tuna *Thunnus thynnus orientalis* (Tem. Schl.), the albacore *Thunnus (Thunns) alalunga* (Bonn.), the bigeye tuna *Thunnus (Parathunnus) obesus mebachi* Kish., the northern bluefin tuna *Thunnus (Kishinoella) tonggol* (Blkr.), the yellowfin tuna *Thunnus (Neothunnus) albacares macropterus* (Tem. Schl.), the oceanic skipjack *Katsuwonus pelamis* (Linn.), the Atlantic little tunny *Euthynnus alletteratus* (Ref.) and the mackerel tuna *Euthynnus affinis affinis* (Cantor) are now well known. The representatives of the family Istiophoridae in the seas around India are the sailfish *Istiophorus gladius* (Brouss.), the striped marlin *Tetrapturus audax* Philippi, the shortbill spearfish *T. angustirostris* Tanaka, the black marlin *Makaira indica* (Cuv.) and the blue marlin *M. nigricans* Lac. Of the family Xiphiidae, there is a lone representative, the swordfish *Xiphias gladius* Linn. which is cosmopolitan in its distribution. Their size range is very wide. The mackerel tuna and the frigate mackerel grow to about 60 cm. the yellowfin tuna to over 1·8 metres and the billfishes to over 3 metres in length. The blue marlin and the swordfish grow to about 4 to 4·3 metres.

Excepting in Minicoy, in the Laccadive Archipelago, where the oceanic skipjack is fished in considerable quantities, there is no organised tuna fisheries on the Indian coasts. The species obtained from the inshore waters are commercially less important ones unlike those from the high seas. Although India's catch of these fishes is negligible at present, her central position in the Indian Ocean offers considerable advantage over other countries for the development of the latent oceanic fisheries of this region (Jones and Silas, 1964; Jones, 1967 *b*).

In the inshore fisheries the annual average catch of this group of fishes for 1961–65 period is 4,657 metric tons forming 0·63%. Among the major coastal states Kerala ranks first with 2,153 metric tons and Madras second with 1,025 metric tons of tunas and related fishes as annual averages for the period 1956–65. In Kerala and Madras the maximum yields are in the fourth quarter; in Andhra the highest catch for the year is in the second quarter. These fishes are obtained as incidental catches in types of gear operated for other fishes. In Minicoy, shoals of skipjack when sighted are chummed by throwing bait-fishes into the sea and caught by pole and line fishing. The hooks are unbarbed and unbaited. The tuna-fishing boats are very much sturdier and stronger than the types of boats usually employed in the inshore fishing operations for other fishes. Tuna meat is boiled in brine, smoked and sun-dried. The product thus cured known as *masmin* is exported to neighbouring countries (Jones and Kumaran, 1959).

Barracudas and Grey Mullets

The barracudas (family Sphyraenidae), the grey mullets (family Mugilidae) and the hardyheads (family Atherinidae) comprise a supergroup (order Mugiliformes) the members of which inhabit mostly the inshore waters, often entering the estuaries and backwaters.

The barracudas are represented in Indian waters by several species under the genus *Sphyraena* of which the more common ones are *Sphyraena commersoni* (Bl.), *S. obtusata* Cuv. and *S. jello* Cuv. The first and the last named species grow to over 1·5 metres. They are active predatory fishes. In the all-India catch of the marine fishes for 1961–65, the annual average of the barracudas is 1,471 metric tons forming 0·2%. As these fishes form a very insignificant proportion in the landings, in most states their yields are recorded along with other miscellaneous fishes. In Madras State where they are landed in some quantities, the catches are the highest in the third quarter (Fig. 11). These are among the prized game fishes in Indian waters caught by hook and line and trolling artificial lures.

The grey-mullets are represented in India by the genera *Mugil, Valamugil, Liza, Rhinomugil, Sicamugil, Plicomugil, El'ochelon* and *Crenimugil.* A few of the mullet species are restricted to the river systems. The more common marine species fall under the genera *Mugil, Liza* and *Valamugil,* they being *M. cephalus* Linn., *L. macrolepis* (Smith), *L. parsia* (Ham.), *L. tade* (Forsk.), *V. seheli* (Forsk.) and *V. buchanani* (Blkr.). They are active but non-predatory fishes feeding on detritus and the smaller components of the phytoplankton and zooplankton. They are more abundant on the east coast than on the west coast. Mullets lend themselves for fish farming. The fry are plentiful in salt-water lagoons, streams and creeks. They can easily be collected and stocked in marine and brackishwater fish farms. Some of the species thrive well in freshwater environments also. Most of them grow to a maximum size of 25 to 45 cm. The mullets form 0·2% of the marine fish catches in the annual average for 1961–65.

The hardyheads are small, fishes congregating in dense shoals in shallow water lagoons, the more common species among them being *Atherina forskalii* (Rupp.) which has a prominent silvery lateral stripe.

Bregmaceros

This belongs to the family Gadidae, and is a small-sized fish growing to about 13 cm. in length supporting a seasonal fishery around Bombay. In 1961–65 the annual average catch of *Bregmaceros* amounted to 4,338 metric tons forming 0·59% in the marine fish catch of India. In Maharashtra in the 1956–65 period the annual average catch was 3,614 metric tons which formed 2·4% of the state's marine fish catch. The landings are the highest in the fourth quarter and lowest in the third quarter. The fishery starts in October after the south-west monsoon with peak landings, but dwindles by about March. The common species supporting the fishery is stated to be *Bregmaceros mcclellandi* (Thompson). Along other coastal regions of India *Bregmaceros* occurs only in stray catches. The family Gadidae, although poorly represented in Indian waters, includes important commercial fishes like the cod in temperate waters.

Soles

Soles and other flat-fishes are bottom feeding, carnivorous and asymmetrical with both the eyes being present either on the right or the left side. They are represented in the Indian waters by a large number of genera, as *Psettodes* (family Psettodidae), *Poecilopsetta* (family Pleuronectidae), *Bothus, Pseudorhombus* (family Bothidae), *Solea* (family Soleidae), *Paraplagusia* and *Cynoglossus* (family Cynoglossidae). *Psettodes erumei* (Schn.) known as the Indian halibut, occurs in some quantities in Bombay-Saurashtra waters and the south-eastern coasts. Most of the flat-fish species occur in small numbers in the miscellaneous catches all along the coast, except *Cynoglossus semifasciatus* Day, the Malabar sole, which supports an important fishery from Quilon in Kerala to

Moolki in South Kanara. The heaviest landings, however, are in the region between Edakad and Kadapuram on the Malabar coast.

The annual average catch of the soles for the period 1961–65 is 10,027 metric tons forming 1·36% of the marine fish. In the 5-year period the highest landing was 17,644 metric tons in 1962 and the lowest 6,146 metric tons in 1964. From the annual averages of categories of fishes for the period 1956–65 as shown in Figs. 7 to 13, it is seen that the bulk of the soles are landed in Kerala (8,456 metric tons) and only very little quantities in Mysore (486 metric tons) and Madras (565 metric tons). In all the three states the third quarter's landings are the highest. In Mysore and Kerala catches are moderate in the fourth quarter and poor in the first and second quarters. In Madras there appears to be no significant variation of sole landings from quarter to quarter, they being poor all the year round.

The maximum size of *C. semifasciatus* is about 18 cm. The fish grows to about 10 to 12 cm. in the first year and 14 to 16 cm. in the second year. The peak fishery is supported by one-year olds. The fishing season is from late August or September to December. The bulk of the catch is obtained at the commencement of the season, *i.e.*, in September itself. The sudden appearance of the soles in the surface or subsurface waters of the inshore region is phenomenal and is known in Kerala as *Manthayilakom*, when they are captured in huge quantities in boat-seines (*Thattum vala, Paithu vala*), cast-nets and shore-seines (*Noona vala*). The soles spawn for the first time at the end of the first year of their lives. In the peak of the fishery 75 to 80% of the fish are fully mature potential spawners. After the peak fishery the soles begin to disappear as suddenly as they have appeared at the commencement of the season. Spawning seems to take place in the deeper waters and for a protracted period from October to January. The eggs and larvae are pelagic. After metamorphosis the young settle down in the inshore region in November–December to May with a peak in about March. They feed at the bottom on polychaetes, amphipods and molluscs. The migration of the soles from the offshore to inshore waters and *vice versa* appears to be for the purpose of feeding and breeding respectively. The types of gear presently employed in the sole fishery are effective only when the fish are shoaling in the surface and subsurface waters but ineffective if they are at the bottom.

Among the flat-fishes which grow to about 30 cm. or more in length are *Psettodes erumei* (Schn.), *Pseudorhombus arsius* (Ham.), *Synaptura commersoni* (Swainson), *Cynoglossus bilineatus* (Lac.), *C. lingua* Ham. and *C. microlepidotus* (Blkr.).

Crustaceans

The crustaceans have formed 11·26% of the total marine fish catches of India in the annual average landings for the period 1961–65. Among them the penaeid prawns form the major component to the extent of 55·52%, non-penaeid prawns 41·56% and the other crustaceans a little less than 3%. In the state-wise landings of crustaceans Maharashtra leads with a catch of 49,102 metric tons followed by Kerala with 19,650 metric tons and Gujarat with a catch of 12,590 metric tons. In Madras, Andhra, West Bengal and Orissa and Mysore the landings are in the decreasing order from 4,380 metric tons to 934 metric tons. As regards seasonal trends, in Gujarat and Maharashtra crustacean catches are the highest in the second quarter and lowest in the third quarter; in the first and the fourth quarters the landings are fairly high. In the rest of the states except West Bengal and Orissa the catches are the highest in the third quarter. In Mysore the catches are moderate in the fourth quarter and poor in the first and second quarters. In Kerala they are moderate in the second and fourth quarters and poor in the first quarter. In Madras, although the fourth quarter's catches are the lowest, there is no significant variation from quarter to quarter. In Andhra catches are moderate in second quarter and poor in first and fourth quarters. In West Bengal and Orissa the catches are the highest in the fourth quarter, moderate in the first quarter and poor in the second and third quarters (Figs. 7 to 13).

Prawns

In the landings of the crustaceans, prawns, as stated earlier, form a very high percentage. During the 8-year period of 1958–65 the annual average of prawns has been 77,461 metric tons, which formed 97·14% of the crustacean landings and 10·68% of the total marine fish landings. The average state-wise contribution to prawn landings for the period has been to the extent of 9·07% from Gujarat, 52·73% from Maharashtra, 0·16% from Goa, 1·23% from Mysore, 26·55% from Kerala, 3·41% from Madras, 4·45% from Andhra and 2·39% from West Bengal and Orissa.

The major portion of the marine prawn catch is contributed by penaeid prawns *viz., Penaeus indicus* Milne-Edwards—10%, *P. monodon* Fabricius—0·9%, *Metapenaeus dobsoni* (Miers)—35%, *M. affinis* Milne-Edwards—12%, *M. monoceros* (Fabricius)—10%, *M. brevicornis* (Milne-Edwards)—4%, *Parapenaeopsis stylifera* (Milne-Edwards)—18%, *P. sculptilis* (Heller)—0·8%, *P. hardwickii* (Miers)—0·6% and *Solenocera indicus* Nataraj—0·9%. The main species of non-penaeid prawns are *Palaemon tenuipes* Henderson—3%, *P. styliferus* Milne-Edwards—0·6%, *Hippolysmata ensirostris* Kemp—0·9% and *Acetes* spp.—3·0%.

The commercial fisheries of *M. dobsoni* are on the south-west and east coasts; of *M. brevicornis* in West Bengal, Andhra, Maharashtra and Gujarat; of *P. stylifera* only on the west coast; of *P. sculptilis, P. hardwickii* and *H. ensirostris* in Gujarat, Maharashtra and Andhra; of *S. indicus* in Maharashtra and Andhra; of *P. tenuipes* in Gujarat, Maharashtra and West Bengal and Orissa; of *P. styliferus* in Maharashtra and West Bengal. The rest of the prawns stated above are met with in some quantities in the commercial catches all along the east and west coasts.

Among the comparatively less abundant prawns, which nevertheless contribute to fisheries of some local importance, are *Penaeus semisulcatus* de Haan, more common on the east coast, *P. penicillatus* Alcock in Maharashtra, *P. merguiensis* de Man along the coasts of Karwar, Ratnagiri and their vicinities, *P. canaliculatus* Olivier in Madras, Pulicat and Bombay, *Metapenaeopsis novae-guineae* (Haswell) from Bombay, *Metapenaeus kutchensis* George *et al.* in the Gulf of Kutch, *Trachypenaeus curvirostris* (Stimpson) in Bombay and farther south and *Atypopenaeus compressipes* (Henderson) from Maharashtra.

Macrobrachium rosenbergii (de Man), a giant freshwater prawn, which is common in lakes and estuaries, rarely enters the inshore waters. It is obtained in good quantities in Kerala backwaters in the monsoon and post-monsoon months and about December–July on the east coast from similar environments.

From depths of 275–700 metres off the south-western coast, some deep-water species of prawns have been recorded, they being *Aristeus semidentatus* (Bate), *Penaeopsis rectacuta* (Bate), *Metapenaeopsis* spp., *Parapandalus spinipes* Bate, *Plesionika martia* (A. M. Edw.), *Heterocarpus gibbosus* Bate, *H. wood-masoni* Alcock, *Oplophorus gracilirostris* A. M. Edw., *Acanthophyra sanguinea* Wood-Mason, etc. (George, 1966; George and Vedavyasa Rao, 1966). Some of the species seem to occur in such densities as to support fisheries.

Acetes spp. constitute good fisheries on both east and west coasts. There are three species, *viz., Acetes indicus* Milne-Edwards, *A. erythraeus* Nobili and *A. serrulatus* (Kroyer) all of which occur in larger shoals in the inshore waters.

Most of the penaeid prawns breed in the sea and their young ones enter the estuaries and backwaters. *P. stylifera* completes its entire life-cycle in the sea. The larvae and post-larvae of the species, entering the brackishwater environments, feed and grow to juveniles of fair size in some months and return to the sea for attaining sexual maturity to breed. Some of the species like *M. monoceros, P. indicus* and *M. affinis* seem to enter fairly deeper waters of over 50 metres for breeding. These appear to breed about five times in their life-span, with two to three months interval between two successive periods.

Mohamed (1967) states that the fishing season for prawns extends from November to May in the west coast and from December to August in the east coast with interruptions during the monsoon. However, in June–July prawns in good quantities are fished in close vicinity of the

mud banks in Kerala and in the Gulf of Kutch there is a monsoon fishery for prawns of some magnitude. The gears commonly used for fishing prawns are the fixed stake-nets, boat-seines, cast-nets, dip-nets, shrimp-trawls and other trawl nets.

Other Crustaceans

Among the other crustaceans those contributing to fisheries of importance are the spiny lobsters and crabs. The former represented by *Panulirus polyphagus* (Hbst.), *P. ornatus* (Fabricius) and *P. homarus* (Linn.) inhabit rocky bottoms along both the coasts and grow to over 30 cm. in length. The last-mentioned species supports a freezing industry in the export trade of 'lobster tails' in the south-western coast of India between Trivandrum and Cape Comorin. *Puerulus sewelli* Ramadan is yet another commercial species of lobster in the south-western coast. Lobsters are caught in the wall-seines, gill-nets, anchor-hooks and baited-traps.

Of the crabs, *Scylla serrata* (Forsk.), *Portunus pelagicus* (Linn.) and *P. sanguinolentus* (Hbst.) are common and are caught in the shore-seines, trawl-nets and specialized crab-nets like the *nandu valai* in the Gulf of Mannar and Palk Bay and *noltjal* in the Chilka lake (Jones, 1967 *a*). Along other coasts they are comparatively less.

Cephalopods

The edible cephalopods fall under three groups, *viz.*, the cuttlefish *Sepia aculeata* F. *et* d'Orb., *S. rostrata, Sepiella inermis* F. *et* d'Orb., the squids *Sepioteuthis arctipinnis* Gould, *Loligo indica* Pfeffer, *L. hardwickii, L. affinis* and octopi, *Octopus rugosus* (Bosc), *O. octopodea, O. favonia, O. herdmanii, O. hongkongensis* Hoyle. On the south-east coast of India there is a regular squid fishery of *Sepioteuthis arctipinnis* in the summer months in the Gulf of Mannar and Palk Bay around Mandapam and Rameswaram. Along other coasts the squids and cuttlefish are obtained only as incidental catches along with other fishes in all types of seine-nets. In Rameswaram and Mandapam the squids are caught in shore-seine, the *ola valai*, which has palmyra leaf strips as scares, attached to the wing ropes to drive the squids into the nets (Rao, 1954, 1958). The octopi are caught from the Palk Bay lagoons in sort of traps made out of *Pteroceros* shells strung together on coir ropes. The cephalopods, besides being utilised as food, are also used as bait in hook and line fishing. In the annual average for 1961–65 the cephalopods formed 0·03% of the marine fish catch in India.

Miscellaneous Fishes

All varieties of fishes which individually are obtained only in insignificant quantities are considered as miscellaneous fishes. Fair quantities of juveniles are in this group fetching very low price in the market. Some of the miscellaneous fishes, although occurring in small quantities, are good quality table fishes. In the all-India annual average catch for 1961–65 this group formed 2·91% of the marine fishes. As may be seen from Figs. 7 to 13 the major contribution to the group of fishes comes from the Madras State, ranking next are Kerala, Maharashtra, Andhra, Mysore, Gujarat and West Bengal and Orissa in the drecreasing order of abundance. In Gujarat, Maharashtra and West Bengal and Orissa the miscellaneous fishes are best obtained in the fourth quarter, in Mysore and Kerala in the third quarter and in Madras and Andhra in the first quarter.

V. The Exploited Fisheries of the Offshore Region

The non-powered indigenous craft using traditional types of fishing gear, which cannot fish in the distant grounds, perforce continue their operations to the limited but much exploited, narrow, about seven miles shallow inshore region bordering the coastline, with meagre yields per unit of effort expended. Only the powered fishing vessels, suitably geared and adequately equipped with cold storage facilities can reach the far-off fishing grounds, harvest for long hours and return to

ports with catches fresh and sufficiently big to make these invariably expensive operations remunerative. A knowledge of the fishing grounds, the distribution of fish abundance therein, their seasonal fluctuations and the type of gear best suited to reap the resources to the optimum level without detriment to the available stocks is an essential prerequisite for initiating industrial exploitation by powered fishing vessels. Exploratory surveys of the fish resources on the continental shelf of India were commenced first in 1900 in Bombay coast using a steam trawler and these were repeated subsequently on the same coast and elsewhere with other vessels of the governmental and commercial organisations, but no substantial progress was achieved for about five decades, although some preliminary information has been made available regarding the suitability of certain grounds and the types of fish groups comprising the catches. In the past twenty years, the results of the exploratory fishing by the Government of India fishing vessels at different bases, the Japanese trawler *Taiyo Maru No.* 17, the New India Fisheries Company's vessels of Bombay and Cochin bases, the Indo-Norwegian Project vessels exploring the shelf in the southern portion of the east and the west coasts and the West Bengal cutters fishing in the northern region of the Bay of Bengal have demonstrated the feasibility of deep-sea and offshore fishing as a profitable commercial proposition. At present the exploratory fishing by the governmental departments is continued and the private sector is encouraged to take to offshore fishing using powered vessels and the improved types of fishing gear. The following account deals with the exploited as well as the discovered, yet not fully exploited, resources as revealed by powered vessels fishing on the continental shelf and to some extent a little beyond on the continental slope, under four major geographical divisions, *viz.*, (1) North-Western, (2) South-Western, (3) South-Eastern and (4) North-Eastern coastal divisions of India. The resources dealt with are demersal, they being exploited mostly by trawls operating at the sea bed. The species constituting the catches from the offshore grounds are generally the same as those fished by the inshore craft and gear. The size composition and the magnitude of the yields vary in the two environments. The resources in the inshore and offshore environments are interdependent because of the periodical migrations from one environment to the other. Even the truly pelagic species like the sardines and the mackerel are caught at times in quantities in the trawls. The exclusively deep-sea fish and the crustaceans are very few.

1. *North-Western Division*

The areas covered till 1967 in the exploratory and commercial fishing on the continental shelf lie in this division between latitudes 15° N to 24° N and longitudes 67° E to 74° E. In 1900 the Government of Bombay initiated powered fishing with S.T. *Premier* using a beam trawl but no data have been published. Subsequently during 1921–22, S.T. *William Carrick* (Hefford, 1949) fished in these waters and the results of operations are given in Table II.

TABLE II

Regional catch trends by S.T. William Carrick, 1921–22 (*after Hefford,* 1949)

Fishing grounds	No. of hauls	Catch per hour of all fish in lb.
Bombay grounds ..	270	109
Sind grounds ..	58	114
South Kathiawar grounds ..	30	120
Kathiawar west coast ..	3	132
Gulf of Kutch ..	2	145
Gulf of Cambay (off Daman)	3	30
Southern grounds ..	14	21
All grounds ..	390	107

As compared with the operations of other vessels which have now been fishing in these waters, the catch returns of this vessel were very low, but they have shown the relative abundance of fish in different grounds from South of Bombay to Kathiawar and Sind coasts. The catch returns obtained were comparatively higher from Kutch to Kathiawar coast than from Bombay, Cambay and the southern grounds. In 1923 another steam trawler, *Madras*, of the Bombay Government operated in these waters but no particulars of the operations are available.

The Government of India Deep-Sea Fishing Station, which was established in 1946 at Bombay for exploratory fishing, commenced operations with a steam trawler *Meena*, from January 1948. She covered an area of 7,500 square nautical miles in Bombay and Cambay regions and obtained a total catch of 35,724 lb. of all fish for 2,143 hours at 171·5 lb. of fish per hour, in 200 days of absence from port at 3,689 lb. of fish per day's fishing and 1,948 lb. of fish per day of absence from port (CMFRS, 1954). The operations of this vessel too, as in the case of *William Carrick*, showed low catch rates, but certain productive areas as 11, 18, 19 and 24 were located with catch rates of over 200 lb. per hour. *Meena* was decommissioned in 1949 and two Danish cutters, M.T. *Ashok* and M.T. *Pratap* (240 H.P. each), were put into operation. These proved to be very efficient in charting out the grounds and in testing the relative efficiency of the otter-trawls and the bull-trawls. In otter trawling (midget otter-trawl) by these vessels till 1953, the annual catch rate varied from 94·4 lb. to 125·14 lb. per hour of fishing. In the Japanese method of bull-trawling by the same vessels in 1953–55 the average catch per vessel had increased up to 1,562·4 lb. per hour.

The total catch particulars for 1949–50 to 1954–55 of all the vessels, *viz.*, M.T. *Ashok*, M.T. *Pratap*, M.F.V. *Bumili* (135 H.P.) and M.F.V. *Champa* (135 H.P.) of the Deep-Sea Fishing Station, Bombay and the Japanese fishing vessel *Taiyo Maru No.* 17 (550 H.P.), which started fishing in the same waters in 1951, are given in Table III.

TABLE III

Landings from offshore trawling grounds of Bombay-Saurashtra waters, during 1949–50 *to* 1954–55 *(in lb.)*

Region	1949–50	1950–51	1951–52	1952–53	1953–54	1954–55
Bombay ..	1,21,481	33,655	2,05,313	1,43,069	1,57,545	121
Cambay ..	2,61,576	3,85,346	4,34,327	6,65,301	4,00,447	48,775
Veraval ..	6,105	3,608	3,91,342	1,74,767	82,559	56,497
Porbundar ..	196	..	3,04,426	1,88,347	2,55,836	2,09,920
Dwarka ..	..	..	12,69,878	12,50,392	20,31,773	1,53,417

The operations of *Ashok* and *Pratap* and *Taiyo Maru No.* 17 have furnished for the first time information on the distribution pattern of fish categories in the five regions, *viz.*, Bombay, Cambay, Veraval, Probundar and Dwarka. *Ghol* (*Pseudosciaena diacanthus*) was observed to occur in considerable quantities in all regions. *Dara* (*Polydactylus indicus*) and *Koth* (*Otolithoides brunneus*) were best obtained from Dwarka, *Karkara* (*Pomadasys hasta*) from the same region and Porbundar, *Wam* (*Muraenesox talabonoides*) from Cambay and Veraval and cat-fishes and elasmobranchs from Bombay and Cambay regions. In general, it was found that of the five regions Dwarka was the best for quality fishes (Jayaraman *et al.*, 1959).

The New India Fisheries Company at Bombay commenced commercial exploitation of the fishing grounds in this division with two pairs of bull-trawlers, *Arnala*-cum-*Paj* and *Satpati*-cum-*Pilotan* (250 H.P. each) which landed 26,304 metric tons of fish sold at a wholesale price of Rs. 1·6 crores during 1956–63. While *Ashok* and *Pratap* fished only in five regions from Bombay to Dwarka, these vessels covered also a sixth region, Kutch. For demersal fishes this region has proved to be the best of all regions so far fished on the continental shelf in the Indian territory

The areas covered, the annual landings, the annual average of regional catches and the catch per hour returns are shown in Fig. 14. The catches ranged from 2304,348 kg. in 1956 to 4,248,202 kg. in 1960, the fishing effort from 2850·97 hours in 1956 to 5453·30 hours in 1957 and the overall catch rates from 601·60 kg./hr. in 1957 to 899·66 kg./hr. in 1962. For the period 1957–62 when there was fishing in all the months, the annual average catch and catch rates were the highest in Kutch (1,359,499 kg. at 946·84 kg./hr.) with Porbundar (748,230 kg. at 700·32 kg./hr.), Cambay (731,165 kg. at 666·69 kg./hr.), Dwarka (416,034 kg. at 646·21 kg./hr.), Veraval (280,963 kg. at 603·78 kg./hr.) and Bombay (15,758 kg. at 353·96 kg./hr.) ranking next in the order of abundance. In general, the fishing effort expended by these vessels in the Bombay region was low, but in 1956 when this region was intensively fished the catch rate was high, being 717 kg./hr. To the annual average landings of all fish Kutch contributed to the extent of 38·28%, Dwarka 11·71%, Porbundar 21·07% Veraval 7·91%, Cambay 20·59% and Bombay 0·44%. Taking the landings from all regions together, the catch composition has shown *Ghol* 5·5%, *Koth* 1·36%, *Dhoma* 18·82%, *Dara* 2·53%, *Shende* 3·26%, *Karkara* 8·44%, *Wam* 12·72%, cat-fish 7·96%, *Kati* 3·33%, pomfrets 1·39%, prawns 0·66%, elasmobranchs 14·30% and miscellaneous fishes 20·18% (Fig. 15).

Particulars of the different categories of fishes, their regional abundance, annual average catch rates and the percentage proportion of each in the regional catches and in the total catches of all regions are given in Fig. 16 and Table IV.

Taking the catch per hour return as the criterion for judging the richness of the different regions in respect of the various fish categories, it is found that for (1) *Ghol* Kutch is the best region, followed by Porbundar and Dwarka; (2) *Koth* Dwarka followed by Kutch; (3) *Dhoma* Porbundar followed by Cambay; (4) *Dara* Dwarka followed by Kutch; (5) *Karkara* Kutch followed by Dwarka and Porbundar; (6) *Wam* Cambay followed by Veraval; (7) cat-fish Kutch followed by Porbundar; (8) prawns Cambay followed by Bombay; (9) elasmobranchs Kutch followed by Bombay and (10) miscellaneous fishes Kutch followed by Porbundar. (For further particulars Rao *et al.*, 1966, may be referred.)

The seasonal pattern of abundance of total fish and the individual categories of fishes as shown in Figs. 17 and 18 indicates that (1) the overall catch rates for all fishes are generally very high from January to March and October to December, (2) the catch rates for *Ghol, Dara, Koth, Karkara* and miscellaneous fishes also follow the same trend, they being high towards the beginning and the end of the calendar year, (3) the catch rates of cat-fishes and elasmobranchs are fairly high all round the year and (4) the yields and the yield rates of prawns and *Wam* are generally low at the beginning and the end of the year, but particularly high in the monsoon months. The operations proved the practicability of conducting trawl fishing throughout the year including in the months of July and August when the south-west monsoon is most severely felt in this region.

Taking all the regions together, the depth-wise distribution pattern (Fig. 19) indicated that the major portion of the catches (77·09%) came from the depth zones between 26 metres and 45 metres. Within this range the highest yield (32%) was from 36–40 metre depth zone. The fishing effort expended and the yields obtained in depth zones upto 25 metres and in those beyond 66 metres were negligible. The catch rates for all fish have been observed to be in the decreasing order from 16–20 metre depth zone to 46–50 metre depth zone; in the deeper zones from 51–55 metres onwards the catch rates were fairly high upto 66–70 metre depth zones. The overall catch rates for individual groups of fishes in different depth zones are shown in Fig. 19.

Of the areas fished by *Arnala*-cum-*Paj* and *Satpati*-cum-*Pilotan*, areas 43 and 48 in Bombay region, 10, 11, 17, 18 and 24 in Cambay region, 2 and 3 in Veraval region, A, D, E and H in Porbundar region, K, L, M and N in Dwarka region and P, Q, R, S, T, U, V, X and Y in Kutch region have given over 1,000 kg. of fish per hour of trawling for a pair of vessels in some months. Of these areas 11, 18, 48, A, N, R, S and T have yielded more than 1,500 kg./hr. but below 2,000 kg./hr. The highest area-wise catch rate of 2,914 kg./hr. was for an hour's trawling in area 2 of Veraval region in the month of January 1961.

TABLE IV

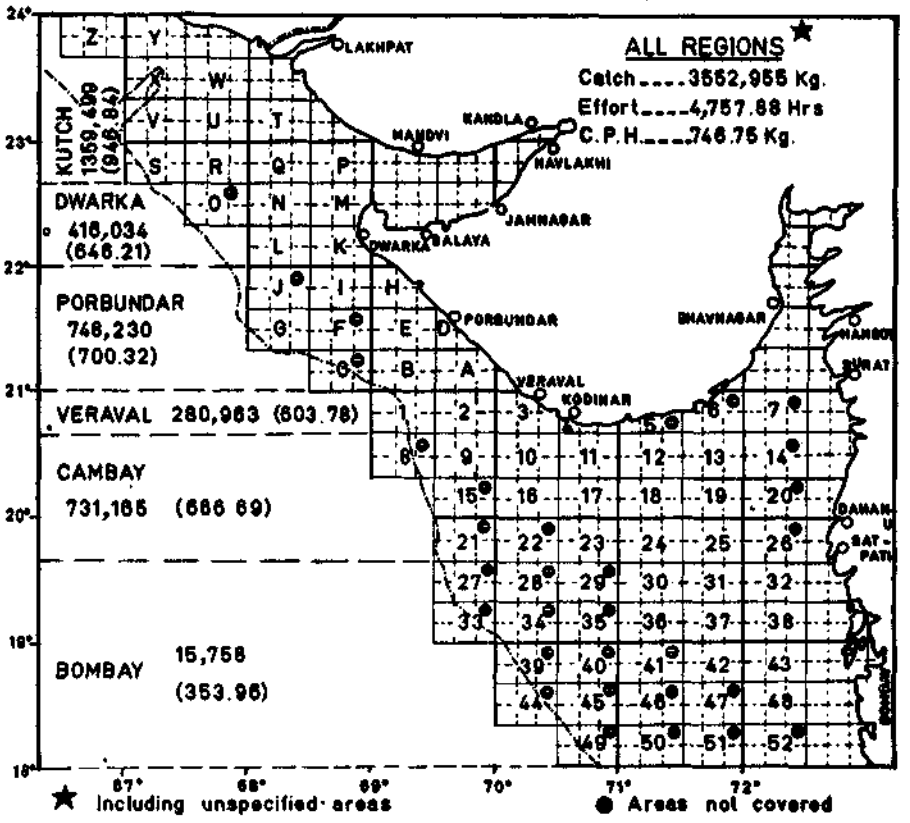
Regional catch trends of fishes (commercial bull-trawl operations, Bombay base, averages for 1957–62)

Name of the fish		Regions						
		Bombay	Cambay	Veraval	Porbundar	Dwarka	Kutch	All regions
Ghol								
*a**	..	380	14,347	9,838	53,452	24,724	92,676	195,417
*b**	..	8·53	13·08	21·14	550·03	38·40	64·55	41·10
*c**	..	2·41	1·96	3·50	7·14	5·94	6·82	5·50
*d**	..	0·19	7·34	5·03	27·36	12·65	47·43	100·00
Koth								
a	..	65	1,377	826	1,637	38,031	6,395	48,330
b	..	1·46	1·26	1·77	1·53	59·07	4·45	10·16
c	..	0·41	0·19	0·29	0·22	9·14	0·47	1·36
d	..	0·13	2·82	1·71	3·39	78·72	13·23	100·00
Dhoma								
a	..	3,351	190,818	69,990	224,043	37,646	142,233	668,081
b	..	75·27	173·99	150·40	209·70	58·47	99·06	140·51
c	..	21·27	26·10	24·91	29·94	9·05	10·46	18·81
d	..	0·50	28·56	10·48	33·54	5·63	21·29	100·00
Dara								
a	..	28	317	380	1,525	64,360	23,094	89,704
b	..	0·63	0·29	0·81	1·43	99·96	16·08	18·87
c	..	0·18	0·04	0·14	0·20	15·47	1·70	2·53
d	..	0·03	0·35	0·42	1·70	71·75	25·75	100·00
Karkara								
a	..	951	8,222	6,123	39,363	37,950	207,217	299,826
b	..	21·36	7·49	13·16	36·84	59·95	144·32	63·06
c	..	6·04	1·12	2·18	5·26	9·12	15·24	8·44
d	..	0·32	2·74	2·04	13·13	12·66	69·11	100·00
Wam								
a	..	3,324	237,372	62,443	41,460	26,607	64,564	435,770
b	..	74·66	216·44	134·19	38·80	41·33	44·97	91·65
c	..	21·09	32·46	22·22	5·54	6·40	4·75	12·27
d	..	0·76	54·47	14·33	9·51	6·11	14·82	100·00
Cat-fish								
a	..	1,806	34,299	18,180	77,895	30,169	120,445	282,794
b	..	40·57	31·27	39·07	72·91	46·86	83·89	39·46
c	..	11·46	4·69	6·47	10·41	7·25	8·86	7·96
d	..	0·64	12·13	6·43	27·54	10·67	42·59	100·00
Prawns								
a	..	336	11,078	2,685	4,351	1,321	3,707	23,478
b	..	7·55	10·10	5·77	4·07	2·05	2·58	4·94
c	..	2·13	1·52	0·96	0·58	0·32	0·27	0·66
d	..	1·43	47·19	11·43	18·53	5·63	15·79	100·00
Elasmobranchs								
a	..	2,050	136,043	44,495	80,969	53,510	191,132	508,199
b	..	46·05	124·05	95·62	75·78	83·13	133·12	106·88
c	..	13·01	18·61	15·84	10·83	12·86	14·06	14·31
d	..	0·40	26·77	8·76	15·93	10·53	37·61	100·00
Misc. fishes								
a	..	3,467	97,292	66,003	223,536	101,716	508,036	1000,050
b	..	77·87	88·71	141·84	209·22	157·99	353·82	210·33
c	..	22·00	13·31	23·49	29·88	24·45	37·37	28·16
d	..	0·35	9·73	6·60	22·35	10·17	50·80	100·00

* *a* = Average catch in kg.; *b* = Average catch per hour in kg.; *c* = Percentage of species in total catch; *d* = Percentage of species in total species.

DEMERSAL FISH DISTRIBUTION IN NORTH WESTERN DIVISION OF INDIA

1. Annual regional average catches (catch/hour) in Kg. based on commercial operations of bull trawlers of Bombay base for 1957-62



2. Landings by Bull Trawlers

ALL REGIONS

YEAR	CATCH (Kg.) (CATCH RATE)	EFFORT (Hrs.)	YEAR	CATCH (Kg.) (CATCH RATE)	EFFORT (Hrs.)
1956	2304,348 (808.27)	2850.97	1960	4248,202 (822.13)	5169.96
1957	3280,646 (601.60)	5453.30	1961	3938,547 (852.90)	4613.62
1958	3580,786 (707.23)	5063.08	1962	3549,540 (899.66)	3945.40
1959	2720,007 (632.27)	4301.95	1963	2682,033 (754.45)	3554.95

FIG. 14. Annual landings and regional catch trends of the commercial bull-trawlers of the N.I.F. Company Ltd., Bombay base, for the period 1956-63.

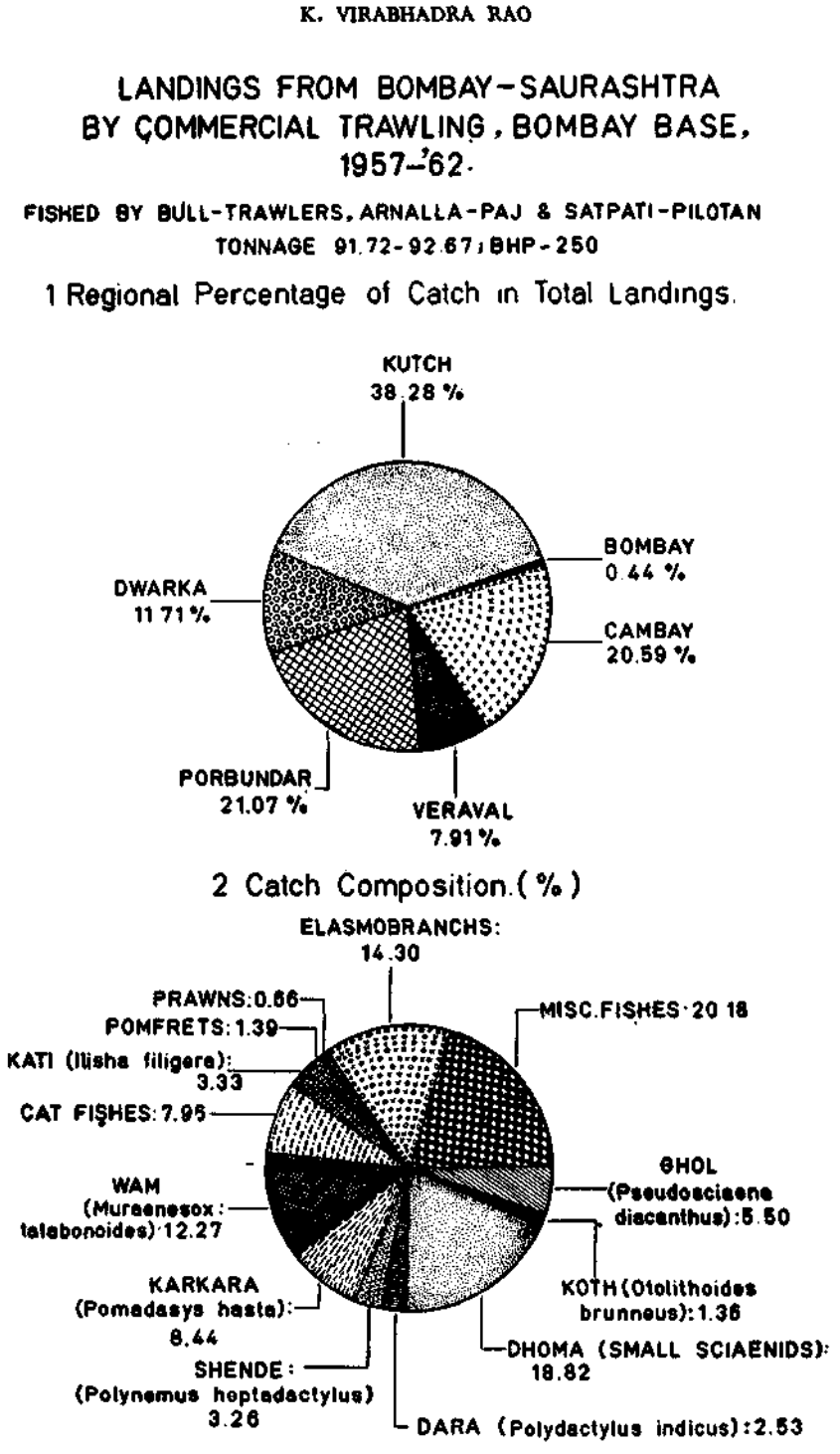


FIG. 15. Regional abundance of total fish catches and the species composition of the landings by the N.I.F. Company's bull-trawlers for the period 1957-62

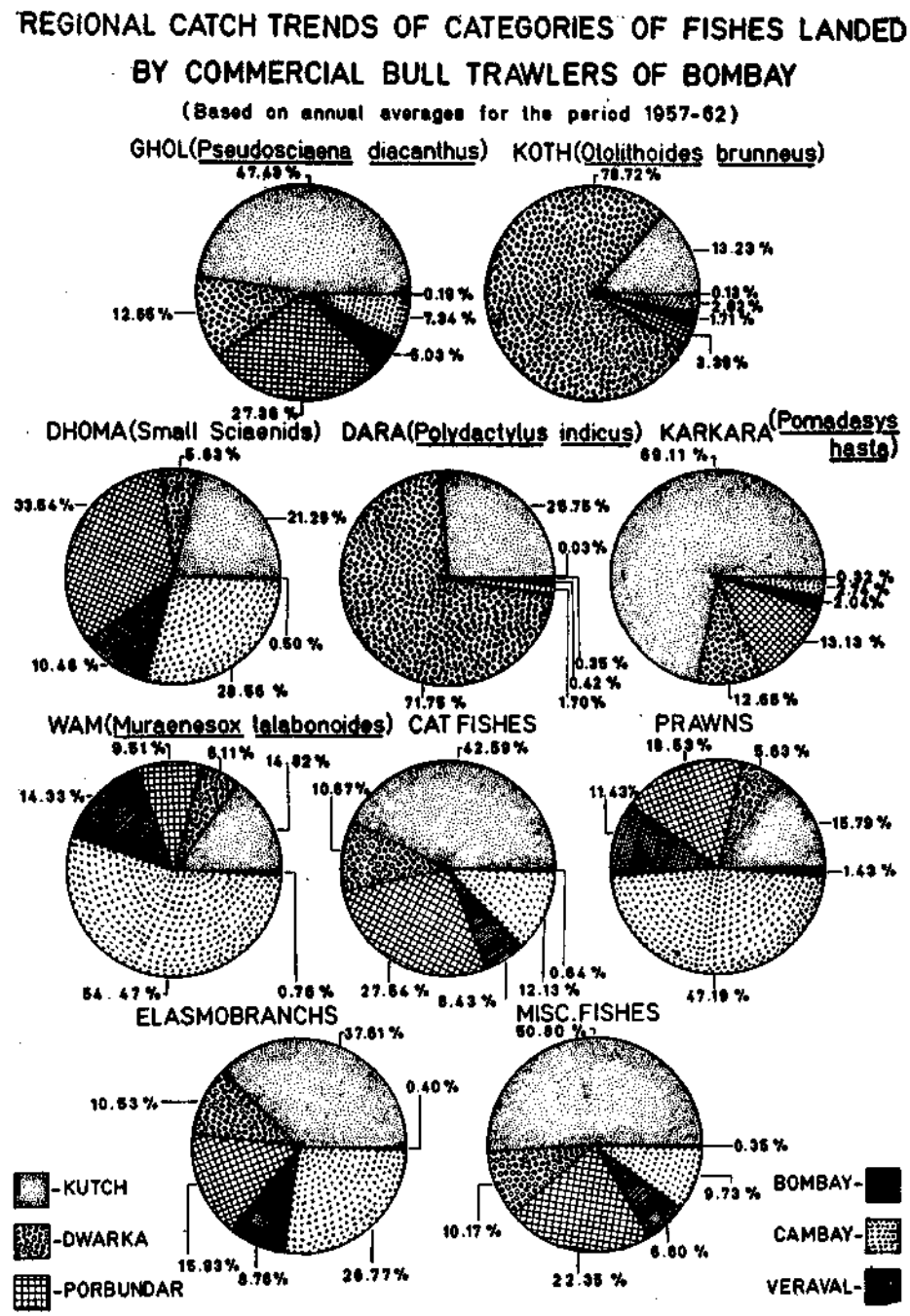


FIG. 16. Pattern of distribution of the categories of fishes landed by the N.I.F. vessels from different regions for the period 1957–62.

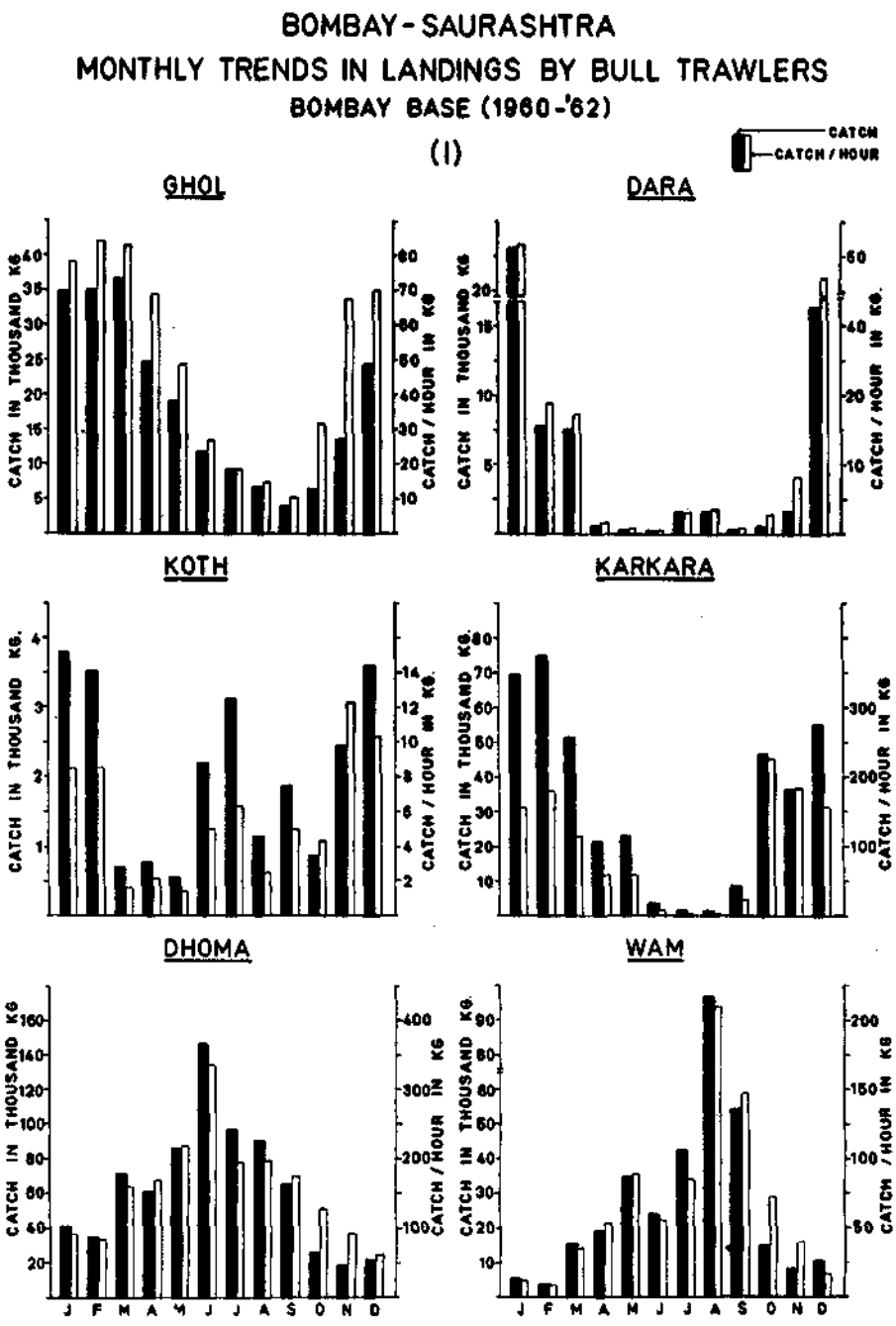


FIG. 17. Seasonal abundance of categories of fishes landed by bull-trawlers of the Bombay base for the period 1960–62.

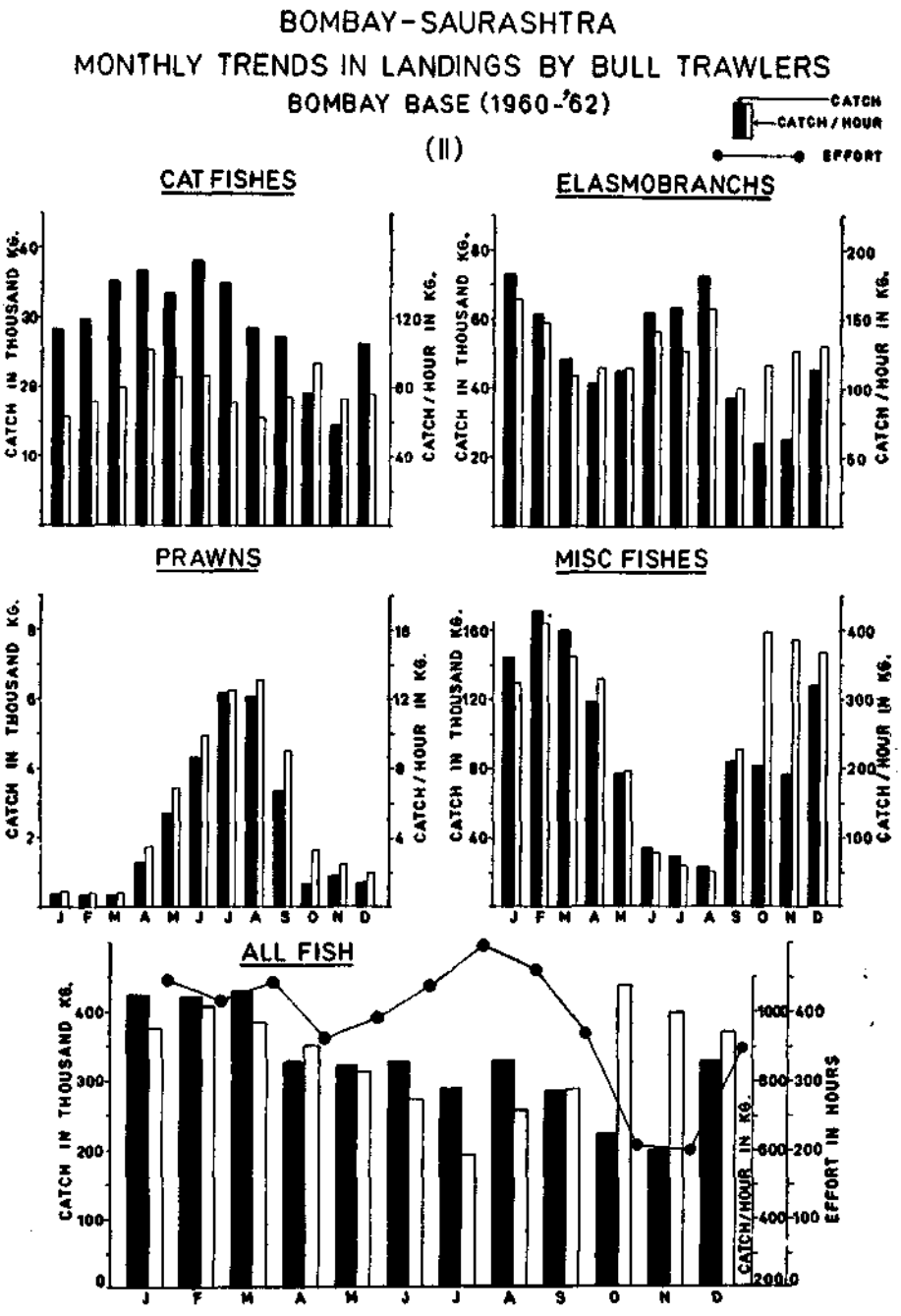
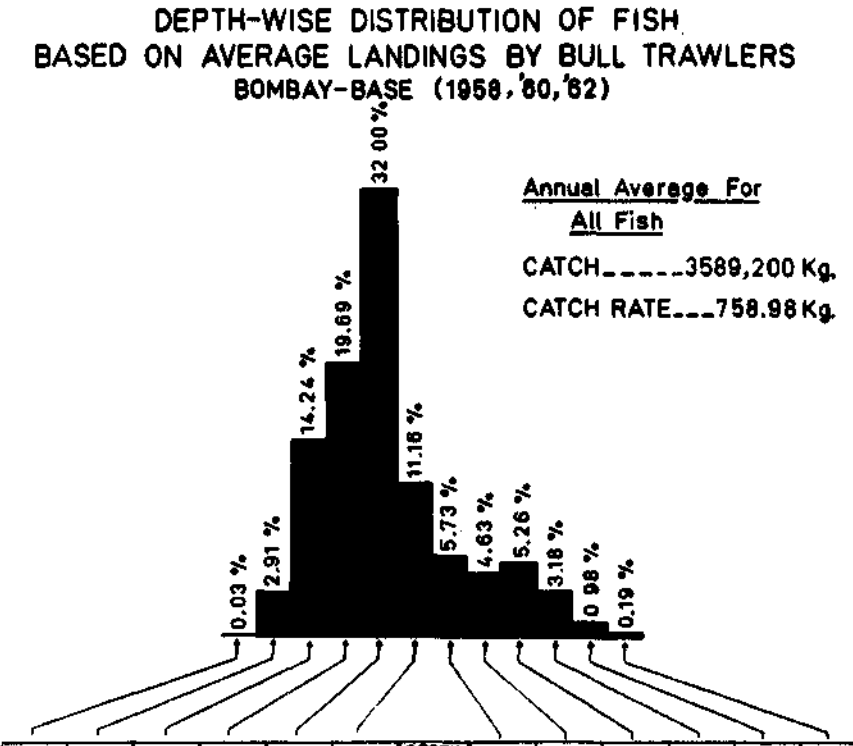


FIG. 18. Seasonal abundance of categories of fishes landed by bull-trawlers of the Bombay base for the period 1960–62



16-20	21-25	26-30	31-35	36-40	41-45	DEPTH IN Mts	46-50	51-55	56-60	61-65	66-70	71-75
CATCH/HOUR (Kg.)						FISHES	CATCH/HOUR (Kg.)					
34	54	56	50	66	35	GHOL	18	18	14	21	37	13
123	50	23	9	4	5	KOTH	3	3	1	1	1	-
16	75	83	116	162	25	DHONA	204	155	252	198	147	91
-	84	33	13	18	3	DARA	2	7	0.1	0.2	0.2	-
-	24	23	23	32	2	SHENDE	9	17	26	28	30	22
31	112	130	82	81	37	KAR-KARA	4	4	5	5	10	10
248	100	35	52	62	126	WAM	85	174	161	127	125	147
93	65	85	83	66	76	CAT FISHES	40	40	26	35	47	16
-	22	34	29	32	21	KATI	20	13	10	12	12	5
16	12	11	13	16	6	POM-FRETS	4	2	2	3	9	18
-	2	2	3	3	10	PRAWNS	9	8	8	7	5	2
448	119	107	104	118	125	ELASMO BRANCH	98	123	134	126	135	54
-	194	291	252	232	86	MISC. FISHES	29	43	36	56	94	47
1009	913	913	831	894	558	TOTAL	524	607	676	620	654	424

FIG. 19. Pattern of distribution of total fish and categories of fishes landed by bull-trawlers of Bombay base from different depth zones.

The Government of India vessels of the Bombay base fishing in this division in the period 1961–67 have confirmed some of the earlier findings and furnished additional information on the fishery resources in the trawling grounds. M.T. *Kalyani* III, IV and V (300 H.P. and 123·24 Gr. tons), M.F.V. *Meenabharati* (262 H.P. and 77·70 Gr. tons), M.F.V. *Jheenga* (153 H.P. and 48·67 Gr. tons), M.F.V. *Bumili* (135 H.P. and 34·53 Gr. tons), M.L. *Meera* (60 H.P. and 9·95 Gr. tons), M.L. *Sagarpravasi* (60 H.P. and 12·88 Gr. tons), M.V. *Sagarkumari* (42 H.P. and 11·24 Gr. tons), M.V. *Sagarkanti* (42 H.P. and 11·77 Gr. tons) and M.V. *Sagarvihari* (42 H.P. and 10·98 Gr. tons) had covered the areas extending over 25,100 nautical square miles on the continental shelf between latitudes 15° N to 23° 10′ N and longitudes 68° 10′ E to 73° 50′ E and obtained a total catch of 2,740,976 kg. of fish; the overall annual average catch, effort and catch rate being 391,568 kg, 1,896·09 hours and 206·5 kg./hr. respectively. Not more than six vessels were operating in any particular year (Figs. 20 and 21). The average annual catch rates were about 284 kg./hr. for vessels of 201-300 horse-power, 235 kg./hr. for vessels of 101 to 200 horse-power and 100 kg/hr. for vessels below 100 horse-power (Rao *et al.*, 1968).

When the catch data of the larger vessels for the five-year period 1963–67 were analysed and grouped under eight latitude zones at 1° intervals, it was noticed that there was a northward increase in the catch rates from 18° N latitude zone with 263·89 kg./hr. of fish to 22° N latitude zone with 346·62 kg./hr. of fish; south of 18° N latitude zone also an increase has been found in the catch rates of fish to 262·04 kg./hr. in 16° N latitude zone and 387·84 kg./hr. in the 15° N latitude zone.

High catch rates of *Ghol* and *Koth* were from 18° N to 22° N, of *Karkara* in 17° N and 18° N, of *Wam* from 19° N to 22° N, of prawns in 18° N and 19° N, of rays in 18° N and 20° N and of miscellaneous fishes in 15° N and 16° N latitude zones. *Dhoma* dominated the catches in all latitude zones, but its catch rates were the highest in 15° N latitude zone. Sharks and skates also were found abundant in all zones, with relatively higher yield rates from 16° N, 19° N, 20° N and 22° N latitude zones.

A study of the seasonal trends in the fish landings has shown that the catches are high in the first, second and fourth quarters and very poor in the third quarter. Generally, the yields are the highest in the fourth quarter, but in some years the catches of the first or the second quarter are higher than those in the fourth quarter. The fishery of *Ghol* has been found to be from October to June with peak catches in January–February and of *Koth* from November to February with peak catches in December. *Dhoma* are best obtained from October to December, *Karkara* from October to May and *Wam* from November to July. Cat-fishes are found abundant all round the year, but best obtained from November to February. Prawns showed generally two peaks, the first in April–May and the second in about October; miscellaneous fishes have been found to occur in particular abundance from October to April and the elasmobranchs in the first quarter (Rao *et al.*, 1968). In Fig. 22 the landings of total fish in each quarter and the percentage proportion of the categories of fishes in the quarterly landings are shown.

For the period 1961–65 the productive areas revealed by the exploratory fishing operations by the larger vessels of the Government of India Deep-Sea Fishing Station have been shown in Fig. 23. During the years 1966 and 1967, the sub-areas 18–72/5C, 5E, 6C, 6D, 19–72/1B and 20–70/6C had given at times over 1000 kg./hr.; areas 15–73/4E, 3D, 18–72/3E, 6B, 19–72/1D and 2A between 750 kg./hr. and 999 kg./hr.; areas 15–73/2D, 3C, 4C, 5C, 18–72/2D, 5B, 19–72/1C and 20–70/5C between 500 kg./hr. and 749 kg./hr.; areas 15–73/4D, 18–72/4D, 4E, 1E, 6E and 19–72/1E between 400 kg./hr. and 499 kg./hr.; areas 15–73/3E, 4B, 5D, 18–72/1F, 2E, 3D, 4C and 19–71/3F between 300 kg./hr. and 399 kg./hr. and the areas 15–73/2C and 16–73/1B between 200 kg./hr. and 299 kg./hr.

It may also be mentioned here that the Government of India Offshore Fishing Station at Veraval was functioning in the Third Five-Year Plan period till 1966 when the base was closed for want of suitable vessels. Three small vessels (42–60 H.P.) fished in major areas 20–69, 20–70, 21–69 and 21–70 during 1963–64, 1964–65 and 1965–66 with catches of 168,380 kg. at 179·20 kg./hr. of trawling, 171,780 kg at 187·71 kg./hr. and 137,087·5 kg. at 181·01 kg./hr. in the respective years. The catches consisted of small sciaenids, elasmobranchs, prawns, *Lactarius*, *Trichiurus* and miscellaneous fishes. In 1965–66 the prawn percentage was 4·60.

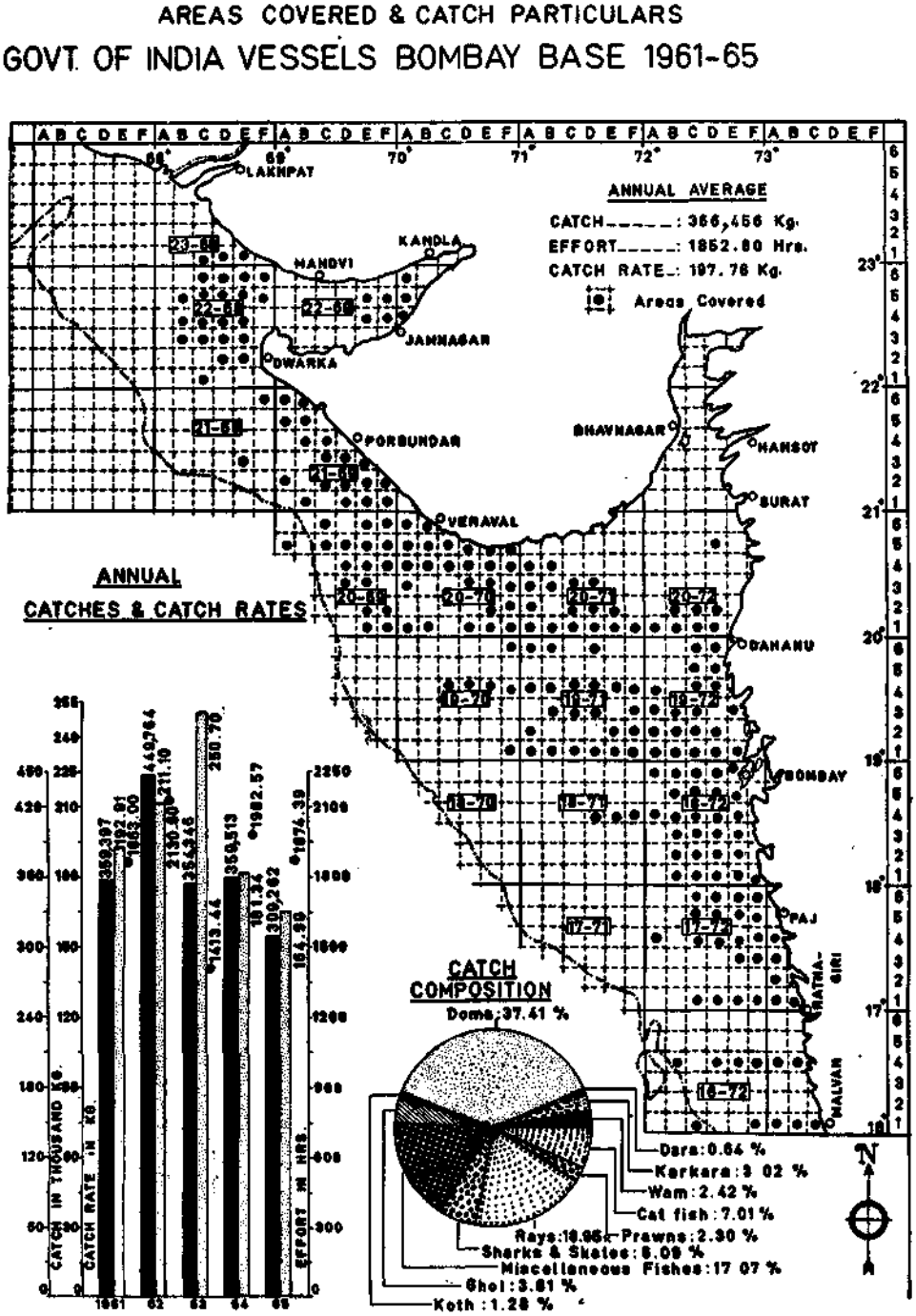
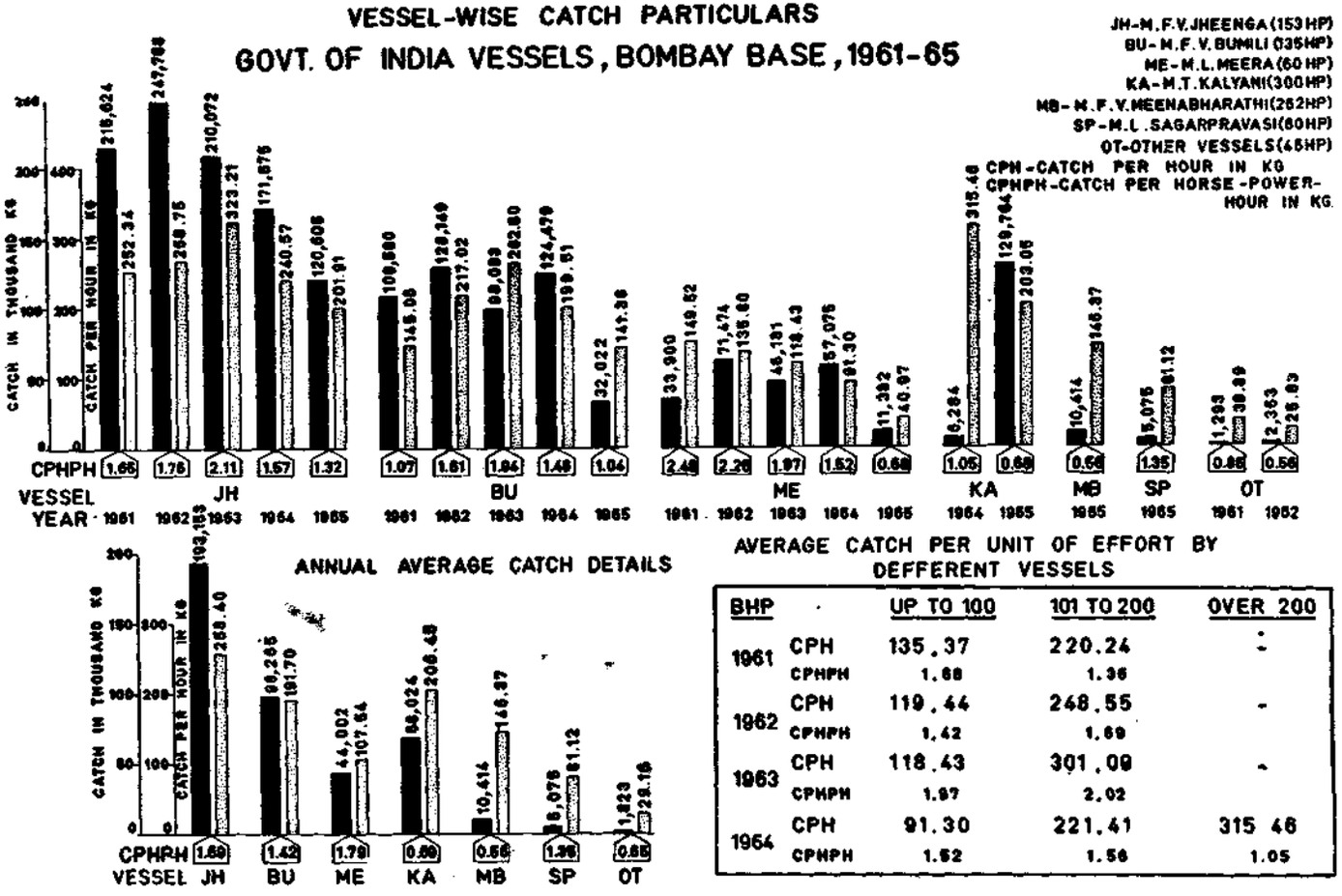


FIG. 20. Annual landings, catch composition and the areas covered in the operations by the Government of India vessels of Bombay base for the period 1961–65.



BHP		UP TO 100	101 TO 200	OVER 200
1961	CPH	135.37	220.24	-
	CPHPH	1.68	1.36	
1962	CPH	119.44	248.55	-
	CPHPH	1.42	1.69	
1963	CPH	118.43	301.09	-
	CPHPH	1.97	2.02	
1964	CPH	91.30	221.41	315 46
	CPHPH	1.52	1.56	1.05

FIG. 21. Vessel-wise catch details of the Government of India vessels of Bombay base for the period 1961-65.

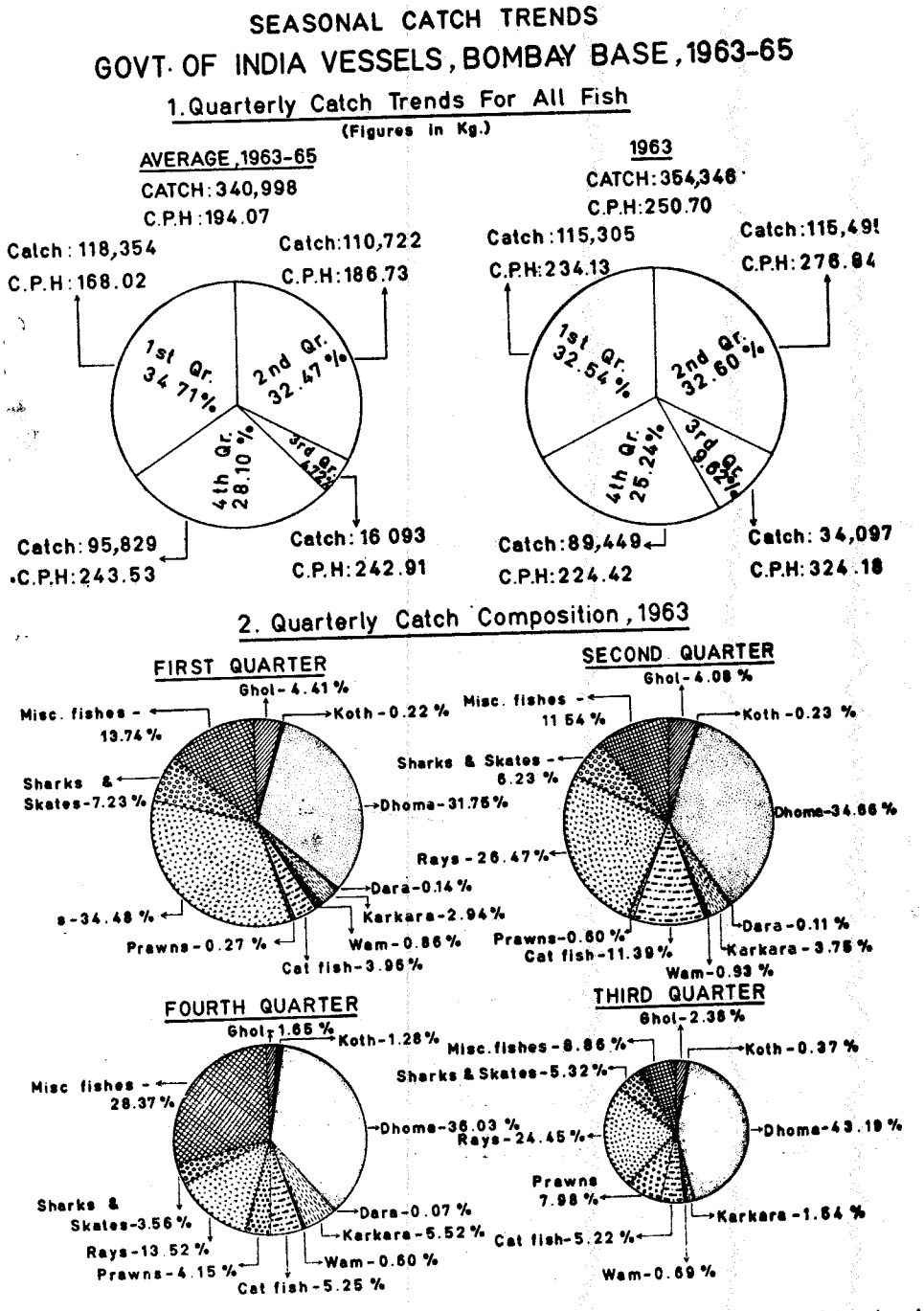


FIG. 22. Seasonal fluctuations in the catch trends by the Government of India vessels of Bombay base for the period 1963-65.

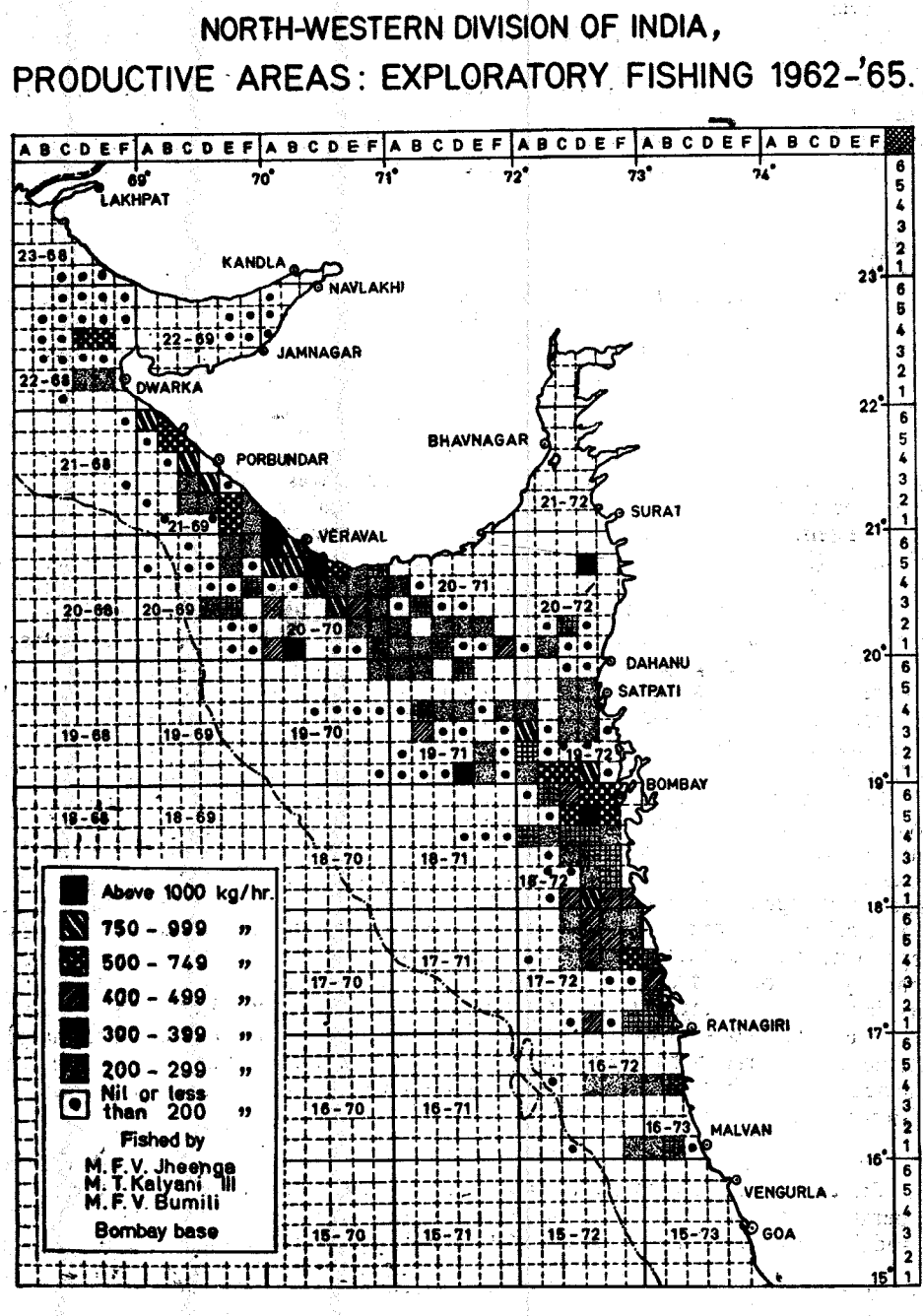


FIG. 23. Productive areas revealed by exploratory fishing operations by the Government of India vessels of Bombay base for the period 1962–65

In general it may be stated that in the North-Western Division the trawling grounds are extensive covering over 68,000 square nautical miles on the continental shelf. There is a preponderance of quality fishes like *Ghol*, *Karkara*, *Koth* and *Dara* which grow to fairly large size and also fair abundance of prawns in some regions. These, along with *Dhoma*, *Wam*, cat-fish, miscellaneous fishes and elasmobranchs give extremely high catch per hour returns. The yields are high all round the year, except in the monsoon months, when the fishing effort expended being poor, the catches are usually low but the catch rates are high. There are in addition excellent facilities for disposal of the catches as the Bombay City markets have an ever-increasing demand for all types of fresh fish.

2. *South-Western Division*

This division includes areas between latitudes 7° 30′ N and 15° N and longitudes 73° 40′ E to 77° 33′ E. In some of the earlier exploratory fishing operations a few good grounds were noted for demersal fishes. The existence of good fishing grounds in the "Wadge Bank" area off the Cape Comorin coast was known to the Indian fishermen of the Tinnevelly, Kanyakumari and Trivandrum Districts, who have been fishing in the area from time immemorial. The trawling surveys conducted by the Steam Trawlers *Violet* in 1907, *Lilla* in 1920–23 and *Nautilus* in 1924–30 indicated the possibilities of successful trawling in the "Wadge Bank" (Sivalingam and Medcof, 1957). During 1927-30 an intensive survey of the deep-sea fishing grounds was undertaken by S.T. *Lady Goschen* of the Government of Madras from Cape Comorin to Mangalore fishing up to about 100 fathoms. A few other vessels, *Bulbul*, *Tongkol*, *Raglan Castle* and *Aringa* (1928–48) and *Braconglen* (1950–) and *Maple Leaf* (1953–) from Ceylon were trawling in the "Wadge Bank". Other vessels, *viz.*, *Kanyakumari*, *Ashokkumari* and *Sagarkumari* of the West Coast Fisheries Company and *Chandrika* (1949–50) of the Department of Marine Biology and Fisheries of Travancore University were conducting trawl fishing and also mothership operations or Dory fishing by leading a number of smaller boats to the offshore fishing grounds for hook and line fishing, in which the species commonly obtained were *Epinephelus* spp., *Lutianus malabaricus*, *L. argentimaculatus*, *Carcharhinus limbatus*, etc. (Gopinath, 1954). In 1954–55 attempts were also made, with the active help of FAO experts, to evolve new designs in craft and gear. The Madras Fisheries Department thus succeeded in designing a surf landing mechanised boat, while on the west coast the possibility of using cotton flat trawl-nets and nylon bottom gill-nets was established over the trawl grounds between Kozhikode and Cannanore. The large schooners of the Indo-Norwegian Project surveyed, at about the same time, in the south-western region, almost the entire width of the continental shelf, experimenting with several types of fishing gear. The Government of India opened Offshore Fishing bases at Cochin in 1957 and at Mangalore in 1962. The Indo-Norwegian Project had intensified exploratory programmes at Cochin base and initiated intensive surveys of the inshore fishing grounds up to 20 fathom depth with medium vessels at a few other bases. Export trade in frozen and canned shrimp had very rapidly developed at Cochin and from the private sector there were substantial investments on trawlers for shrimp fishing. At present there are over 1,000 small trawlers engaged in shrimp fishing. In 1966 the Indo-Norwegian Project had obtained from Norway three large powerful vessels suitable for exploratory fishing in deeper waters beyond the continental shelf. In the following account particulars of fish and shrimp resources revealed by trawlers operating from a few bases in the division in recent years are given.

(*a*) *Karwar* (latitude 14° N and 15° N and longitude 73° 30′ E and 74° 30′ E).—The Indo-Norwegian Project vessels commenced exploratory fishing operations in September 1963. The areas of operation and the catch particulars of these vessels, *viz.*, *Karwar* 1 (90 H.P.), M_1/M_4 (48 H.P.) and *INP* 167 (24 H.P.) for the period 1963–66 are given in Fig. 24 and Table V.

In the 4-year period the effort expended ranged from 399 hours (1966–67) to 846 hours (1963–64). In the initial two years of operations the catch and the catch rates were high and were more or less proportionate to the effort expended. In the latter two years yield and the yield rates were very low. The percentage of prawns was fairly high in 1963–64, but there has been a decrease since the very next year. The catch rates of prawns also showed a gradual decline from 13·16 kg./hr. in the first year of operations to 0·46 kg./hr. in the fourth year.

TABLE V

Catch particulars of INP vessels of Karwar base 1963–66

Year	Effort in hours	Catch in kg. (c.p.h. kg).	Prawns in kg. (c.p.h. kg).	Percentage of prawns
1963–64	846·00	167,092 (197·51)	11,131 (13·16)	6·66
1964–65	749·00	167,103 (219·09)	3,290 (4·39)	2·00
1965–66	822·00	130,912 (159·26)	1,482 (1·80)	1·13
1966–67	399·00	47,386 (118·76)	184 (0·46)	0·39
Average	704·00	127,373 (180·93)	4,022 (5·71)	3·16

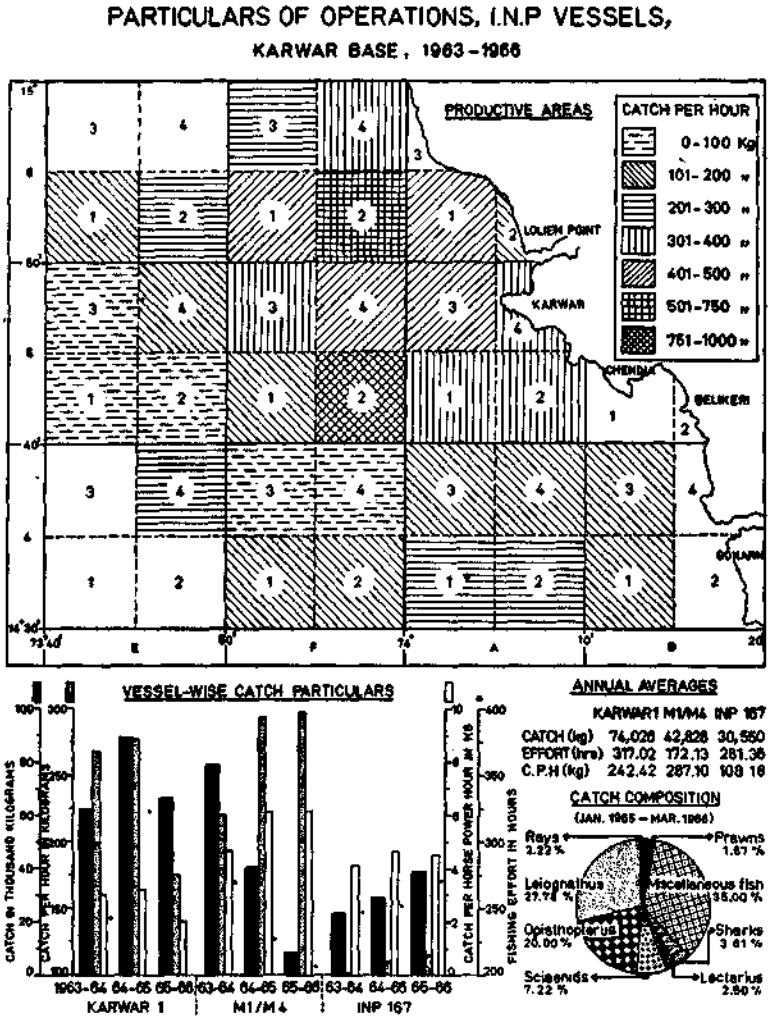


FIG. 24. Catch particulars, productive areas and catch composition of landings by the INP vessels of Karwar base.

In the year 1965–66 silver bellies, miscellaneous fishes and *Opisthopterus* formed the bulk of the catches to the extent of nearly 83% and the rest is made up of sciaenids, sharks, *Lactarius* rays and prawns in the descending order of abundance. The best of the fishing groudus is 14–73/5F2 where the catch rates were between 751 and 1,000 kg./hr. Extremely good catch rates between 501 and 750 kg./hr. were also obtained from 14–73/6F2. The rest of the areas in the descending order of catch rates can be seen from Fig. 24. In general it may be said that the productive areas with higher catch rates are restricted to a limited extent. The catches are composed of small and uneconomical varieties of fish and the prawn percentage is poor.

(*b*) *Mangalore* (latitude 12° 10′ N to 14° N and longitude 73° 30′ E to 75° E).—Three of the Government of India vessels, *viz.*, M.V. *Tarpon*, M.V. *Samudra* and M.V. *Sagarvihari* (all of 42 H.P.) were operating in this region. The overall catch rates obtained were over 200 kg./hr. during the years 1962–63 and 1963–64. The Offshore Fishing Station was closed down in 1965 for want of suitable vessels. Only two major squares were fished. 12–74/6E and 13–74/1E had given very high catch rates of over 750 kg./hr. for all fish. 12–74/6D also registered high catch rates between 501 and 750 kg./hr. The rest of the productive areas with the decreasing order of catch rates are shown in Fig. 25. Miscellaneous fishes comprised the catch to the extent of 66·8% and prawns 21·71%. Elasmobranchs, silver bellies, pomfrets, *Lactarius*, *Nemipterus* and ribbon-fish formed the rest of the catch in the decreasing order of abundance. It may be noted that the overall catch rate for prawn is very high, being 41·7 kg./hr.

The mechanised boats of the Fisheries Training Centre and of the Ex-trainees of the Fisheries Directorate of the Government of Mysore fishing off Mangalore and Malpe had landed in the period 1963–64 to 1967–68 an annual average of 3,624·99 metric tons of which prawns formed 23·52%. The catches by these vessels are mostly by trawling. The operations of other types of gear like the gill-nets are insignificant.

The fishable areas are very few because of the narrowness of the shelf. Inclement weather conditions of the south-west monsoon and periodical appearance of the sand bars in the coast hamper continuity of the fishing operations from this base. Nevertheless, this region has some very good shrimp grounds giving high catch rates.

(*c*) *Cannanore* (latitude 11° 20′ N to 12° 10′ N and longitude 74° 30′ E to 75° 40′ E).—The Indo-Norwegian Project medium vessels, *Ashtamudi*, *Norind* (48 H.P.) and M_1/M_4 were conducting exploratory fishing operations from this base during 1963–66. The vessels were fishing in the major areas 11–75 and 12–75 in depth range of 10–45 metres. The sub-area 11–75/5C had given the highest catch rate of 158 kg./hr. The catch particulars are given in Table VI.

TABLE VI

Catch particulars of INP vessels of Cannanore base for the period 1963–66

Year	Effort in hours	Catch in kg. (c.p.h. kg).	Prawns in kg. (c.p.h. kg).	Percentage of prawns
1963	318·10	84,295 (264·99)	48,151 (151·37)	57·12
1964	662·05	102,314 (154·54)	35,476 (53·58)	34·67
1965	527·25	56,591 (107·33)	8,594 (16·34)	15·18
1966	306·00	17,666 (57·73)	8,479 (27·71)	47·99
Average ..	453·35	65,216 (143·85)	25,175 (55·53)	38·60

As may be seen from Table VI the effort expended in 1963 and 1966 was below average. The annual overall catch rates for 1963 and 1964 were higher than the average for the 4-year period,

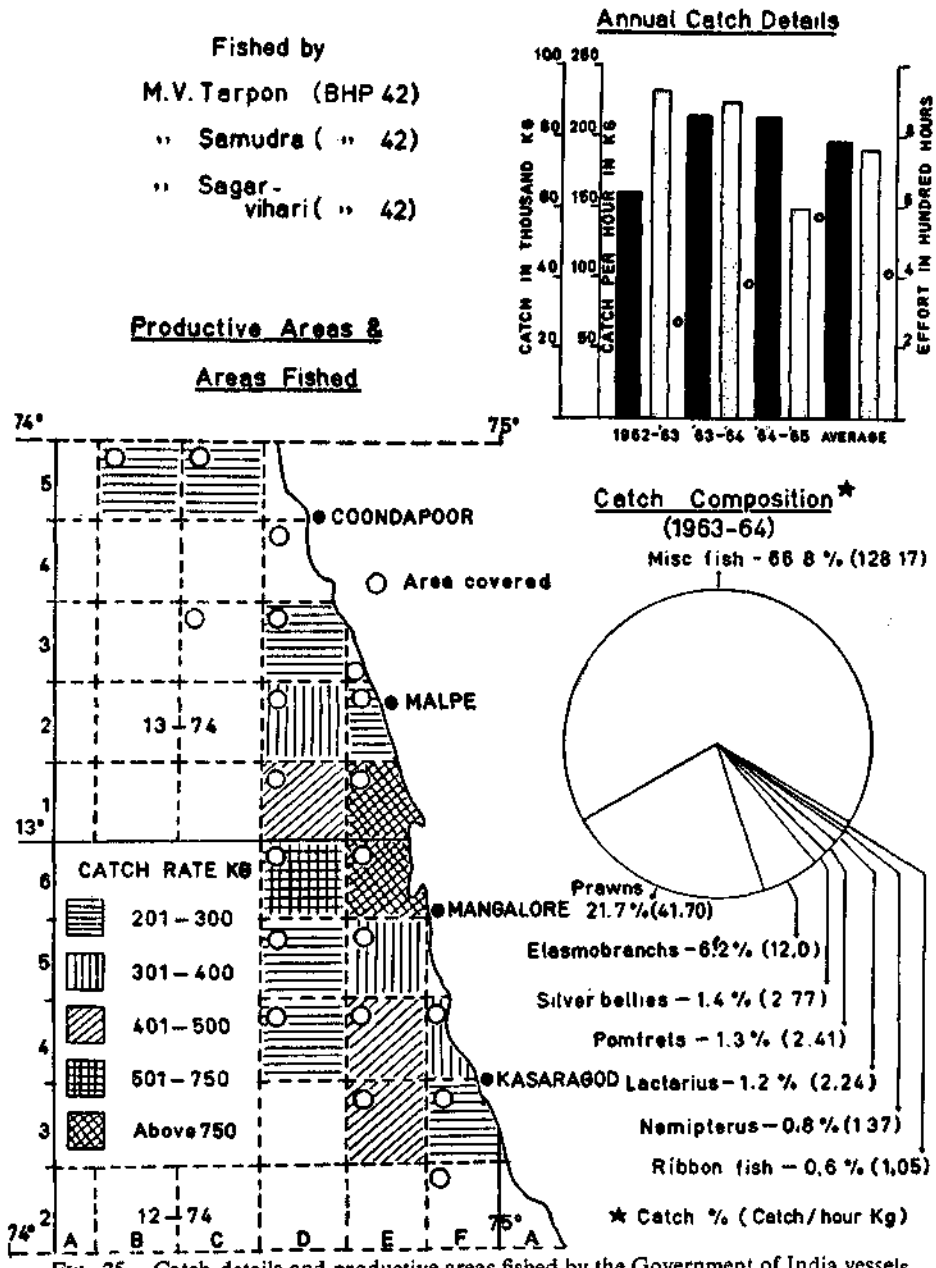


FIG. 25. Catch details and productive areas fished by the Government of India vessels of Mangalore base for the period 1962–65.

which shows that there was a decrease in abundance of stocks in the period from 1965 to 1966. The prawn catch rate was the highest in 1963 and lowest in 1965, with a slight improvement in 1966. The percentage proportion of prawns declined from 1963 to 1965 but it was fairly high in 1966.

The mechanised boats of the Fisheries Directorate of Kerala operating from Cannanore during 1966–67 and 1967–68 have landed an annual average of 1729·805 metric tons of all fishes of which prawns formed 59·40%. The catches in this region consisted chiefly of *Opisthopterus tardoore*, *Lactarius*, *Leiognathus*, *Johnius*, *Parastromateus*, *Cynoglossus*, *Metapenaeus dobsoni*, *M. affinis* and *Parapenaeopsis stylifera*.

(*d*) *Cochin* (latitudes 7° 30′ N to 11° 20′ N and longitudes 74° 50′ E to 78° E).—The Government of India Offshore Fishing Station which was opened in 1957 started bull-trawling operations with M.T. *Ashok* and M.T. *Pratap* which covered, during that year and the next, areas from Cannanore to the Wadge Bank. The areas fall under three regions, *viz.*, the northern region, where 56·97 fishing hours were expended at a catch rate of 1,076·40 kg/hr., the central region, fished for 859·09 hours at 856·20 kg./hr. and the southern region, for 18·08 hours at 429·20 kg./hr. The prawn yields were either nil or of a very low order only. The central region was found to be slightly better for quality fishes than others, with the miscellaneous small fish (55·40%), *Pomadasys* spp. (5·60%), *Drepane* (1·70%) and prawns (1·40%) together forming a high proportion. In the subsequent years a number of other vessels of the Government of India, *viz.*, M.V. *Tarpon*, M.V. *Samudra*, M.V. *Durga*, M.V. *Flying Fish* (56 H.P. each), M.V. *Gudjon* (215 H.P.) and M.F.V. *Bangada* (215 H.P.) started fishing in this region. It is worthwhile noting that off Cochin in 1957–58, when *Ashok* and *Pratap* were bull-trawling the catch rate obtained was 1184·26 kg./hr. and in 1958–59 by the same gear 1015·13 kg./hr. but in 1959–60 when *Pratap* otter-trawled the same grounds the catch rate was as low as 153·67 kg./hr.

The catch particulars obtained by the Government of India vessels of Cochin base for 1961-65 are shown in Fig. 26. During 1961–65 period the vessels covered areas off Calicut, Ponnani, Cochin, Alleppey, Quilon and Trivandrum. The sub-areas fished fall under the major areas 11–75, 10–75, 10–76, 9–75, 9–76 and 8–76. The overall catch composition had shown that nearly one half of the total catch was constituted by miscellaneous small fish; prawns amounted to 20·90%; among the rest *Nemipterus* and elasmobranchs formed good proportion; *Lactarius* and cat-fishes were obtained in small quantities only. Vessel-wise catch data for the period 1961-62 to 1965–66 are shown in Fig. 27. The relative fishing performance of categories of Government of India fishing vessels based on horse power is shown in Fig. 28. Figure 29 shows the productive areas for ground fish in this region. In 10–74/4E, 4F (off Ponnani) and 9–75/5F (off Cochin) the catch rates were over 200 kg/hr. The density of prawns based on the catch per hour returns is shown in Fig. 30. The yields were relatively higher from 9–75/5F and 9–76/5B, where the catch rates were over 40 kg./hr. The depth-wise abundance of fish and prawns are also shown in Fig. 30. The percentage proportion of prawn in 0–9 m. to 20–24 m. depth range was fairly high and in 15–19 m. depth the prawn yields alone amounted to more than 40% of the total catch. These vessels during the years 1966 and 1967 landed total catches of 175,265·5 kg. at 89·48 kg./hr. and 144,643 kg. at 73·78 kg./hr respectively.

The catch particulars of the medium trawlers of the Indo-Norwegian Project for the period 1963–64 to 1967–68, operating from Cochin base are shown in Table VII.

There has been a decline in the catch rates for prawns during 1964–65 and 1965–66, but subsequently there was some improvement. The total catch was the highest in 1967–68 in the 5-year period and the catch rate of prawns was nearly as high in that year as in the year 1963–64. The catch particulars of INP larger vessels and the Cochin Company vessels operating from Cochin in recent years are also given in Tables VIII and IX.

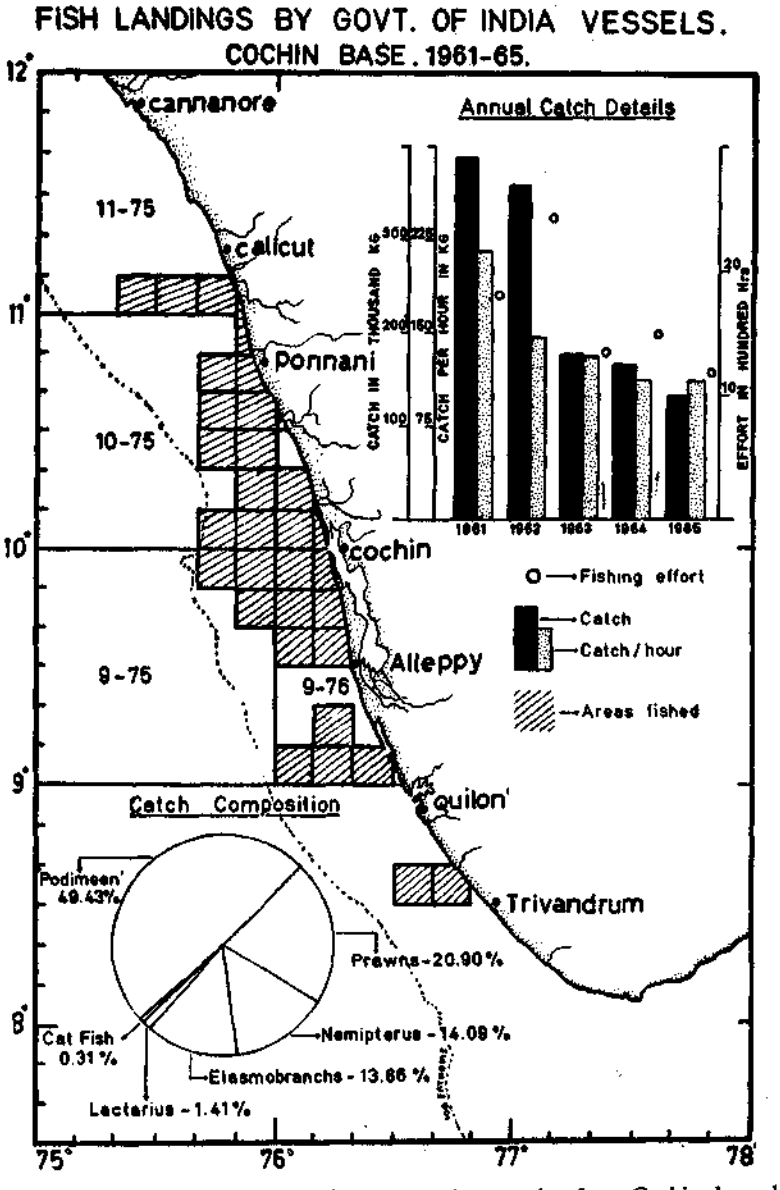


FIG. 26. Catch particulars of the Government of India vessels operating from Cochin base during 1961–65.

The Cochin Company vessels have shown more or less steady catches for prawns from 1964–65 (18·38 kg./hr.) to 1967–68 (23·12 kg./hr.). The percentage proportion of prawns in the catches by these vessels has been more or less on the increase from year to year, the reason for this being that these vessels were fishing in areas fairly well known for shrimps. The INP larger vessels *viz.*, *Klaus Sunnana* (220 H.P.), *Velameen* and *Tuna* (480 H.P. each) which started fishing towards the end of 1966 have since been obtaining extremely high catch rates. These, along with the research vessels *Kalava* (120 H.P.) and *Varuna* (400 H.P.), have discovered the occurrence of some deep-sea prawns as *Parapandalus*, *Heterocarpus*, *Aristeus*, *Plesionika*, etc., in grounds beyond the continental shelf as stated earlier.

TABLE VII

Catch particulars of INP medium vessels of Cochin base for the period 1963–68

Year	Effort in hours	Catch in kg. (c.p.h. kg.)	Prawns in kg. (c.p.h. kg.)	Percentage of prawns
1963–64	865·00	98,272 (113·61)	20,323 (24·49)	20·68
1964–65	208·08	24,944 (119·87)	3,546 (17·04)	14·21
1965–66	279·32	29,621 (106·05)	3,901 (13·96)	13·17
1966–67	1,802·19	100,511 (55·77)	25,730 (14·28)	25·59
1967–68	4,491·81	229,800 (51·16)	103,334 (23·00)	44·96
Average ..	1,529·28	96,630 (63·18)	31,367 (20·51)	32·46

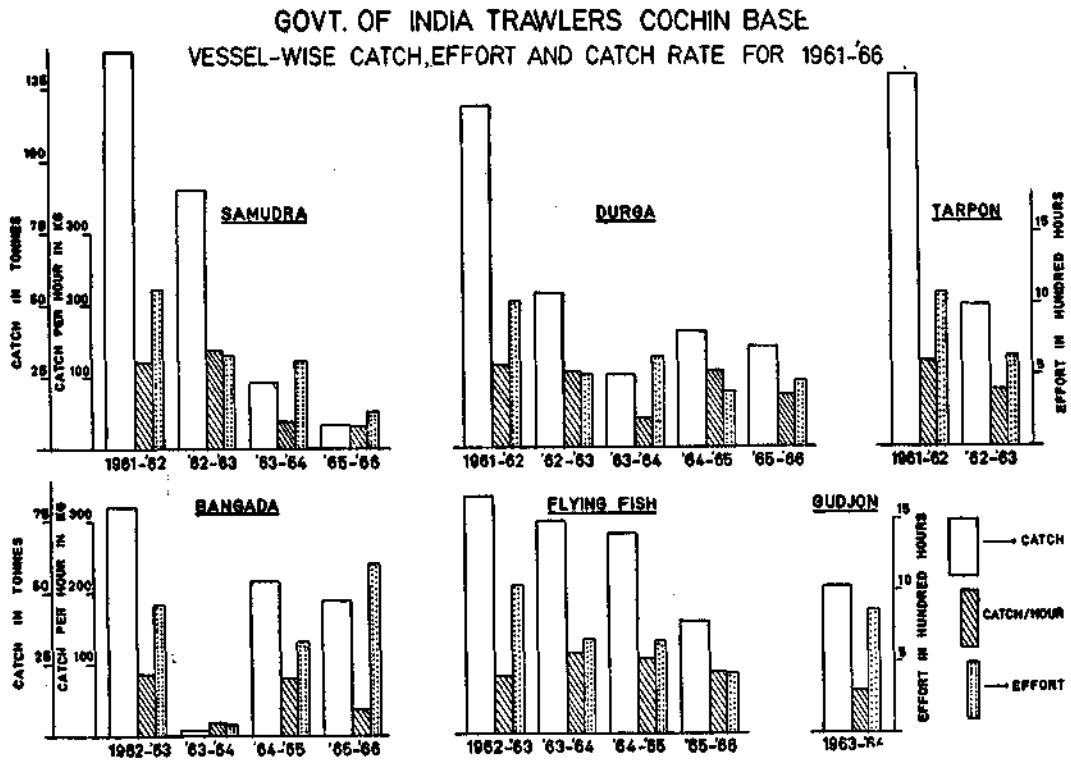


FIG. 27. Vessel-wise catch trends in the operations by the Government of India vessels of Cochin base for the period 1961–66.

The Government of India vessels M.T. *Pratap*, M.T. *Kalyani IV & V* from Cochin base in the Arabian Sea up to Minicoy were operating tuna long lines from 31–3–1964 to 11–2–1965. In 52 days of operations during 82 days of absence from port for 5,151 baskets, the catch by weight composition obtained was 70% sharks, 14·7% tuna, 13·2% of spearfish and 2·1% of other fishes. The yields were rather low and discouraging.

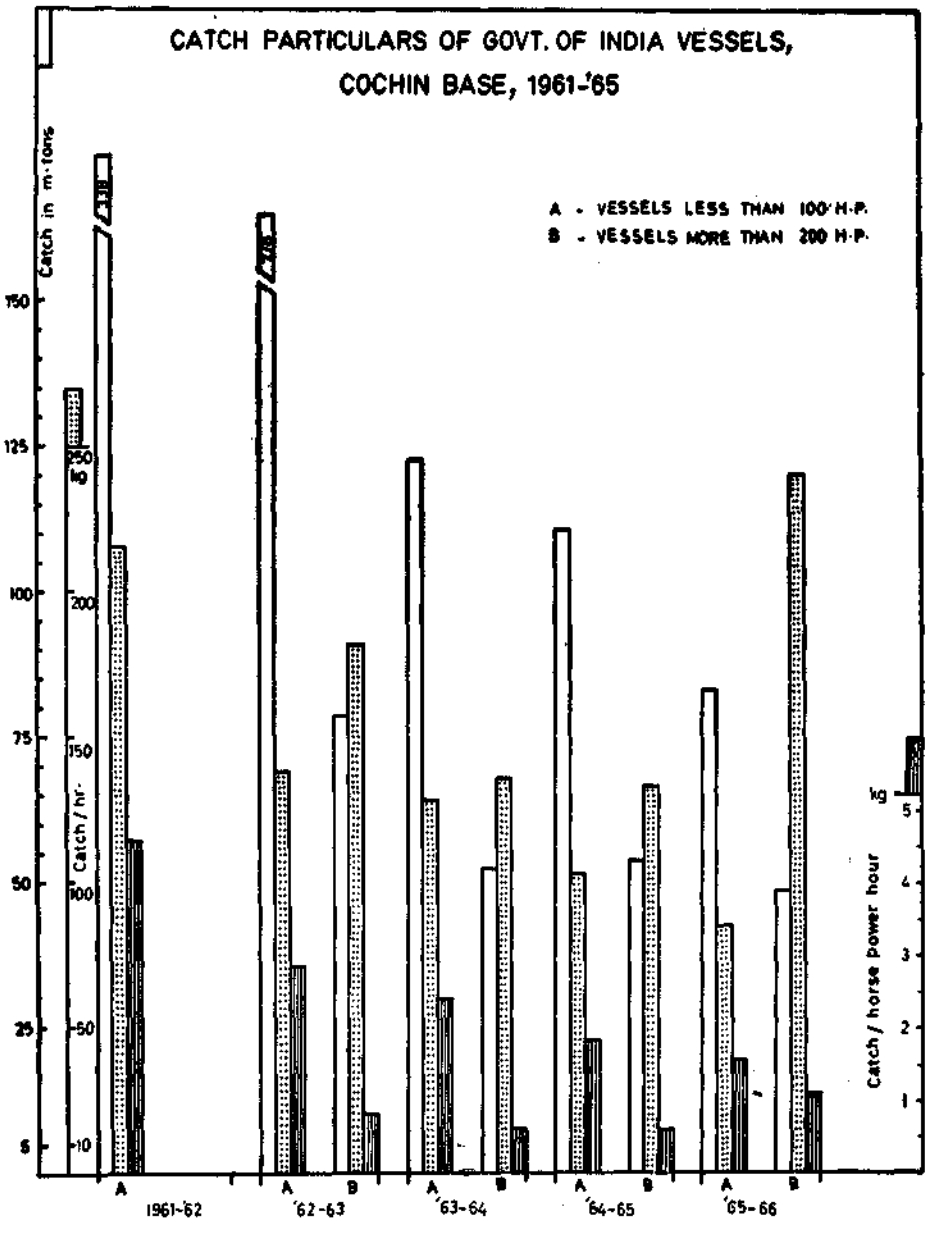


FIG. 28. Fishing performance of the Government of India trawlers of varied specifications at Cochin base during the years 1961-65.

Taking the South-Western Division as a whole, it may be stated that the narrowness of its shelf restricts trawling operations to a much limited extent as compared with the North-Western Division. That this region is better than any other region for shrimp trawling has been proved by the fact that all the chief shrimp fishing and processing industries are located around Cochin and efforts are constantly made to step up production to meet the needs of the ever-increasing export trade. There is the possibility of the deeper regions of the shelf and depths beyond the continental shelf

TABLE VIII

Catch particulars of INP larger vessels of Cochin base during the period 1966-68

Year	Effort in hours	Catch in kg. (c.p.h. kg.)	Prawns in kg. (c.p.h. kg.)	Percentage of prawns
1966-67	650·06	72,999 (112·29)	19,992 (30·75)	27·38
1967-68	1,218·81	324,306·5(266·08)	41,526·5(34·07)	12·80
Average ..	934·43	198,653 (212·59)	30,759(32·92)	15·48

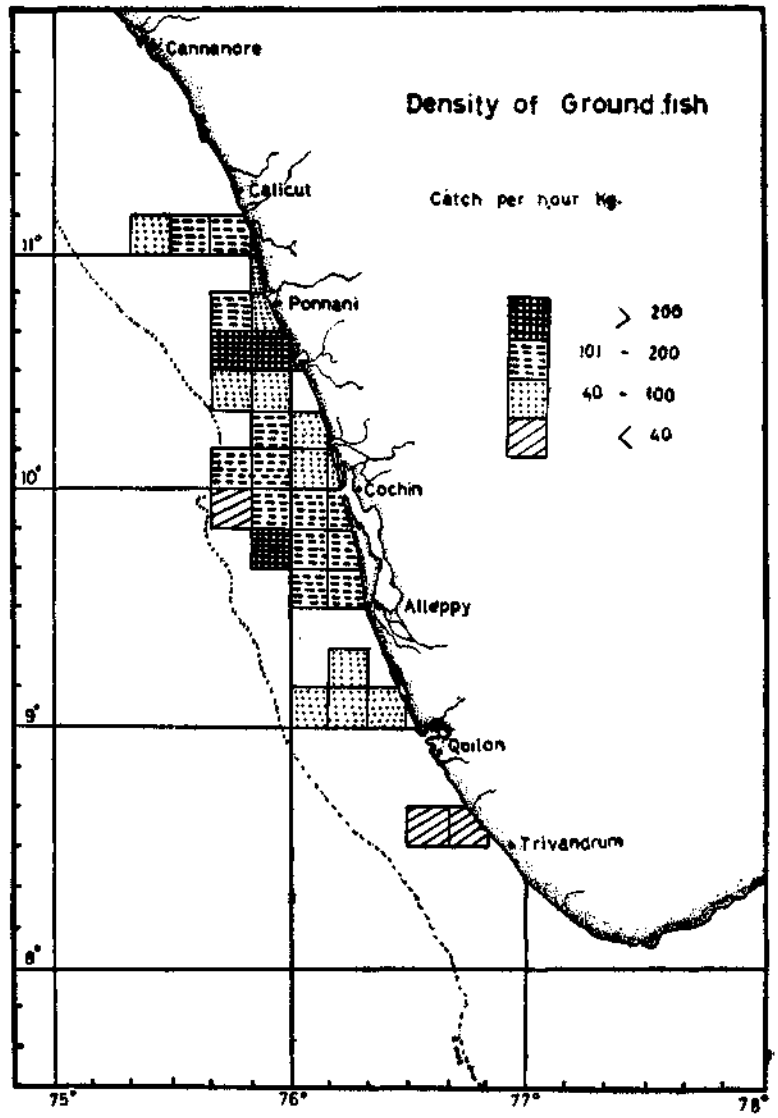


FIG. 29. Density of ground fish revealed by exploratory fishing operations of the Government of India vessels of Cochin base for the period December 1963 to June 1966.

being exploited for shrimp resources in the very near future. The ground fish catch rates are sometimes very high, particularly in the region between Quilon and Alleppey, but they are mostly the elasmobranchs, *Nemipterus* and other small varieties of miscellaneous fish the market value of which is too negligible for commercial trawling. Purse-seining for mackerel and oil sardines is bound to come into operation in regions where they are abundant to supplement the landings by indigenous craft and gear. The prospect for development of the oceanic fisheries is bright, but the fishing techniques need improvement.

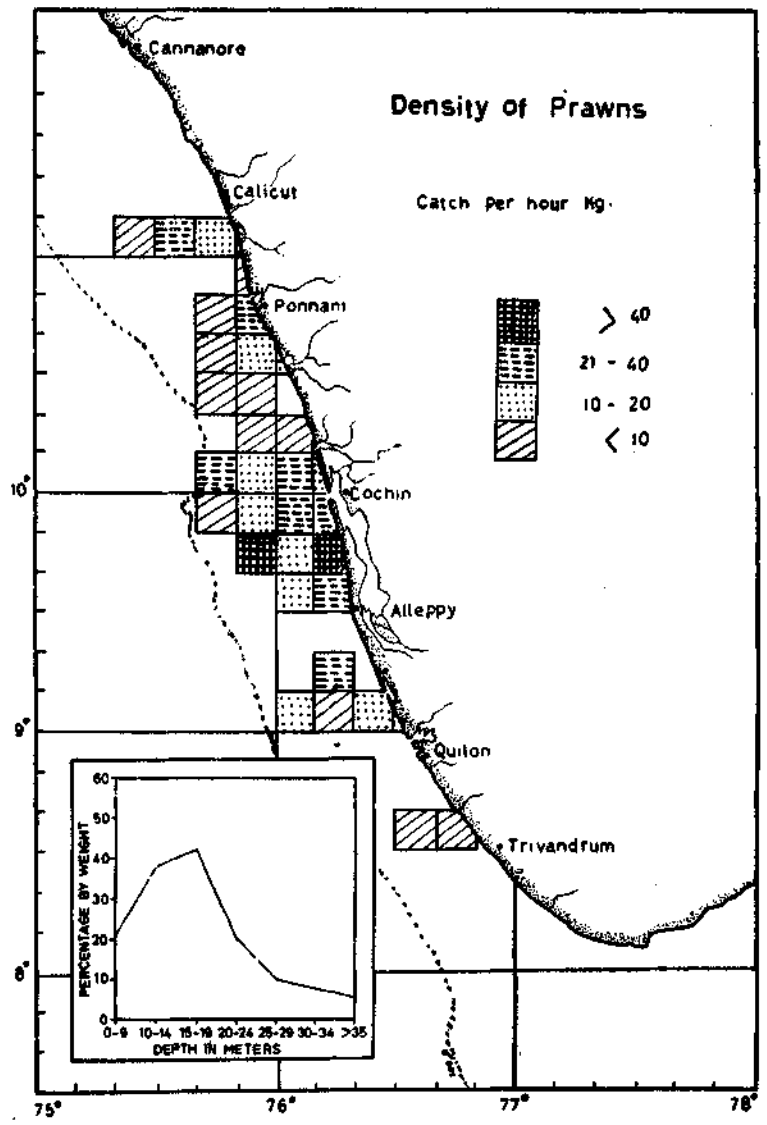


FIG. 30. Density of prawns in different areas and different depth zones revealed by exploratory fishing operations of the Government of India vessels of Cochin base for the period December 1963 to June 1966.

TABLE IX

Catch particulars of Cochin Company vessels of Cochin base for the period 1964–68

Year	Effort in hours	Catch in kg. (c.p.h. kg.)	Prawns in kg. (c.p.h. kg.)	Percentage of prawns
1964–65	768	154,044 (200·58)	14,111·5 (18·38)	9·16
1965–66	2,666	197,714 (74·16)	55,168 (20·69)	27·90
1966–67	3,578	242,657 (67·82)	88,856·5 (24·83)	36·62
1967–68	2,561	129,634 (50·62)	59,207 (23·12)	45·67
Average ..	2,393	181,012 (75·64)	54,366 (22·72)	30·03

3. *South-Eastern Division*

As a result of the earlier operations in the South-Eastern Division the suitability of the "Wadge Bank" off Cape Comorin, already mentioned, and the "Pedro Bank", a shallow plateau across the mouth of the Palk Strait and extending up to Nagapattinam and having an approximate area of 1,000 square nautical miles for trawling purposes was established. Although covered with heavy growths of sponges and gorgonoids, this Bank formed the traditional fishing ground of the Indian fishermen of the Tanjore coast and offered good trawling grounds in certain regions. The initial surveys of this Bank revealed a fairly high fisheries potential. The Government of Madras with the help of a motor launch *Sea Scout* initiated some surveys in 1922 but the results were poor, as the vessel was unsuitable for the purpose. During 1927–30 the Department of Fisheries of Madras with a steam trawler *Lady Goschen* conducted surveys and revealed the existence of fairly good trawling grounds off Point Calimere, Nagapattinam, Tranquebar, Porto Novo, Cuddalore, Pondicherry and Sadras. As more attention was paid to the surveys, the feasibility of commercial trawling on these grounds was not studied in any detail. However, some important findings revealed then were the existence of a shark fishing ground off Point Calimere, lobster ground from there up to Cuddalore, perch grounds up to Pondicherry and horse mackerel grounds from Pondicherry to Madras. Sharks were repeatedly sought after using improved types of chain-hooks because of the high demand for liver oil for medicinal purposes. Systematic exploration of the offshore fishing grounds was commenced by the Government of India Offshore Fishing Station at Tuticorin and the Indo-Norwegian Project at Mandapam in recent years, the particulars of which are detailed below:

(*a*) *Tuticorin* (*latitude* 8° *N to* 12° 10′ *N and longitudes* 77° *E and* 81° *E*).—The Government of India Offshore Fishing Station was opened in 1959 and since then several vessels were engaged in the exploratory fishing operations using trawl-nets, gill-nets and hooks and lines. The Cape Comorin region and the Pondicherry region were poorly fished. Much of the fishing by the vessels of this base was confined to one major area 8–78 (Fig. 32). The names of the fishing vessels and the catch particulars for the period 1961–65 are given in Fig. 31. In 1966 only one vessel M.V. *Sagarsundari* (42 H.P.) was trawling the grounds near Tuticorin and obtained a catch of 168,846 kg. of fish at 234·27 kg./hr. and in 1967 three vessels M.V. *Sagarsundari*, M.F.V. *Jheenga* and M.F.V. *Meenabharathi* were trawling for a total catch of 240,853 kg. at 169·00 kg./hr.

In the 1961–65 period, the annual average catch by the gill-nets was 17,095 kg. of fish at 48·70 kg./set. The catch comprised mostly of elasmobranchs, miscellaneous fishes and a small amount of perches and by hooks and lines 1,564 kg. of fish at 24·27 kg./100 hooks; the catch was elasmobranchs and miscellaneous fishes. The annual average for trawl catch in the said period was 92,867 kg. of fish at a catch rate of 106·13 kg./hr. The catch consisted chiefly of sciaenids, silver bellies, elasmobranchs, miscellaneous fishes, perches, prawns and polynemids (Fig. 32). The prawn landings in

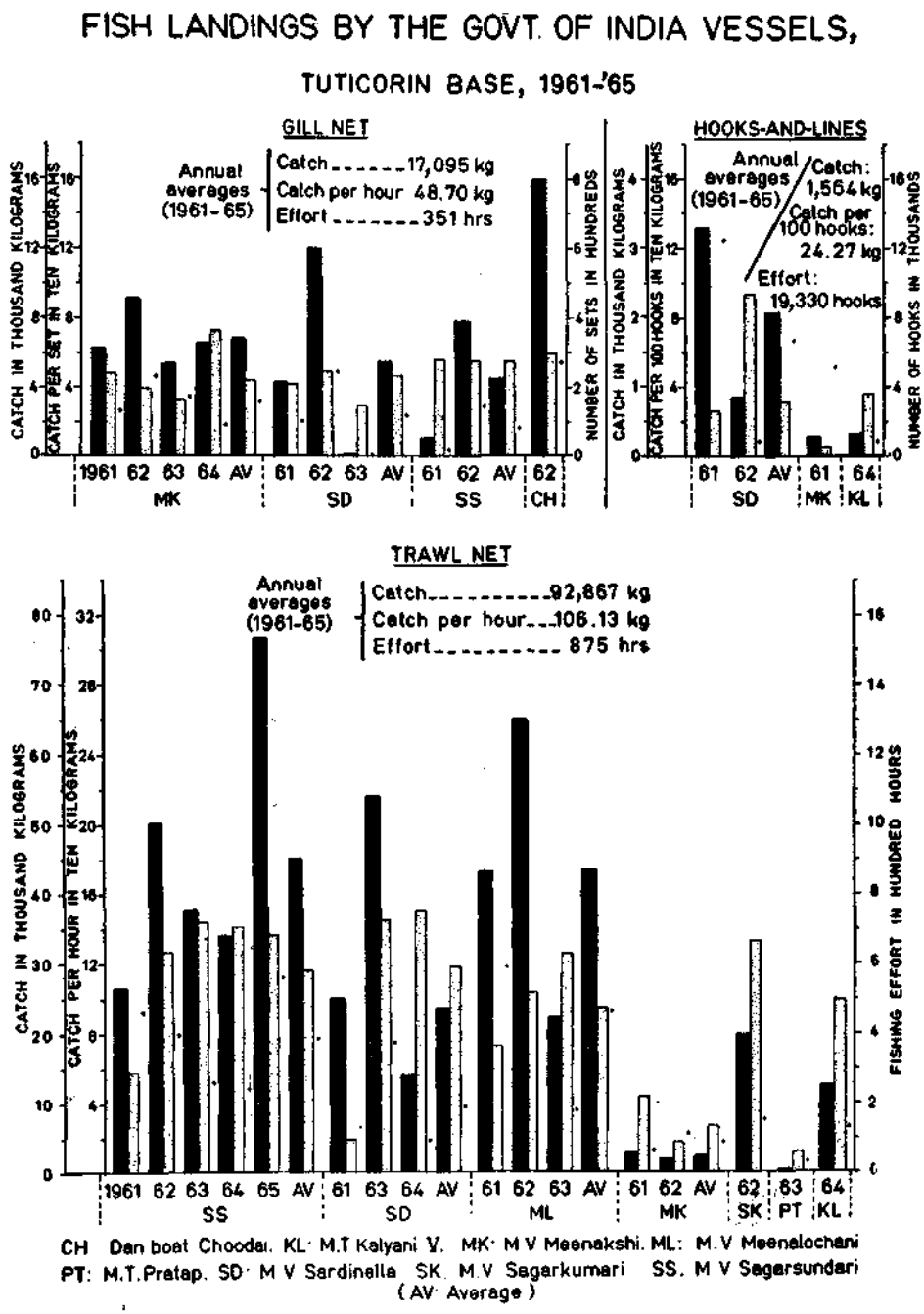


FIG. 31. Catch particulars of the Government of India vessels of Tuticorin base for 1961-65.

AREAS FISHED AND CATCH PARTICULARS

GOVT. OF INDIA VESSELS, TUTICORIN BASE, 1961-'65

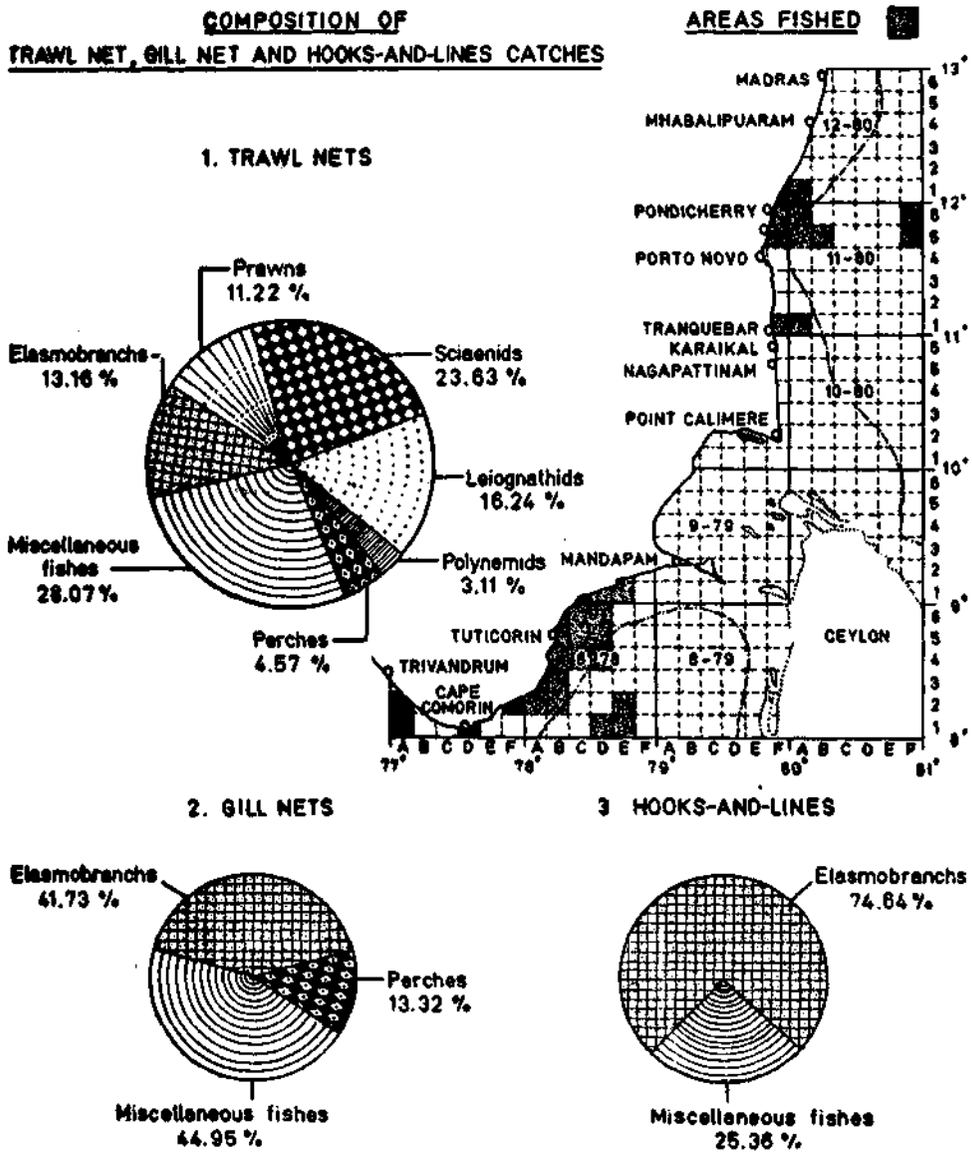


FIG. 32. Areas covered and the catch composition by different types of gear operated by the Government of India vessels of Tuticorin base for 1961–65.

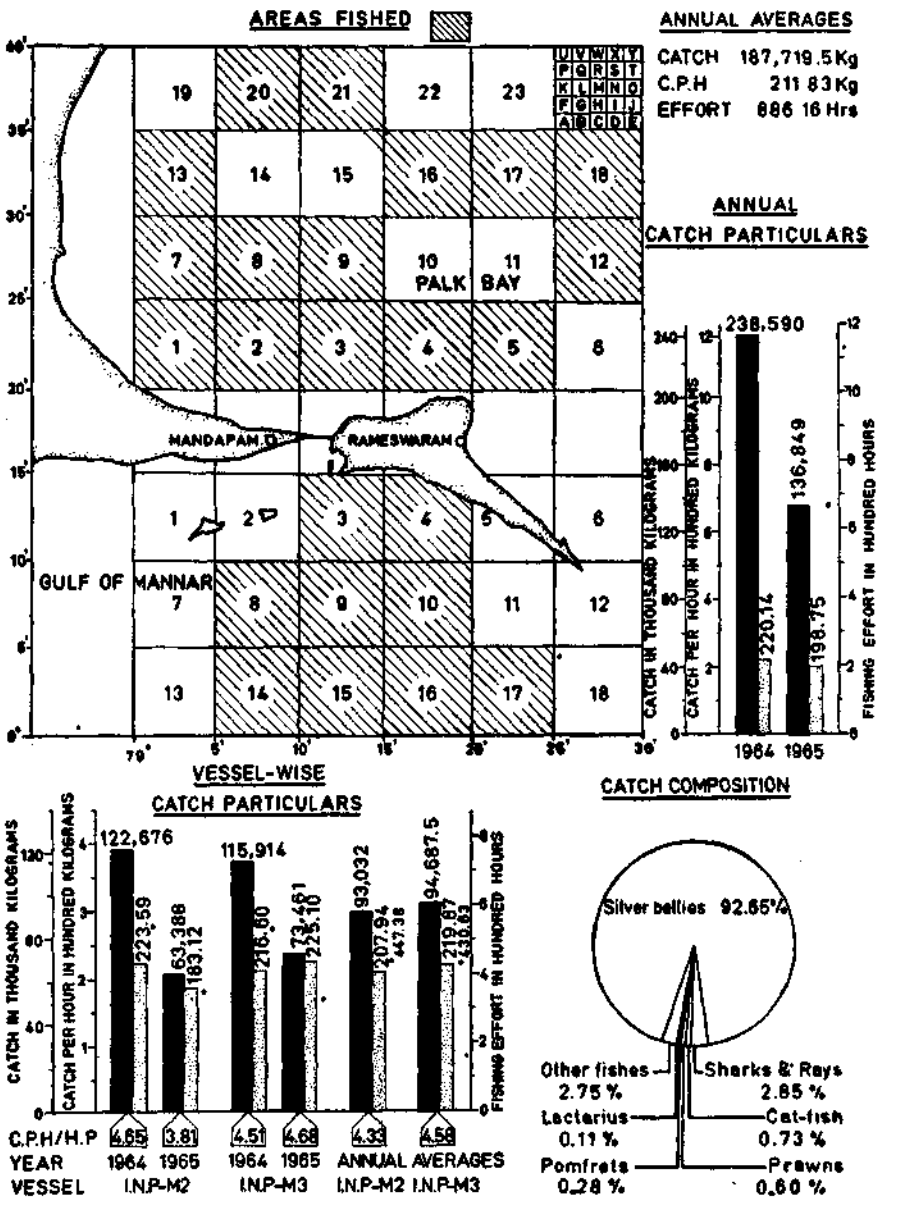
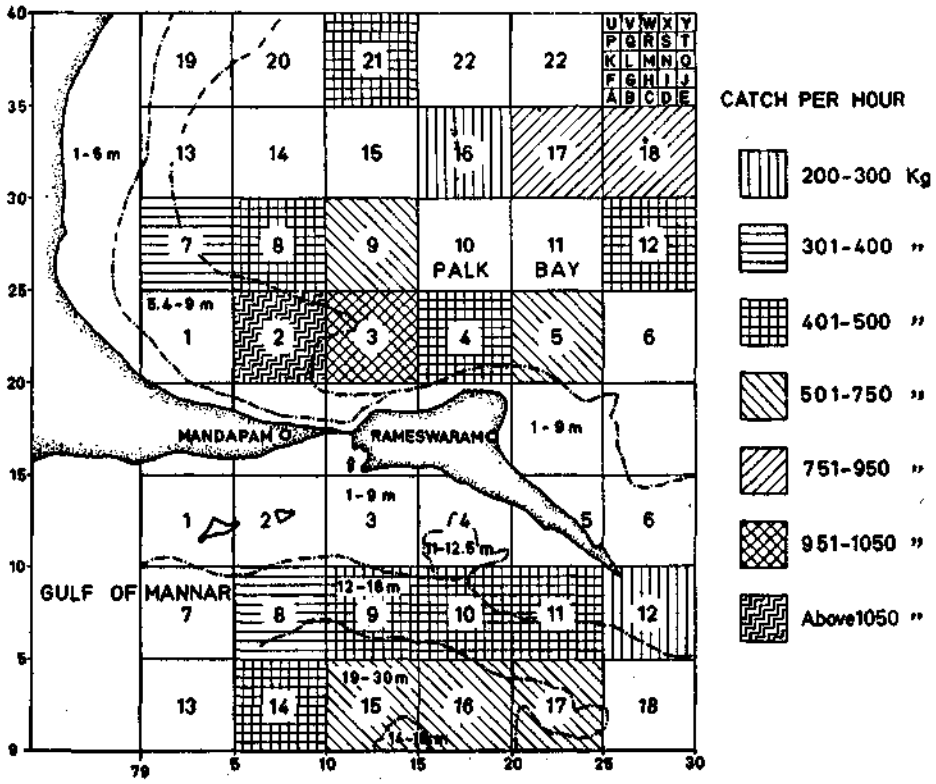


FIG. 33. Catch particulars of the INP vessels fishing from Mandapam base during the period 1964 and 1965.

PRODUCTIVE AREAS & DEPTH-WISE CATCH COMPOSITION

INDO-NORWEGIAN PROJECT VESSELS, MANDAPAM BASE, 1964 & 1965

PRODUCTIVE AREAS



CATCH COMPOSITION

	PALK BAY		GULF OF MANNAR
	5.4-10 m	11-14.5 m	12-18 m & 19-30 m
Silver bellies	83.56 %	94.27 %	90.81 %
Cat-fish	8.34 "	1.72 "	0.18 "
Lactarius.....	0.17 "	0.02 "	2.11 "
Sharks & Rays	4.24 "	2.24 "	0.31 "
Prawns..... ...	0.45 "	0.03 "	1.31 "
Pomfrets	....	....	1.91 "
Other fishes.....	3.30 "	2.04 "	3.34 "

FIG. 34. Productive areas and catch composition in different depth zones in Palk Bay and Gulf of Mannar fished by INP vessels during 1964 and 1965.

this region are generally not steady althougn in some years the catches are appreciably high (Rao and Dorairaj, 1968).

(*b*) *Mandapam* (latitude 9° N to 9° N 40′ N and longitudes 79° E to 79° 30′ E) The Indo-Norwegian project opened the fishing base at Mandapam in 1964 and commenced fishing operations with the help of a few medium vessels of 48 H.P. in the Gulf of Mannar and Palk Bay. The areas covered and the catch particulars obtained are shown in Fig 33. The annual average catches and catch rates for the two-year period 1964-65 were high being 187,719·5 kg. of fish at a catch rate of 211,83 kg./hr. In 1966 the catch and catch rates were 123,723 kg. and 202·25 kg./hr. In 1967 when the vessels were operating only in the first quarter the catch and catch rates were 10,102 kg. and 138·38 kg./hr. respectively. Taking the Palk Bay and Gulf of Mannar regions together, the catch composition showed 92·65% of silver bellies. The quality fishes and prawns formed a negligible proportion. Cat-fishes and elasmobranchs formed a slightly higher proportion in the landings from Palk Bay than from Gulf of Mannar. The silver bellies were a little less and the cat-fishes, *Lactarius*, elasmobranchs, prawns and other fishes were slightly more in 4·5 m to 10 m depth zone than in the deeper zones of 11 m to 14·5 m in the Palk Bay. The areas yielding high catch rates from Palk Bay and Gulf of Mannar are shown in Fig. 34.

4. *North-Eastern Division*

Exploratory fishing in the Bay of Bengal was commenced as early as 1908 by a British steam trawler *Golden Crown* of the Government of Bengal in the northern reaches of the Bay, in depths from 10 to 100 fathoms, revealing the possibilities of initiating commercial trawling. In 1950 the West Bengal Government procured two Danish trawlers *Baruna* and *Sagarika* which started systematic surveys of the fishing grounds using different types of gear. The results being encouraging, three more vessels, the Japanese trawlers, were added in 1955 and the fishing fleet was renamed as *Kalyani I to V*. These vessels in the period from 1951–60 landed a total quantity of 3,726·06 metric tons of fish. The very first year of their operation gave extremely high catch being 603·5 metric tons for a pair of vessels. Some important fishing grounds have been located off Western Channel, Eastern Channel, Sand Heads, Tiger Point, Baitarani River mouth, Debi and Prachi River mouths, Black Pagoda, Puri coast, Chilka Lake and Gopalpur. It has also been found that each of these fishing grounds is dominated by different types of fishes. In general, the sciaenids formed the bulk of the catches; *Kurtus indicus*, leiognathids and clupeoids ranked next. Grounds off Black Pagoda, Debi and Prachi River mouths and Western Channel were found to give better yields than others. The winter months, December to February, yielded very high catches. In 1960 a very productive ground "Swatch of no grounds" was explored by *Kalyani V* between latitudes 20° 13′N and 21° 14·4′N and longitudes 89° 16·4′ E and 89° 17·6′ E, at 20 to 70 fathom depth. This ground has a preponderance of quality fishes as *Lutjanus*, *Parastromateus*, *Pomadasys*, *Lactarius*, etc. Although very useful surveys were conducted, the Fisheries Directorate of West Bengal incurred rather heavy expenses on exploratory fishing operations owing to which the base was closed down in 1962 and the vessels were transferred to the Government of India Deep-Sea Fishing Station at Bombay.

The Government of India Offshore Fishing Station at Visakhapatnam came into operation during the Second Five-Year Plan period (1959) and has been conducting intensive exploratory surveys on the continental shelf between the river mouths of Godavari and Mahanadi on the Andhra and Orissa coasts (latitudes 16° 40′ N to 21° N and longitudes 82° 30′ E to 88° 50′ E). The reports of the FAO experts who had occasion to study the different aspects of the early work of this station are available in FAO/UN 1961, FAO/UN 1962 and Poliakov 1961.

The Government of India fishing vessels, *viz*., M.T. *Ashok* (240 H.P.), M.V. *Gudjon* (215 H.P.), M.F.V. *Champa* (135 H.P.), M.V. *Seahorse* (56 H.P.), and M.V. *Sagarkumari* (42 H.P.) were conducting trawling operations in this region. Currently M.T. *Ashok* and M.F.V. *Champa* alone are fishing. During 1959–60 a total of 131,170 kg. of fish at a catch rate of 89·8 kg./hr. were landed. The grounds between Visakhapatnam and Bimlipatnam were fished more intensively than others.

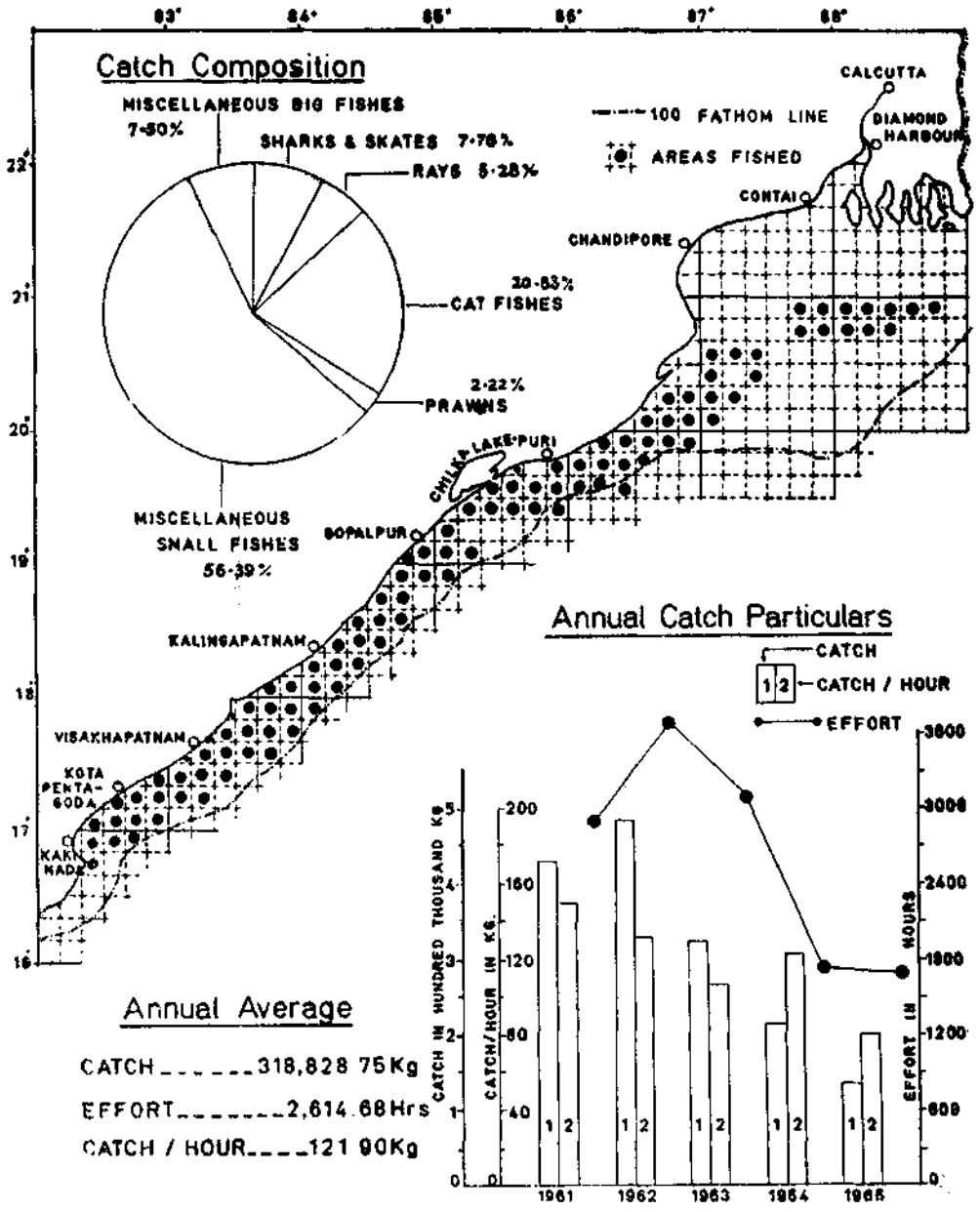


FIG. 35. Catch particulars and areas covered by the Government of India vessels of Visakhapatnam base for the period 1961-65.

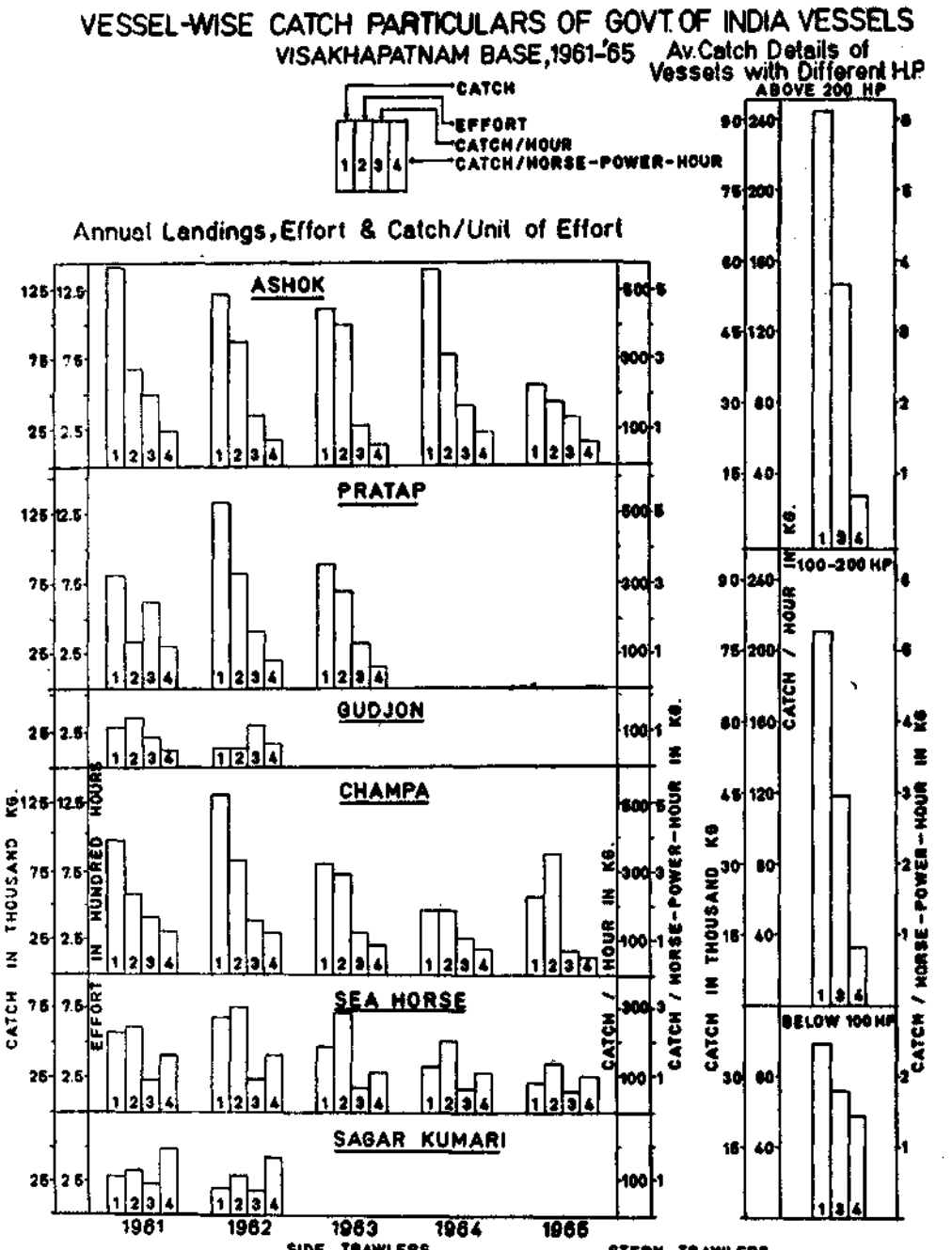


FIG. 36. Vessel-wise catch particulars and the gear operated by the Government of India vessels of Visakhapatnam base for the period 1961–65.

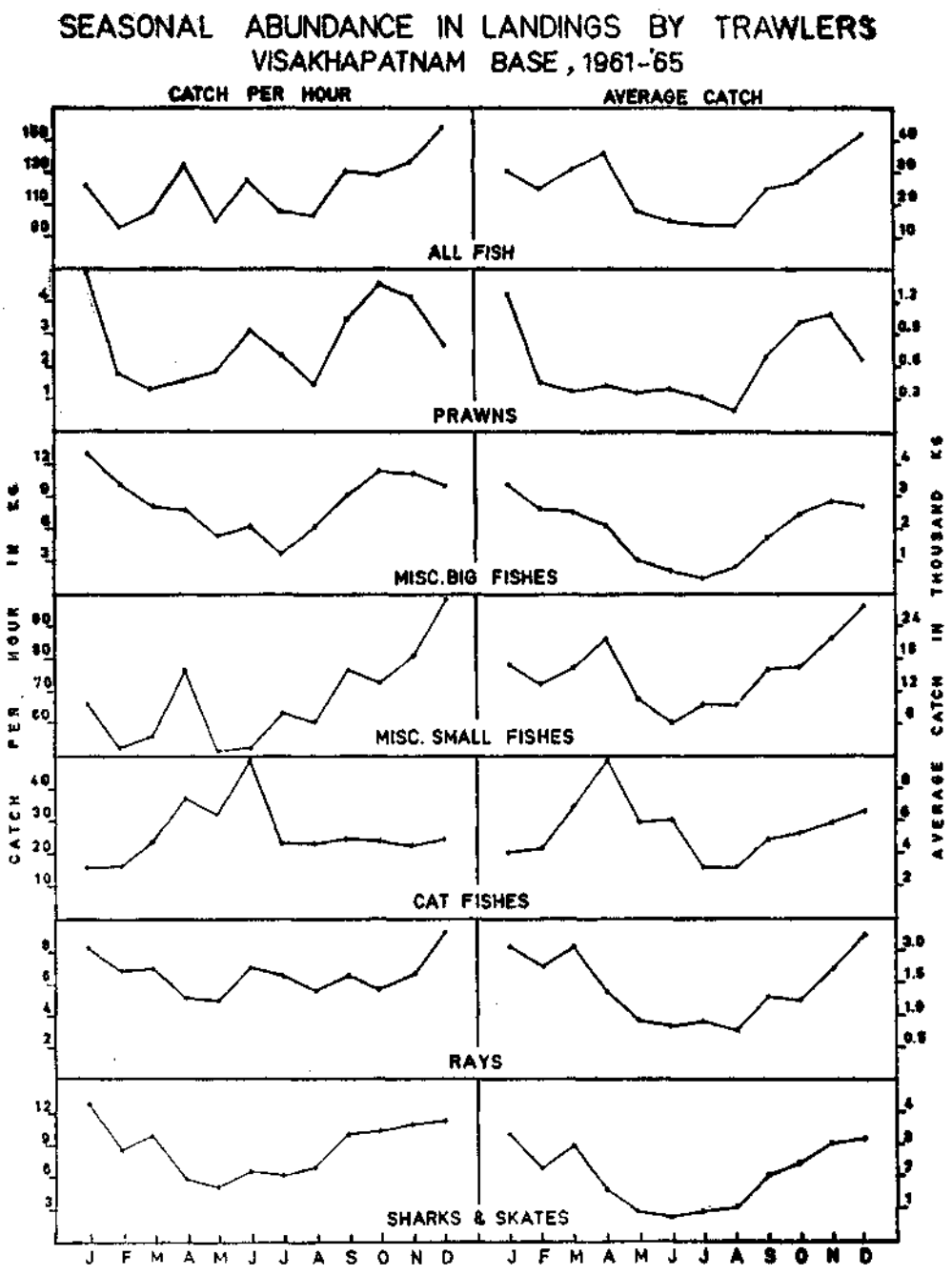


FIG. 37. Seasonal catch trends of the categories of fishes landed by the Government of India vessels of Visakhapatnam base for the period 1961-65.

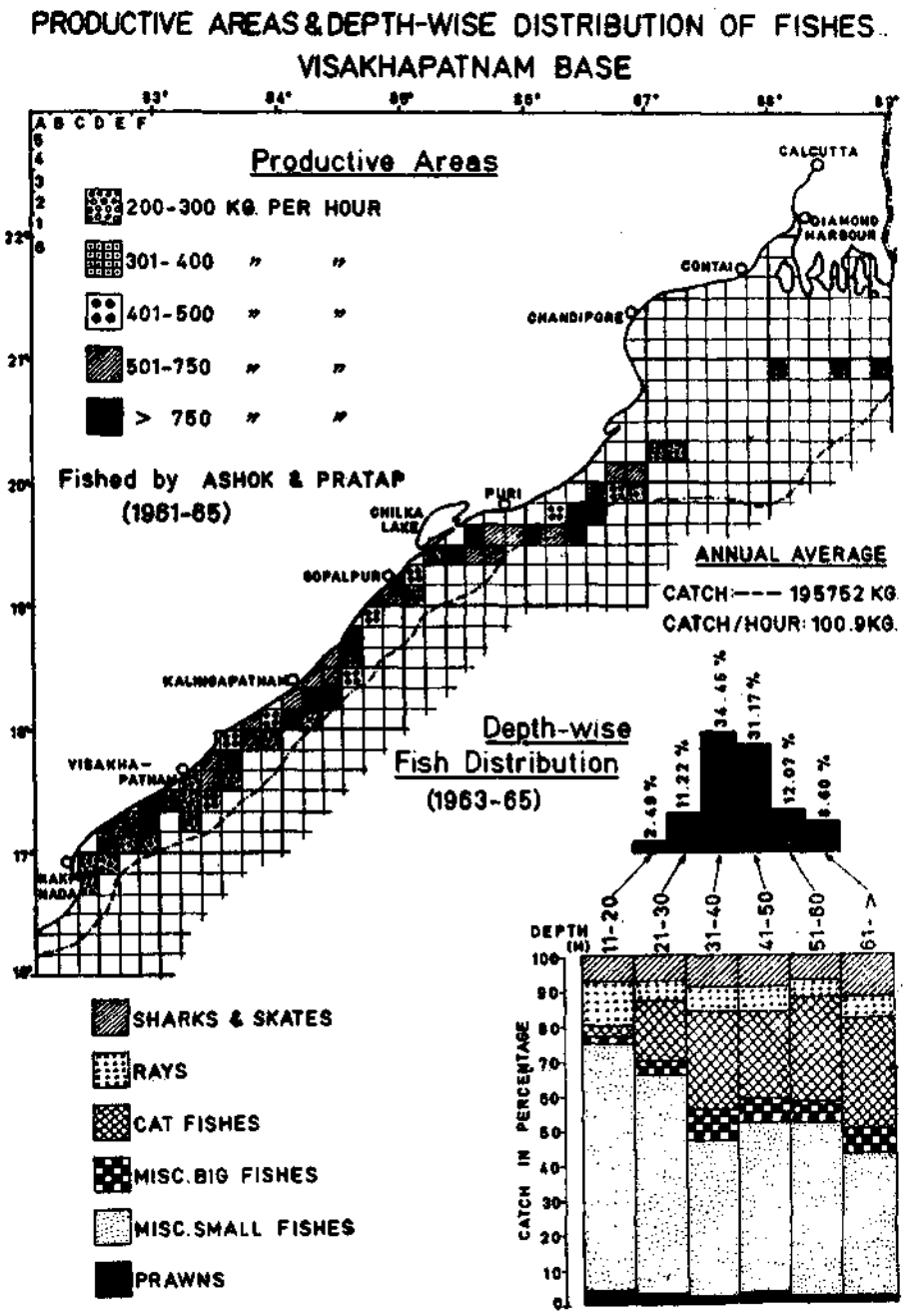


FIG. 38. Productive areas and catch composition of categories of fishes in different depth zones fished by the Government of India vessels of Visakhapatnam base.

For the period 1961–65 the grounds fished, the annual catch particulars and the composition of the catches are given in Fig. 35. The annual average for the 5-year period is 318,828·75 kg. at a catch rate of 121·90 kg./hr. In recent years the effort expended and the catch rates obtained are low. Miscellaneous small fishes (56·39%) and cat-fishes (20·93%) formed the bulk of the catches. Miscellaneous big fishes, elasmobranchs and prawns comprised the rest of the catches. The overall catch of prawns in this region formed about 2% (Fig. 35).

Vessel-wise catch particulars and the types of gear operated are shown in Fig. 36. When the vessels are grouped under three categories based on horse-power, it is seen that nearly 150 kg./hr. are obtained by those whose horse-power is about 200 H.P.; about 120 kg./hr. for those having a horse-power of 100 to 200 H.P. and about 70 kg./hr. for those below 100 H.P.

Figure 37 shows monthly averages of catches, catch rates of all fish and the different groups of fishes. In general for all fish the catches are low from April to August.

Figure 38 shows the productive areas and the depth-wise abundance of fish catches (1963–65) in this region. Very productive areas which have given over 750 kg./hr. are off Puri, near Chilka lake and in the vicinities of Gopalpur and Kalingapatnam. In general it has been found that there is an increase in the abundance of fish from southern to northern latitude zones. Other areas giving below 750 kg./hr. in a graded pattern of distribution are shown in Fig. 38. The bulk of the catches, about 65%, came from depth zones 31–50 m. The percentage proportion of miscellaneous small fishes was higher in the shallow depth zones between 11 and 30 m than in the deeper zones. Cat-fish percentage was much higher in greater depth zones from 31 to 61 m and over.

In general the trawling grounds in the two eastern divisions are less extensive than on the west coast, the quality fishes are meagre and the catch rates for vessels of the same specifications are far lower. Off Tuticorin, the inshore catches generally show quality fishes as the seerfishes and tunnies and possibly a more intensive exploration of the region may reveal the existence of these resources to an appreciable degree in the offshore waters. In southern regions around Mandapam in the Palk Bay and the Gulf of Mannar the catch rates for small trawlers are very high for low quality fishes as the silver-bellies which if utilised in a satisfactory manner as in the production of high protein concentrates for human consumption, hold promise for a successful industry of some magnitude. Off Chilka lake, Kalingapatnam and in some of the northern grounds of the Bay of Bengal there are productive areas which can be profitably exploited for commercial trawling.

VI. Marine Biology and Oceanography in Relation to Fisheries

The physical features of the land bordering the ocean, the periodic fluctuations in the land and the sea temperatures, the influence of the wind and water currents, variations in the salinity media, upwelling, intensity in the production of the standing crop, levels of oxygen saturation and a number of other corollary factors have a great bearing on the scope for fisheries exploitation of a country. As stated earlier, of the countries bordering the Indian Ocean, India's marine fish production is the highest. The country's coastline is about 2,900 miles long and has the continental shelf (130,000 square nautical miles) which is much wider in certain regions on the west coast than on the east coast. A wider shelf invariably supports a greater abundance of demersal fishery resources. Although the narrowness of the shelf has an adverse effect on the supply of demersal fishes in some countries, there may be other factors which are particularly favourable for the development of pelagic fisheries. For instance, off Peru the plankton production is so dense that it supports the world's largest anchovy fisheries. Fortunately for this country there are good pelagic fishery resources supported chiefly by the sardines and the mackerel and also fair abundance of demersal fishery resources constituted by a variety of ground fishes, besides the shrimp and other crustaceans which occur in no insignificant quantities. At the present level of exploitation the fish production on the east coast of India is only about a fifth of the total production of the country. A large number of research vessels which participated in the exploratory and scientific expeditions since the latter part

of the nineteenth century and those which took part in the International Geophysical Year Programme have furnished valuable data on the oceanographic features of the Indian Ocean. With the help of the research vessels of the Indo-Norwegian Project, *viz.*, *Kalava* and *Varuna*, very useful data on the hydrography and planktology of the zones especially where the oil sardine and the mackerel occur in abundance have been collected by the Central Marine Fisheries Research Institute for the past ten years. The movement of the water masses, the relation of the monsoon winds determining the coastal drifts, the upwelling in specified zones, the annual phosphate cycle, etc., which have been studied in great detail by the Institute have helped in understanding the reasons for high productivity of the west coast as also to some extent the factors determining the fluctuations in the important zonal fisheries. The results of the recent International Indian Ocean Expedition are now coming in.

Water Masses

In the region of subtropical convergence at about 40° S latitutde in the Indian Ocean below the surface waters several layers of water masses are recognised, they being the Indian Ocean Central Water, the Indian Ocean Equatorial Water and the Deep Water at a depth of 2,000 metres. Besides these there are the Antarctic Intermediate Water and the Red Sea Water. The movement of the cold Antarctic Bottom Water (Deep Water) from polar regions into the Arabian Sea and the Bay of Bengal has a bearing on the organic productivity in the region. There are three main tongues in this deep-water drift, one of which strikes the east coast of Madagascar while the second tongue which strikes the Carlsberg Ridge is deflected to the surface (in the Arabian Sea) where its effect is felt by the presence of low salinity, low temperature and rich nutrients. One branch of the third tongue strikes the coast of Ceylon and enters the Laccadive Sea while the other travels northward between Carpenter's Ridge and the Andaman-Nicobar Ridge. The Red Sea Water penetrates to great depths across the equator and meets the Antarctic Bottom Water (Fig. 39).

Currents

One striking characteristic of the surface currents of the Indian Ocean is their reversal with the change of the monsoon winds. The equatorial current system during the winter months (November to March) is similar to the general pattern observed in the Pacific and the Atlantic, with the westbound South Equatorial Current (8° S to 20° S) and the North Equatorial Current (2° S to 5° N) driven by trade winds, having the eastward flowing Equatorial Counter Current in between them. The South Equatorial Current and the Equatorial Counter Current are steady throughout the year. The velocity of the South Equatorial Current is the greatest during the summer season (June to September), when water from the Pacific flows along the northern coast of Australia to join this current. On reaching the coast of Madagascar, this current divides into two, one branch feeding the Agulhas Stream along the east coast of Africa and the other joining the Somali Current flowing northwards along the coasts of Africa and Arabia. The Somali Current is seasonal, driven by the monsoon winds and therefore it is present only during the south-west monsoon period. When this current does not exist, the second branch of the South Equatorial Current feeds the eastward flowing Equatorial Counter Current. A part of the Agulhas Stream on reaching the southern tip of South Africa turns round and flows westwards, while the rest joins the West Wind Drift across the southern part of the Indian Ocean. There is a strong flow of water from the Pacific to the Indian Ocean through the Straits of Malacca during the north-east monsoon period. The low salinity water of the Bay of Bengal is carried by the westward flow even up to Seychelles. The entire current system north of the Equator completely changes with the onset of the south-west monsoon. During this time the North Equatorial Current ceases to exist, being replaced by an eastward flowing Monsoon Current. The flow from the Pacific Ocean into the Bay of Bengal is accordingly either reversed or stopped.

Circulation of Waters in the Arabian Sea and the Bay of Bengal

The circulation of the waters in the Arabian Sea and the Bay of Bengal is much influenced by the pattern of winds associated with the summer and winter monsoons. The general circulation

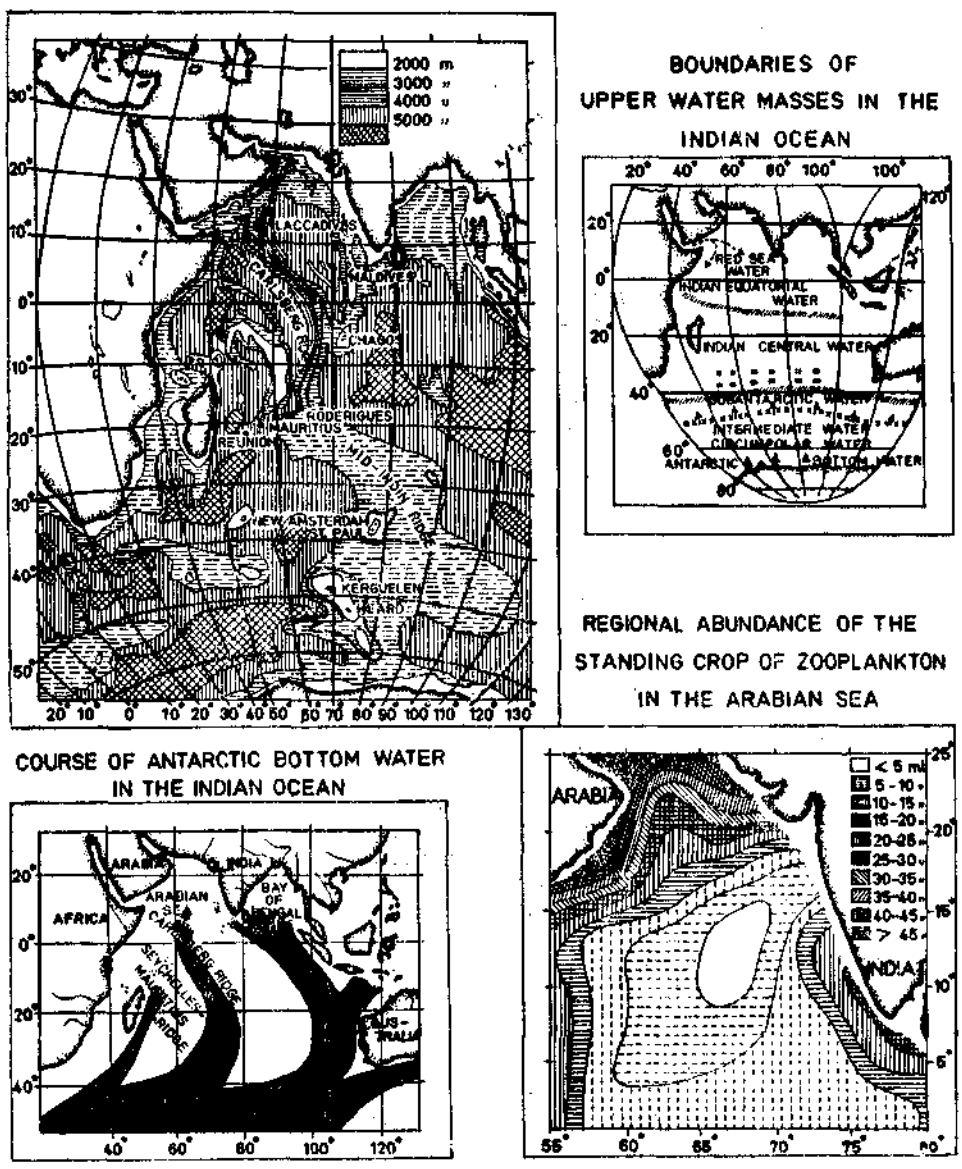


FIG. 39. Bathymetric chart of the Indian Ocean, water masses, movement of Antarctic Bottom Water coursing into the Arabian Sea and the Bay of Bengal and regional intensity of zooplankton production in the Arabian Sea (*after* Raghu Prasad, 1951 and 1966).

in the oceanic areas conforms to the wind pattern but the water movements near the coast are governed by coastal configuration. A south to south-easterly surface current from February to September and a north-westerly current from November to January occur on the west coast of India. On the east coast between February and July the surface drift has a north-easterly direction with an occasional easterly component. This changes to south-westerly in the northern part of the coast and to southerly in the southern part about September–December. In January a weak westerly drift is also observed (Panikkar and Jayaraman, 1966). The southerly drift from the Bay of Bengal joins the North Equatorial Current which has its westward flow. A deviation of this flow taking a northerly direction on the western side of the sub-continent may be of much importance from the point of view of the commercially important pelagic fisheries like the sardines and mackerel which enter the Indian fishery apparently from the southern latitudes (Murthy, 1967).

Salinity, Temperature, Thermocline and Upwelling

The average values of salinity range between 34‰ and 37‰ in the Arabian Sea and 30‰ and 34‰ in the Bay of Bengal. The higher salinity of the waters of the Arabian Sea is mainly due to high saline water flowing from the Red Sea and the Persian Gulf. There are no major river systems on the west coast of India except the Indus, Narmada and Tapti flowing out into the sea. During the south-west monsoon the rain-water which enters the Arabian Sea from the Western Ghats is carried away by a coastal current towards the south and on touching the coasts of Ceylon this is carried northwards to the Bay of Bengal. The waters of the Bay of Bengal have low salinity because of the influence of large river systems, *viz.*, Cauvery, Krishna, Godavari, Mahanadi, Ganges and Brahmaputra opening into it from the Indian border and also a few others from the Burmese border.

The fluctuations in the surface temperature are very wide in the Arabian Sea whereas the usual range along the Indian coast is from 23° C to 29° C. However, a comparatively lower temperature reaching a value of 21° C occurs during November–December period on the north-western coast of India (Jayaraman and Gogate, 1957). In the Bay of Bengal the usual range of surface temperatures is between 27° C and 29° C and the fluctuation here is much less than in the Arabian Sea. In respect of the vertical distribution of temperature it may generally be stated that in the Bay of Bengal of the Indian coast the thermocline level is usually below 50–55 metres and at times going down to 100–125 metres level whereas off the west coast of India the thermocline fluctuates a great deal showing a definite seasonal trend. In the Bay of Bengal the shelf waters in general are mostly isothermal or nearly isothermal. Off the south-west coast of India the thermocline is found at 100–125 metres during winter. During the stable period between the monsoons the thermocline level is between 75 and 90 metres. With the progress of the south-west monsoon there is an upward movement of the thermocline level reaching 20–30 metres or even to still lower levels. This is a regular feature and during this period the shelf receives cold, dense, poorly oxygenated water rich in nutrients (Ramamirtham and Jayaraman, 1960). Thus it has been concluded that the late monsoon and the early post-monsoon periods show upwelling of the waters along the west coast of India. The rich biological and fishery productivity in the Arabian Sea is attributed to the seasonal upwelling. Some observations made by the individual scientific workers on the subject of upwelling are briefly outlined in the following account.

Banse (1959) has shown that off the west coast of India from 8° N to about 15° N strong upwelling occurs during the whole of the south-west monsoon season. The oxygen content of the upwelled water is further reduced by the increased consumption on the shelf. Consequently, the demersal fishes disappear from a rather wide belt parallel to the coast. He has concluded that bottom trawling is profitable either in very deep waters or occasionally in very shallow waters (Fig. 40).

Sharma (1966) states that in the area between 7° N and 14° N from longitude 73° 30′ E to 77° 30′ E the thermocline depth does not exceed 150 metres in any month of the year and it is the deepest in the months of January and February. The upward tilting of the thermocline towards the coast starts from about February and it reaches the surface by July indicating an upward movement of the water. After August the thermocline is reversed indicating sinking near the coast.

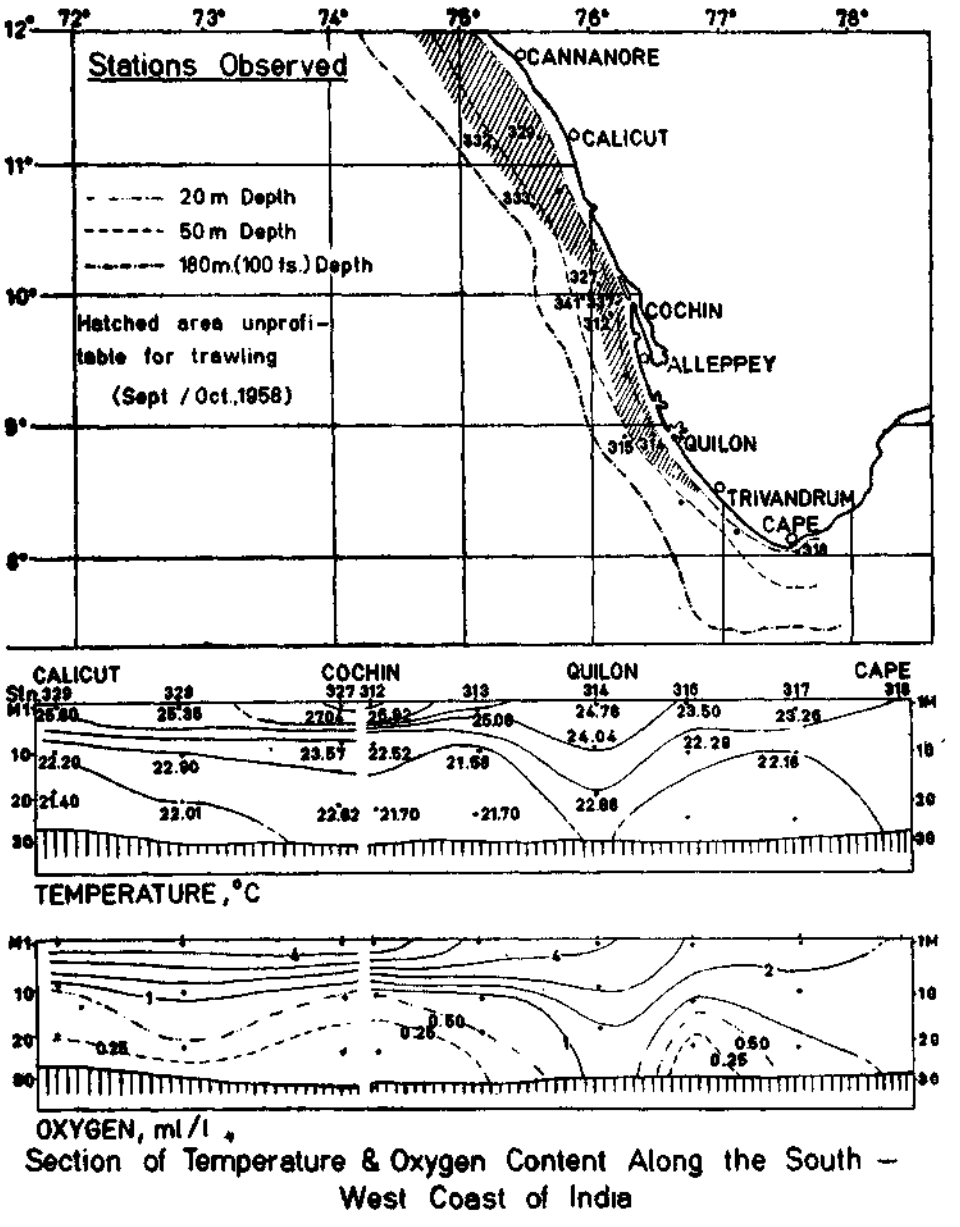


FIG. 40. Hydrography of the west coast of India in the monsoon period showing upwelling (*after* Banse, 1959).

On the hydrography of the north-western coast of India in the pre-monsoon period, Patil *et al.* (1962) have stated that the stable summer conditions of the shelf waters gradually progress towards the unstable conditions with the approach of the south-west monsoon by about the middle of May. In the upper layers of the waters a tongue-like drift has been observed running towards the south. The tidal influence of this region and the cold waters off Veraval and neighbouring regions may possibly bring about this effect. In the southern region a north-east bound weak drift was also noticed. This tongue seems to be formed as a result of the mixing of river-waters off Sabarmathi, Tapti and Narmada which enter the Gulf of Cambay. An increasing trend in salinity is observed with increasing latitude. The first half of May represents winds mostly from north-west direction and more or less with constant speed. The second half shows varying winds (Fig. 41).

Ramamirtham and Patil (1965) state that in the region from Cape Comorin to Ratnagiri the hydrographic features in the pre-monsoon period show weak sinking phenomenon during March-April in the northernmost region (14° N to 17° N). A two-layered nature of the thermocline is noted and wherever sinking is noticed a three-layered nature also. The continental shelf waters are highly oxygenated but the oxygen minimum layer started at the top of the thermocline is found extending along the entire west coast. The values of temperature, salinity, density and dissolved oxygen content of the waters at various depths in stations off Marmagoa, Karwar, Mangalore, Calicut, Cochin and Cape Comorin are indicated in Fig. 42.

Upwelling has also been noticed off the north-west coast of India off Bombay during October-November (Carruthers *et al.*, 1959). It has been pointed out that as a result of this upwelling the demersal fishes from deeper areas are driven nearer to the shore due to shoreward uplift of the oxygen minimum layer.

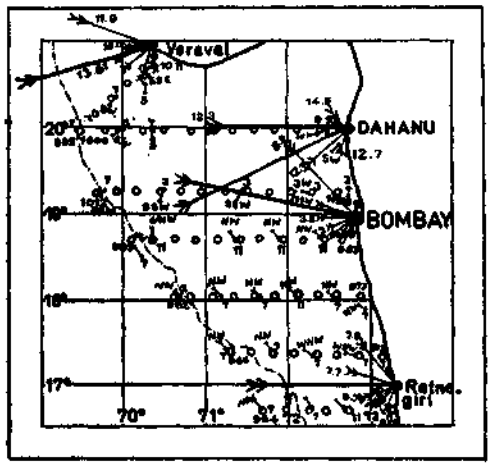
Nutrients and Plankton Production

The replenishment of nutrient salts in the productive layers is important in governing the magnitude of the annual organic production. Phosphorus and nitrogen are the two important elements mainly determining the organic productivity. In deep waters of 500–1,000 metres the concentration of the inorganic phosphates and nitrates is very high. It is the process of upwelling or turbulence that brings these nutrients to the surface waters to be used by the phytoplankton. In coastal waters where the euphotic zone is in direct contact with the bottom a striking correlation exists between temperature and production. In the open sea the euphotic zone gets the replenishment of nutrient-rich water from neighbouring area by horizontal circulation or directly from the deeper layers by vertical circulation (Prasad, 1966).

Off the south-west coast of India the direct correlation between high concentration of phosphates and a rich crop of phytoplankton was observed during the monsoon months. The hydrographical conditions during this period seem to be responsible for the rate of replenishment of the nutrients far exceeding their utilization. This replenishment is partly by the influx of nutrient-rich water into the region and partly by bacterial action on the dead and decaying matter present at the bottom. The presence of oxygen low water and prevailing turbulent conditions bring about a high rate of mortality of the bottom living organisms (Jayaraman and Seshappa, 1957). It is of interest to note that although upwelling is reported as seasonal phenomenon on the east coast region also, in general the nutrients in high concentrations are absent (Panikkar and Jayaraman, 1966). It has also been observed that around the isolated oceanic islands like the Laccadives there is high rate of organic production.

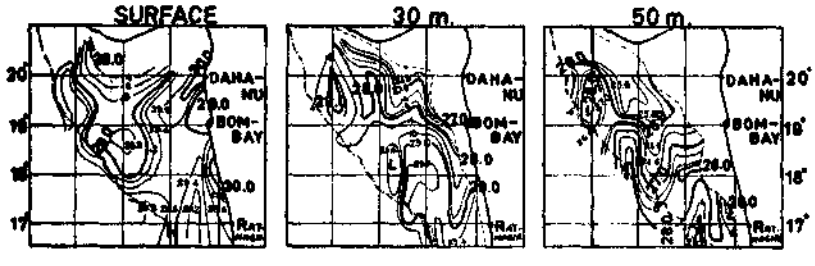
On the west coast the maximum production of phytoplankton takes place during the south-west monsoon (June-September). There is another peak of lesser magnitude in the north-east monsoon months between December and February. The magnitude of the south-west monsoon bloom on the west coast waters surpasses those from some of the most fertile waters of the world. Similar peaks of phytoplankton blooms are noticed on the east coast also corresponding to the south-

HYDROGRAPHY OF SHELF WATERS
NORTH-WEST COAST OF INDIA, PREMONSOON PERIOD (1962)



Location of stations & Percentage distribution of wind directions with Average speed.

Distribution of Temperature at Specified Lateral Planes



Distribution of Salinity at Specified Lateral Planes

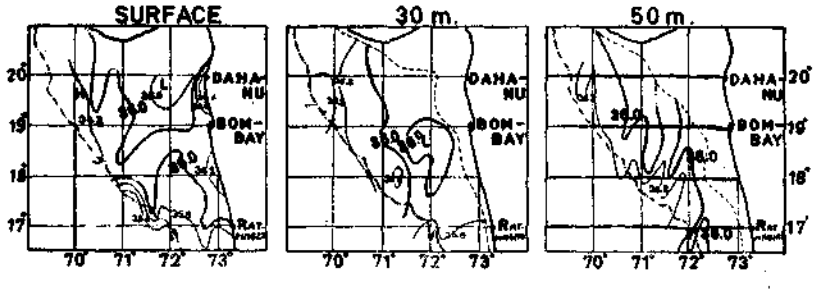


FIG. 41. Hydrography of the waters in the north-western coast of India in the pre-monsoon period (*after* Patil *et al.*, 1962).

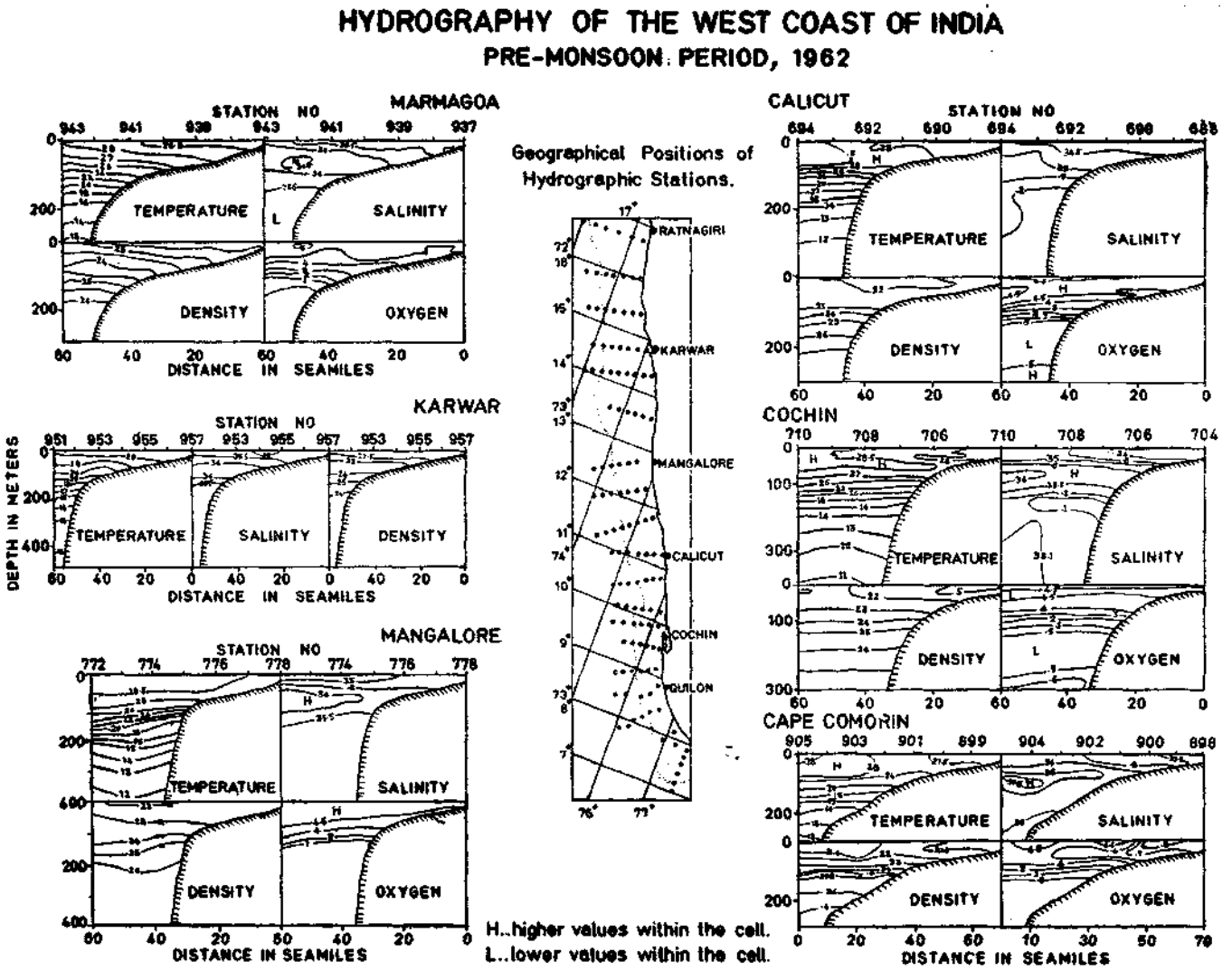


FIG. 42. Hydrography of the west coast of India during pre-monsoon period of 1962 (*after* Ramamirtham and Patil, 1965).

west and north-east monsoon seasons, although of much lesser magnitude. The ratio of phytoplankton production to the fish landed on the west coast of India works out at 0·029% which is about one half of the corresponding figure of 0·06% of the North Sea which is an intensively fished area. It therefore stands to reason that fish landings on the west coast could be increased to at least two times or more by increasing the fishing effort (Subrahmanyan, 1967).

The regional fluctuation of the standing crop of zooplankton estimated from the west coast of India is indicated in Fig. 43. In general it has been found that the standing crop in the continental shelf area is about 2·5 to 21 times greater than in the adjacent oceanic areas. In the inshore waters the zooplankton crop shows two peaks in June and October. In general the zooplankton crop was particularly high between Calicut and Quilon, Karwar and Cannanore and in the proximity

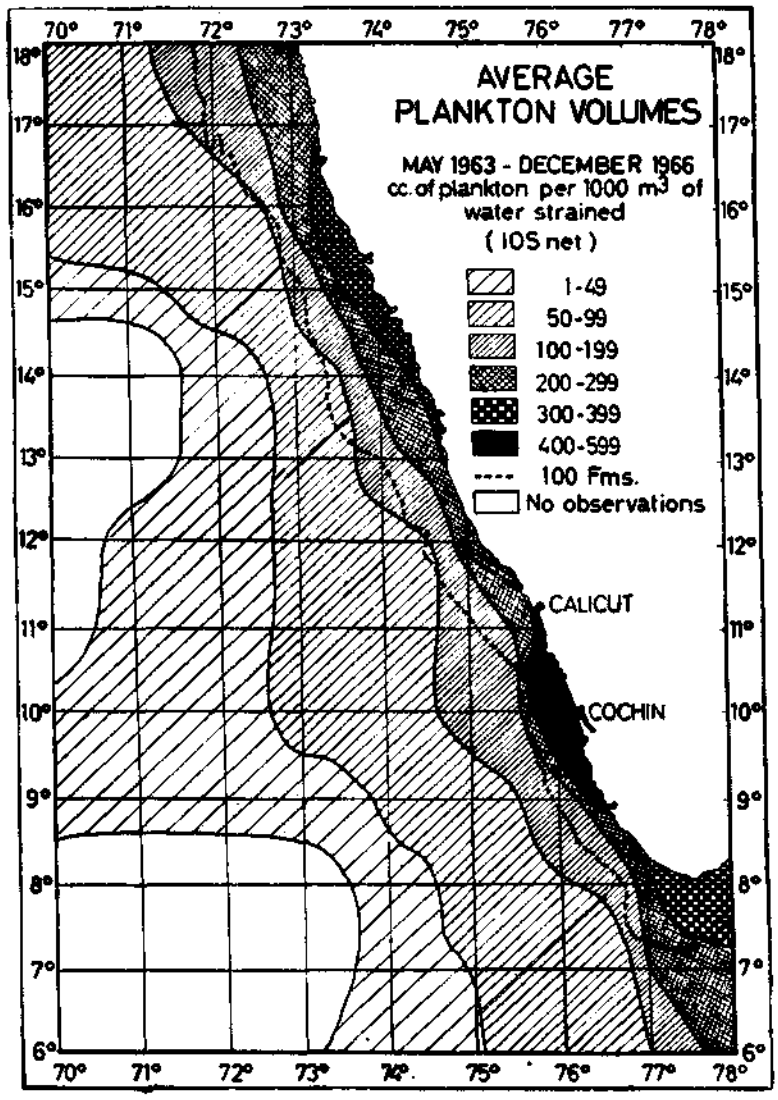


FIG. 43. Regional plankton intensities in the shelf waters of the south-west coast of India (Silas, E. G., personal communication).

of the Wadge Bank (Silas, pesronal communication, 1968). In Figs. 44 and 45 the major square-wise distribution of the standing crop of zooplankton along with certain hydrographic data is given. In respect of the oceanic waters of the Arabian Sea the relative abundance of zooplankton is indicated in Fig. 39.

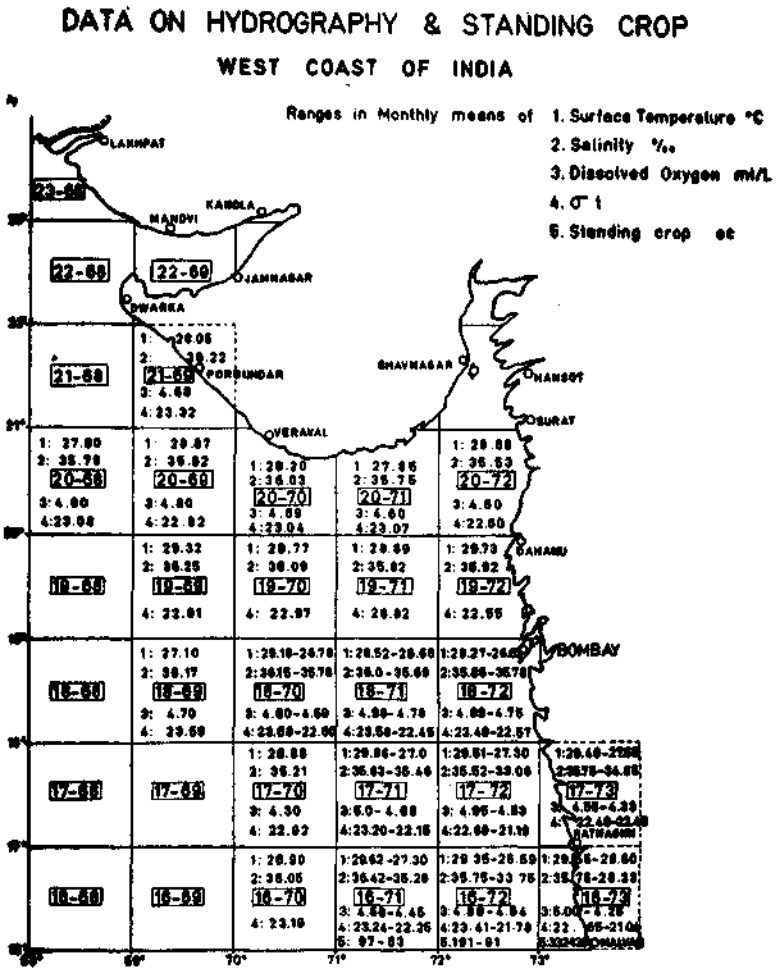


FIG. 44. Square-wise observations on salinity, dissolved oxygen, standing crop, etc., in the shelf waters of the north-western coast of India, based on collections of R.V. *Varuna*.

It may not be out of place to mention here that the sudden blooms of certain phytoplanktonic organisms like *Noctiluca*, *Hornellia*, *Trichodesmium* and *Gonyalaux* appear in such great abundance as to bring about discolouration of waters and certain adverse factors causing heavy mortality of fish (Bhimachar and George, 1950; Subrahmanyan, 1954; Prakash and Sharma, 1964).

Organic Production

While studies on standing crop of plankton in the coastal waters have been extensive for a considerable time, the investigations on organic production to assess the relative fertility of the regions of the sea are of recent development. Carbon-14 experiments on primary production initiated at the Central Marine Fisheries Research Institute for the first time in India, about a decade ago have since furnished valuable results on the regional productivity of the inshore and offshore

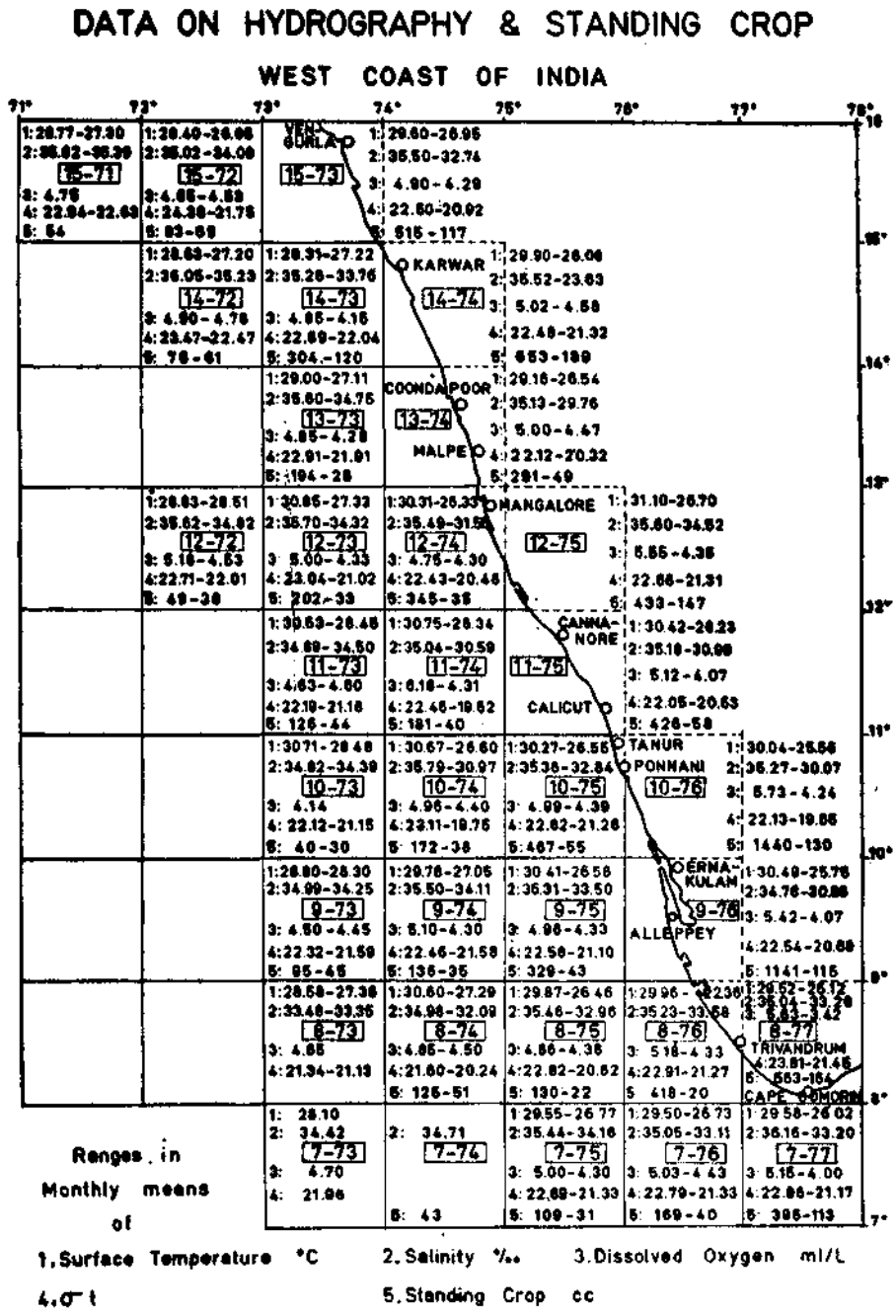


FIG. 45. Square-wise observations on salinity, dissolved oxygen, standing crop, etc., in the shelf waters of the south-western coast of India, based on collections of R.V. *Varuna*.

waters of the east and the west coasts. In some of the shallow waters of the south-eastern coast, the annual gross production has been estimated at 75 gC/m³. Off Tuticorin in the Gulf of Mannar in the euphotic zone at about 45 metres, the production rate has been over 5 gCm²/day, off Cape Comorin in the shallower waters 2·0–4·5 gC/m²/day and outside the shelf less than 0·5 gC/m²/day. The rates of organic production are very high in the inshore waters, especially of the Gulf of Mannar and Palk Bay and these rates are almost equal to those obtained in some of the world's most productive waters as in the regions of the Somali Current.

Observations carried out on the west coast have clearly indicated a gradual decrease in the rate of production from the very shallow waters towards the coast to the deeper regions of the shelf and the slope. The mean value of production in depths upto 50 metres is 1·19 gC/m²/day and beyond 200 metres only 0·18 gC/m²/day. Very high production with 50 mgC/m³/day were observed in the waters around Minicoy in the Laccadive Sea. Observations carried out beyond the shelf region have shown that the productivity is dependent on the ascent of waters rich in nutrients from below. In a general way the trend and magnitude of production are reflected in the fishery potential of the regions concerned. Experimental findings on primary production have been substantiated by the magnitude of yields obtained in exploratory fishing. Based on the mean production rates observed, the potential fishery yield is estimated annually at 1·7 million tonnes on the west coast and over 0·6 million tonnes on the east coast, a total of which is about three times the present marine fish production in India (Prasad, 1967; Prasad and Nair, 1963; and Nair *et al.*, 1968).

Mud Banks

In the region between Alleppey and Calicut there is a vertical accelaration resulting in the lifting up of the silt-laden bottom waters. This silt is kept in a state of suspension extending over wide regions known popularly as the Mud Banks, which are the store-houses of rich nutrients like the phosphates promoting rich plankton production. The abundance of planktonic organisms therein attracts a large number of fish and crustacean groups. The waters in the regions of the Mud Banks are calm and therefore afford shelter to the organisms during the monsoon when the adjacent areas are subjected to severe turbulent conditions. This phenomenon which is peculiar to the south-west coast of India occurs with cyclic regularity during the south-west monsoon period and is associated with fisheries of some magnitude especially those related to prawns, oil sardine, other sardines, mackerel, soles, etc. (Sadananda Rao, 1967; Prasad, 1966).

Summary

India's marine fish production was estimated at an average of 0·68786 million metric tons a year for the 15-year period of 1951–65. In 1966 she registered a catch of 0·8901 million metric tons which accounted for over 40% of the total yield of 2·2 million metric tons of marine fish catch from the entire Indian Ocean. During the same 15-year period Kerala's contribution of the marine fish catch was the highest, being about 31%, followed by Maharashtra 22%, Madras 15% and Gujarat 13% while the other maritime states and the Union Territories together made up the rest. According to the survey census of 1961–62 there are 1,797 fishing villages with a total fishermen population of 9,58,937. Among them the active fishermen are over 2 lakhs, using over 90,000 indigenous fishing craft. Mechanisation of the fishing craft has rapidly progressed and by 1966 there were 5,073 mechanised fishing boats in the various states, besides some hundreds of large and medium fishing vessels engaged in exploratory and commercial trawling. The types of fishing crafts and gear used are varied and they are suited to the local conditions and the types of fishes caught.

Among the fish groups the annual averages of which ranged between 35,000 metric tons and about 175,000 metric tons were the oil sardines *Sardinella longiceps*, the Bombay duck *Harpodon nehereus*, the crustaceans (prawns, lobsters and crabs) and the elasmobrnachs (sharks, skates and rays), while those between 15,000 and 35,000 metric tons were the other clupeiform fishes, sciaenids, ribbon-fishes, cat-fishes, silver-bellies, pomfrets and miscellaneous fishes; perches, seerfishes and

soles ranged between 10,000 and 15,000 metric tons; eels, gar fishes, half-beaks, red mullets, polynemids, *Lactarius*, tunnies, barracudas, grey mullets, *Bregmaceros* and cephalopods were between 236 and less than 10,000 metric tons each. The regional distribution pattern of the aforesaid fish and crustacean groups and their seasonal abundance have been dealt with in detail along with some information on their biology in relation to fisheries. While all the above groups are utilised as food either in the fresh or cured condition, some of them are much valued for by-products like the body oil from the oil sardine used in the lubrication of the machinery, preservation of timber, tanning of leather, etc., the liver oils of elasmobranch fishes with their high vitamin A content for medicinal purposes, dried shark fins for soups relished in the Far Eastern countries and the fish bladders chiefly of sciaenids, cat-fishes and eels for the manufacture of isinglass for clarifying wines, etc. Sharks, sardines and silver bellies are on a small scale made use of in making quality fish-flour for human consumption and a variety of small fishes and their offal on a fairly large scale for fish-meal as cattle and poultry feeds. When the landings are heavy and the opportunities for their utilisation are limited they are converted into fish-manure, much in demand as a fertilizer in the tea and cocoanut plantations.

The exploratory trawling operations conducted in the past two decades on the continental shelf of India by the governmental and other agencies have demonstrated that the deep-sea and offshore fishing is commercially profitable. Some of the outstanding results obtained in offshore fishing operations in recent years have been briefly outlined under four major geographical divisions, the North-Western, the South-Western, the South-Eastern and the North-Eastern coastal divisions.

In the North-Western Division the trawling grounds are very extensive. The catch rates for all types of powered vessels employed in trawling are very high. There is a preponderance of large-sized quality fishes like *Pseudosciaena diacanthus*, *Pomadasys hasta*, *Otolithoides brunneus* and *Polydactylus indicus*. The yields of total fish are high all round the year, except in monsoon months when the catches are low because of the low-fishing effort expended. The catch details of the Government of India vessels and the New India Fisheries Company's vessels operating in this division for the past ten years have been presented and the regional and seasonal abundance of the different fish categories discussed. Productive areas have been charted. A northward increase in catch rate for all fish from Bombay to Kutch and a similar southward increase from Bombay to Goa have been indicated. Within the division the quality fishes are present to a larger extent in the northern latitude zones and the prawns in greater abundance in southern regions from Cambay.

In the South-Western Division the continental shelf is narrow and the trawling grounds therefore are less extensive. However, India's best trawling grounds for shrimps are located in this region and the extent of exploitation of shrimps is also far higher than in any of the other divisions. The proportion of the quality fishes is far too negligible for commercial trawling. The prospects for the development of oceanic fisheries are high and there is also scope for stepping up of pelagic fisheries by introducing purse-seining operations during the mackerel and sardine fishing seasons. The regional abundance of fish catches obtained by trawlers of the Government of India, the Indo-Norwegian project and the commercial fishing companies in Karwar, Mangalore, Cannanore and Cochin bases in recent years is dealt with.

As compared with the trawling grounds in the west coast divisions, those in the South-Eastern and North-Eastern Divisions are very much restricted in their extent and the catch rates for all fishes are far lower. Off Tuticorin the shrimp catches are occasionally high but never steady. Around Mandapam in the Palk Bay and the Gulf of Mannar the catch rates for small trawlers are very high for low quality fishes like silver bellies. Off Chilka lake, Kalingapatnam and some of the northern grounds in the Bay of Bengal there are good trawling grounds suitable for commercial exploitation. The catch statistics of the Government of India vessels, the Indo-Norwegian Project's vessels and the West Bengal cutters which fished from Tuticorin, Mandapam, Visakhapatnam and Calcutta bases have been discussed to assess the regional abundance of fish categories. The productive areas have been charted.

The Government of India fishing vessels operating from different bases on the east and west coasts have been grouped under three categories based upon the horse-power, *viz.*, those having a horse-power up to 100, those between 101 and 200 and those above 200 horse-power. The annual aveage catch rates of each of the categories of the vessels have been found to serve as indices to judge the relative richness of the fishing grounds in the four major geographical divisions.

The water masses and the principal currents of the Indian Ocean, water circulation in the Arabian Sea and the Bay of Bengal which changes with the onset of the North-East and the South-West monsoons, fluctuations in the salinity and the temperature values of the inshore waters of the east and west coasts, instances known of the periodic upwelling of waters, plankton crop in relation to nutrient cycles, destructive plankton blooms bringing about mass mortality of fishes and the formation of mud banks supporting fisheries of some magnitude have been briefly outlined. A study of the ratio of phytoplankton production to the fish harvested from the west coast waters of India had shown that the fishing effort could be increased to at least two times more.

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