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Editors

V.K. Pillai
S.A.H. Abidi
V. Ravindran
K.K. Balachandran
Vikram V. Agadi

Department of Ocean Development
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Department of Ocean Development (DOD)
Government of India
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India

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Distribution of finfish resources along southeast coast of India in relation to certain environmental parameters

S.Sivakami, P. Maricharny, P. Livingston, G. Gopakumar, R. Thiagarajan, E. Vivekanandan, Kuber Vidyasagar, G. S. Daniel Selvaraj. S, Muthusamy, N. G. K.Pillai & M. Zafar Khan

Central Marine Fisheries Research Institute, P.B. No.- 1603 Cochin - 682 014

ABSTRACT

This paper embodies the distribution pattern of major finfish resources along the southeast coast of India as observed during the cruises operated by *FORV Sagar Sampada*. A total of 16 cruises (1985-90) operated along latitude 7°15'- 15°00' N and longitude 75°50'- 82°31' E hauled a total catch 37.5 tonnes with a catch rate of 537 kg/hr. The catch was constituted mainly by threadfin breams (43%), perches (14%), barracudas (9.72%), carangids (8.56%) and elasmobranchs (4.81%). Seasonally higher catch rates were obtained during July- September period. Depth range of 60 - 80 m had denser population of finfish resources. Water temperature and salinity appeared to influence the distribution of major finfishes more than dissolved oxygen. Groups such as threadfin breams were found preferring cooler waters of Wadge Bank area, while barracudas appear to occupy warmer waters of Gulf of Mannar.

INTRODUCTION

Though it has been conventionally believed that the coastal waters along the east coast of India are less productive as compared to its counterpart along the west coast, there has been a growing awareness during the recent past to acknowledge a change in the scene. Evaluating the fishery potential of the east coast, Sudarsan & Joseph (1978) opine that the difference in the potential yield between the two coasts is very less being only 16.26 %.

Southeast coast of India, with its narrow shelf region being influenced by the reverine discharge and with one of the productive waters along the Palk Bay and Gulf of Mannar, tend to have a dynamic ecosystem influencing the distribution of its fishery resources. Unlike along the west coast of India, the distribution of various fish groups along the southeast coast in relation to prevailing environmental characters is

not much understood except for the general studies made by Misra & Menon (1955), Virabhadra Rao (1973), Subrahmanyan (1973), and Murthy *et al.* (1990). The present paper is an attempt to evaluate the distribution and abundance of major finfish resources in relation to certain hydrographical parameters based on the reports of the cruises undertaken by *FORV Sagar Sampada*.

MATERIALS AND METHODS

Reports of 16 cruises (Table 1) operated by *FORV Sagar Sampada* during 1985 to 1990 along the southeast coast of India (within the area of lat. 7°15′- 15°00′N and long. 75° 50′- 82° 31′ E) were analysed for their station wise catch particulars qualitatively and quantitatively. Fish caught in bottom trawl alone were considered for this study. Catch per effort was worked out based on the effort input in terms of hours/minutes.

With a view to obtaining the seasonal pattern of the catch, cruises operated during the months of June to September were considered for the premonsoon season, those operated during October to January for monsoon season (northeast monsoon) and those during February to May for postmonsoon season.

Gear depth in each station was noted and stations operated in depth ranges 0 -20 m, 20-40 m, 40-60 m, 60-80 m, 80-100 m and 100-150 m and above 150 m were grouped together and average catch per hour worked out in reckoning the depthwise catch data. Likewise, catch rates for different areas of fishing operations were also noted.

Data pertaining to the water temperature, salinity and dissolved oxygen from the nearest depth to that of the fishing depth were noted and averages worked out for comparison with the catch rates in various depth ranges in different fishing areas.

RESULTS

Exploitation

Catch details of various cruises are presented in Table 1. A total of 37499 kg of fish, crustacean and cephalopod resources were obtained, with a catch rate of 537 kg/hr. A comparative assessment of cruise-wise catches showed that cruise no.33 (07°31′- 9°00′ N, 76°22′- 77°32′ E) hauled the maximum catch of 25864 kg with a catch rate of 2874 kg/hr during July 1987. The lowest catch rate of 1.64 kg/hr was from 11° 10′- 13°37′ N and 79° 57′- 80° 28′ E during December 1989.

Species composition

Details regarding the percentage contribution of different fish groups are given in Table 2. It may be noticed that the catch was dominated by *Nemipterus* spp (43%) followed by barracudas (*Sphyraena* spp) (9.72%), carangids (8.56%) and elasmobranchs (4.81%). Perches were represented by species such as *Epinephelus* spp.

Table 1 - Particulars of fish catch in cruises operated along the southeast coast of India during 1985-90

Cr.no.	St. no.	Period of opern.	Depth range(m)	Position		Total catch (kg)	Catch rate (kg/hr)
				Latitude	Longitude		
3	4	June 1985	45-631	10° 29′- 13° 30′	08° 13′-08° 30′	409	109
5	2	July 85	42-221	07° 50′- 10° 00′	75° 50′-77° 51′	2051	1025
13	6	Feb. 86	23-68	10° 30′- 15° 00′	80° 00′-81° 26′	980	42.15
13	6	March 86	40-86	11° 30′- 14° 13′	79° 54′-80° 29′	1881	26871
25	5	Dec. 86	39-75	10° 30′- 13° 00′	90° 10′-80° 28′	488	89.6
26	1	Jan. 87	38	14° 31′	82° 31′	220	220
30	0	May 87	No fishing				
33	11	July 87	30-83	07° 31′- 09° 00′	76° 77′-77° 32′	25864	2873.78
34	5	Aug. 87	22-91	11° 00′- 14° 12′	79° 53′-80° 58′	3316	72.98
35	2	Sept. 87	84-168	14° 12′- 14° 59′	80° 18′-80° 23′	1575	787.5
59	4	June 89	52-82	10° 30′- 14° 11′	80° 09′-80° 23′	640	213.33
61	2	Aug. 89	79-85	11° 00′- 13° 58′	79° 00′-81° 25′	2300	1533.33
63	1	Sept. 89	85	13° 25′	80° 28′	40	120
67	3	Dec. 89	50-60	11° 10′- 13° 37′	79° 57′-80° 28′	5	1.64
70	2	Feb. 90	48-60	11° 23′- 14° 05′	80° 23′-80° 27′	574	287
72	4	April 90	48-78	10° 30′- 15° 00′	80° 14′-80° 30′	197	69.35
Total stns=58						37499	537

Table 2 - Seasonal abundance (kg/hr) of various groups of fishes along the southeast coast of India

Groups/Species	Premonsoon				Monsoon		Postmonsoon			Total	
	June	July	August	Sept.	Dec.	Jan.	Febr.	March	April	[kg/hr]	[%]
Elasmobranchs	1.93	96.54	0	0	0	92	7.17	44.43	53	25.9	4.81
Carangids	5.33	110.64	180.7	0	6.67	80	12.81	66.14	0.71	45.97	8.56
Nemipterids	0	1437.73	14.61	0	0	1	2.85	18	4.59	230.7	42.96
Epinephelus spp	2.52	79.55	1.04	0	3.64	0	1	19.86	0	15.6	2.91
Lethrinus spp	19.26	23.64	0	0	14.58	0	0	50	0	12.21	2.27
Lutjanus spp	0	2.27	23.83	0	10.14	0	0	14.86	0	4.94	0.92
Lutianus spp	19.26	19.09	0	0	0	0	0	0	1.06	4.91	0.91
Pomadasys spp	22.22	0	0	0	0	0	0	0	0	2.15	0.4
Diagramma spp	0	21.82	0	0	6.97	0	0	0	0	65.78	1.07
Pentaprion spp	42.96	0	2.08	0	0	40	1.7	0	0	5.51	1.02
Other perches	3.7	2.82	43.48	2	0	0	1.66	0	0	5.05	0.94
Cat fishes	0	5.82	0	0	0	3	0	0	0	0.95	0.17
Sciaenids	0	0	0	0	0	0	8.52	0	0	3.07	0.57
Lizard fishes	0	28.09	10.26	0	0	0	0	2.86	1.06	4.68	0.87

Contd...

Table 2 — *Contd...*

Groups/Species	Premonsoon				Monsoon		Postmonsoon			Total	
	June	July	August	Sept.	Dec.	Jan.	Febr.	March	April	[kg/hr]	[%]
Goat fishes	0	8.64	0.35	0	0	0	6.88	2.14	0	4.09	0.76
Leiognathus spp	4	3.64	5.21	0	2.32	0	5.39	0	0	3.59	0.67
Sphyraena spp	0	322	0	0	0	0	3.33	2.28	0	52.16	9.72
Seer fish	0	4.54	0	0	1.32	0	0	0	1.77	0.97	0.18
Mackerel	0	0	86.96	0	0	0	0	0	0	7.16	1.33
Dussummieria spp	0	0	0	0	0.09	0	0	0	0	0.34	0.06
Psenes indicus	0	59	0	0	0	0	0	0	0	9.29	1.73
Psenopsis cyaena	0	0	0	100	0	0	0	0	0	3.58	0.66
Priacanthus spp	0	8.64	0	500	0	0	0	0.74	0	19.33	3.66
Balistids	0	30.72	0	0	0	0	0	0	0	4.84	0.9
Miscell.fishes	20.44	229.21	52.52	24	7.87	4	6.91	47.43	5.48	51.68	9.63
Jelly fish	4	0	0	0	0	0	0	0	0	0.38	0.07
Crustaceans & cephalopods	9.78	39.11	33.91	20	1.74	0	3.2	0	1.77	12.04	2.24
Total catch (kg/hr)	155.4	2537.7	454.96	646	58.39	220	61.57	268.71	69.43	537	

(3.9%), *Lethrinus* spp (2.27%), *Diagramma* spp (1.07 %), *Lutjanus* spp (0.92%), *Lutianus* spp (0.91 %) and *Pomadasys* spp (0.40%). Other demersal fish represented were lizard fish (0.87%), goat fish (0.76%), *Leiognathus* spp (0.67%) and Sciaenids (0.57%). Pelagic groups such as seer fish (0.18%), mackerel (1.33%) and *Dussumieria* spp (0.06%) were also represented in the catches. Mesopelagic fish like *Priacanthus* spp (3.60%), *Psenus indicus* (1.73%), *Psenopsis cyaena* (0.66%) and balistids (0.9%) were also caught occasionally. Apart from finfish, crustaceans and cephalopods constituted 2.24% of the total catches.

Seasonal abundance

Catch rate (kg/hr) of various groups of fish caught during different months/seasons of the year is given in Table 2. The catch rate was more during the premonsoon months of June to September with the maximum catch rate of 2537 kg/hr recorded during July followed by September (646 kg/hr). During the northeast monsoon season, the catch was generally less, with no cruises undertaken during October-November months. However, cruises operated during December and January brought catch rates of 58.4 kg/hr and 220 kg/hr respectively. Postmonsoon (February to May) brought a higher catch rate ranging from 61.57 to 268.71 kg/hr during February and March respectively.

Qualitatively, nemipterids were the maximum, with a catch rate of 1437 kg/hr followed by *Sphyraaena* spp (322 kg/hr), carangids (100 kg/hr) and lizard fish (28 kg/hr) during July. Perches like *Epinephelus* spp (79.55 kg/hr) and *Diagramma* spp (31.82 kg/hr) were represented during the premonsoon month of July, while *Priacanthus* spp (500 kg/hr) was caught during September.

Bathymetric distribution

Depthwise catch details are presented in Table 3. It is discernible that the maximum catch rate of 1500 kg/hr was obtained from 60-80 m depth range. The next abundant catch rate of 535 kg/hr was recorded from deeper waters of >150 m depth. Deeper waters of 80-100 m range and shallow waters of 20-40 m, range brought almost similar catch rate of 423.45 kg and 410 kg respectively. The next catch rate in abundance was obtained from 40-60 m depth range (29.85 kg/hr) while there was no catch recorded from 100-150 m depth range.

Specieswise, 60-80 m depth range had *Nemipterus* spp (1171.45 kg/hr) followed by carangids (98.90 kg/hr), mackerel (45.45 kg/hr), and *Epinephelus* spp (167.56 kg/hr) as the dominant form while surprisingly at the depth range of 20-40 m, other forms such as *Sphyraena* spp (196.35 kg/hr), elasmobranchs (64.61 kg/hr), carangids (24.5 kg/hr) and *Lethrinus* spp (28.04 kg/hr) were the dominant forms. It may be pointed out that forms such as *Psenes indicus, Psenopsis cyaena, Priacanthus* spp. and balistids were dominant in deeper waters above 80 m in depth.

Table 3 - Bathymetric distribution and abundance (kg/hr) of various fishery resources along the southeast coast of India

Groups/species	Depth, range[m]				
	20-40	40-60	60-80	80-100	>150
Elasmobranchs	64.61	16.71	8.63	0	0
Carangids	24.5	55	98.9	4.46	0
Nemipterids	0.61	63.4	1171.45	167.56	0
Epinephelus spp	11.44	19.93	26.18	0	0
Lethrinus spp	28.04	11.43	0.9	0	0
Lutjanus spp	6.5	2.56	10.9	4.08	0
Lutianus spp	0	11.16	0.27	0.63	0
Pomadasys spp	0	5	0	0	0
Diagramma spp	10.09	7.46	0	0	0
Pentaprion spp	2.91	10.26	2.27	0	0
Other perches	1	1.23	24.36	3.83	0
Cat fishes	1.57	1.3	0	0	0
Sciaenids	8.16	6.9	0	0	0
Lizard fishes	0	4.43	13.9	5.72	0
Goat fishes	53.45	7.03	1.72	0.25	0
Leiognathus spp	11.06	1.7	0.27	0	0
Sphryaena spp	196.35	3.83	2.45	0	0
Seer fish	3.25	0.33	0	0	0
Mackerel	0	0	45.45	0	0
Dussumieria spp	1.34	0	0	0	0
Psenes indicus	0	2.51	20.45	12.77	83
Psenopsis cyaena	0	0	0	31.92	0
Priacanthus spp	0	0.83	4.54	156.44	16.16
Balistids	0	11.26	0	0	0
Miscell.fishes	37.46	2.83	46.81	21.07	425.33
Jelly fish	0	0.9	0	0	0
Crustaceans & cephalopods	5.83	11.76	21.27	15.32	10
Total(kg/hr)	410.1	291.85	1500.6	423.45	535

Areawise distribution

Details regarding the distribution and abundance of different groups of fish occurring in different areas are given in Table 4. It is evident that area 7°-77° (Wadge Bank) brought a catch rate of 2456 kg/hr contributed mainly by nemipterids (1807 kg/hr). Area 8 °- 78°(Gulf of Mannar) also indicated an abundant distribution with a catch rate of 4032 kg/hr,contributed mainly by pelagic groups such as *Sphyraena* spp (2801 kg/hr) followed by elasmobranchs (561.6 kg/hr) and carangids (161 kg/hr). Areas 11°-79° (Pondicherry) and 14°-80° (Krishnapatnam) with catch rate of 465.83 kg/hr and 266.31 kg/hr respectively had carangids as the main component. It is interesting to note that deep water forms such as *Psenopsis cyaena* and *Priacanthus* spp were caught mainly from 14°-80° area.

Distribution in relation to hydrographical parameters

Particulars on the distribution of dominant finfish resources in relation to hydrological parameters such as water temperature, salinity and dissolved oxygen are presented in Figs. 1 and 2. Maximum catch rate of nemipterids was obtained from 60-80 m depth range (1171 kg/hr) of area 7°- 77° (Wadge Bank), where water temperature was low being 24.37°C while salinity was moderate (35.33×10^{-3}). It may also be pointed out that at a particular station from where a catch rate of 9375 kg/hr of nemipterids was obtained, the water temperature and salinity were 22.10°C and 33.9×10^{-3} respectively. It is also evident that in other areas such as 11°- 79°, 11°-80°, 12°-80°, 13°- 80° and 14°- 80° of high water temperature regime and low salinity, low catch of nemipterids was obtained. Dissolved oxygen, however with a narrow range of 3.46 - 5.37 ml/l does not appear to have any influence on the distribution of nemipterids.

Other perches represented by species like *Epinephelus* spp *Lethrinus* spp, *Lutianus* spp, *Lutjanus* spp, *Pomadasys* spp, distributed mainly in 7°-77°, 7°-78°, 10°-80° and 11°-79° areas were found concentrated in 20-60 m depth range where generally low temperature (24.35°C - 25.21°C) and moderate salinity (35.78×10^{-3}) prevailed. Dissloved oxygen was in a range of 3.45 - 4.2 ml/l in different areas.

Barracudas and elasmobranchs were caught mainly from 20-40 m depth range of area 8°-78° (Gulf of Mannar) where the average water temperature was warmer (24. 9°C) with moderate salinity (35.6×10^{-3}) and high dissolved oxygen content (4.2 ml/l). It may also be noticed that in the depth range of 40 - 60 m in the Gulf of Mannar area, where the temperature was very high being 27.5°C with higher salinity range of 35.9×10^{-3} catch was negligible in spite of high dissolved oxygen content (4.3 ml/l). Carangids were found distributed more in 60-80 m depth in 11°-79° area and 40-60 m depth range of 7°-78° and 14°-80° area, where salinity was moderate within the range of $28.9 - 29.5 \times 10^{-3}$. It may be noticed that temperature was low (24.35°C) in 7°- 78° area, but was moderate or high in other areas of their

Table 4 - Areawise distribution (kg/hr) of various fishery resources along the southeast coast of India during 1985-90

Groups	Areas								
	7°-77°	7°-78°	8°- 77°	8°-78°	10°-80°	11°- 79°	12°-80°	13°-80°	14°-80°
Elasmobranchs	34.27	0	120	561.6	0	39.42	13.2	2.86	20.86
Carangids	77.87	600	70	161	6.62	141.98	2.49	6.22	58.85
Nemipterids	1807	0	0	0	0	1.57	10.15	9.53	0.32
Epinephelus spp	85.71	0	250	0	7.43	5.25	0.36	6.22	8.44
Lethrinus spp	12	6	200	6.43	10.05	45.99	0	0.56	11.89
Lutjanus spp	0	0	0	6.43	5.48	22.33	0	0.23	2.21
Lutianus spp	14.85	160	0	0	0	0	0.92	0.16	9.83
Pomadasys spp	0	0	0	0	17.14	0	0	0	0
Diagramma spp	0	400	0	120	2.74	0	0	0	2.45
Pentaprion spp	0	0	0	0	1.37	0	0.02	18.67	3.27
Other perches	3.54	0	0	0	2.05	32.85	0.55	1.26	0
Cat fishes	4.11	0	0	22.4	0	0	0	0	0.24
Sciaenids	0	0	0	0	0	1.07	0	11.67	0
Lizard fishes	28	0	0	0	0	7	1.84	0.39	0.08
Goat fishes	9.71	20	0	0	2.45	2.89	0	3.76	6.55

Contd...

Table 4 — *Contd...*

Groups	Areas								
	7°-77°	7°-78°	8°- 77°	8°-78°	10°-80°	11°- 79°	12°-80°	13°-80°	14°-80°
Leiognathus spp	0	50	0	12	11.22	7.75	0	3.02	0
Sphyraena spp	4.8	0	0	2801	0	0	2.86	3.51	3.44
Seer fish	0	0	0	40	0	0	0.46	0.28	0.24
Mackerel	0	0	0	0	0	65.7	0	0	0
Dussumieria spp	0	0	0	0	0	0	0	1.34	0
Psenes indicus	71.31	50	0	0	0	0	0	0	0
Psenopsis cyanea	0	0	0	0	0	0	0	0	20.49
Priacanthus spp	10.85	0	0	0	0	0	0.46	0	102.45
Balistids	37.48	120	0	0	0.59	0	0	0	0
Miscell.fishes	221.51	590	40	214.4	15.7	72.46	5.52	10.82	11.47
Jelly fish	0	0	0	0	0	0	0	1.51	0
Crustaceans and cephalopods	32.6	120	20	60	6.97	20.76	6.04	7.85	3.21
Total catch	2456.06	2000	770	4032	89.71	465.83	38.96	85.86	266.31

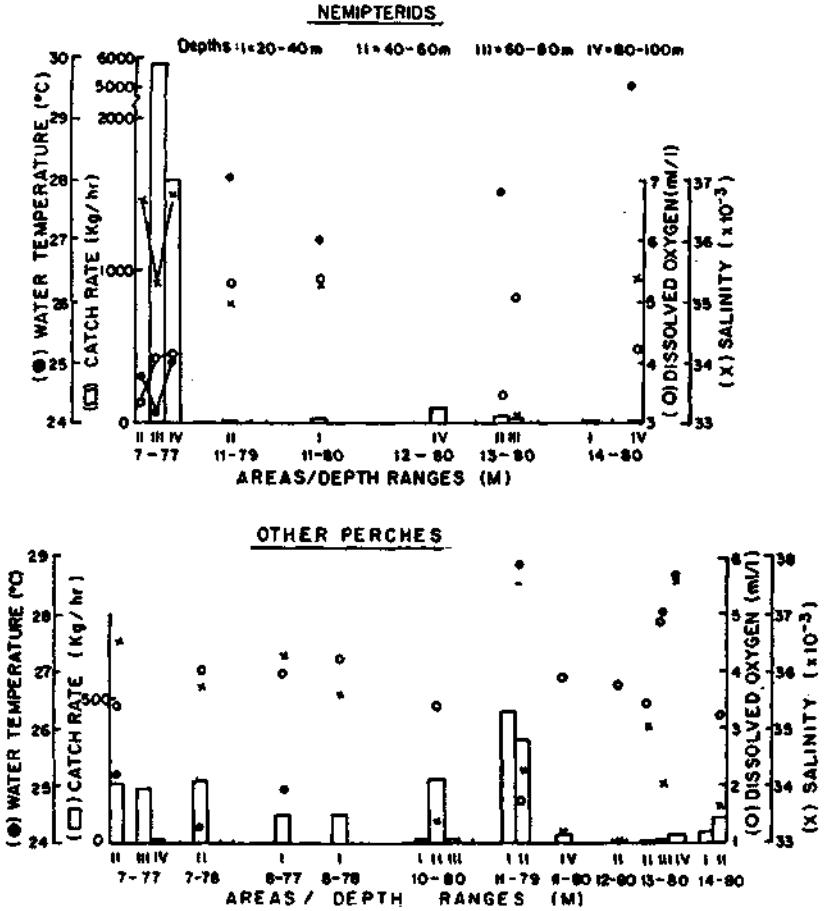

Fig. 1 — Catch rate (kg/hr) of Nemipterids and other perches caught in relation to water temperature, salinity and dissolved oxygen of the nearest fishing depth from the southeast coast of India

occurrence. Dissolved oxygen was fairly high within the range of 3.45 - 5.27 ml/l, except in 11°- 79° area where it was only 1.81 ml/l.

DISCUSSION

The higher catch rates obtained during the premonsoon season (June-September) in the present study may be attributed to the higher phytoplankton production which is accounted to be 2 to 2.5 times more than that of northeast monsoon period along the southern part of Bay of Bengal (Sukhanova, 1964). This view is supported by the fact that along Palk Bay region, very high values of organic production to the tune of 435 mg C/m / day to 2340 mg C/m /day was reported during June to July months, and also because of the time lag involved in the drifting nature of plankton blooms, a slightly extended periodicity up to September can be justified in yielding good catches.

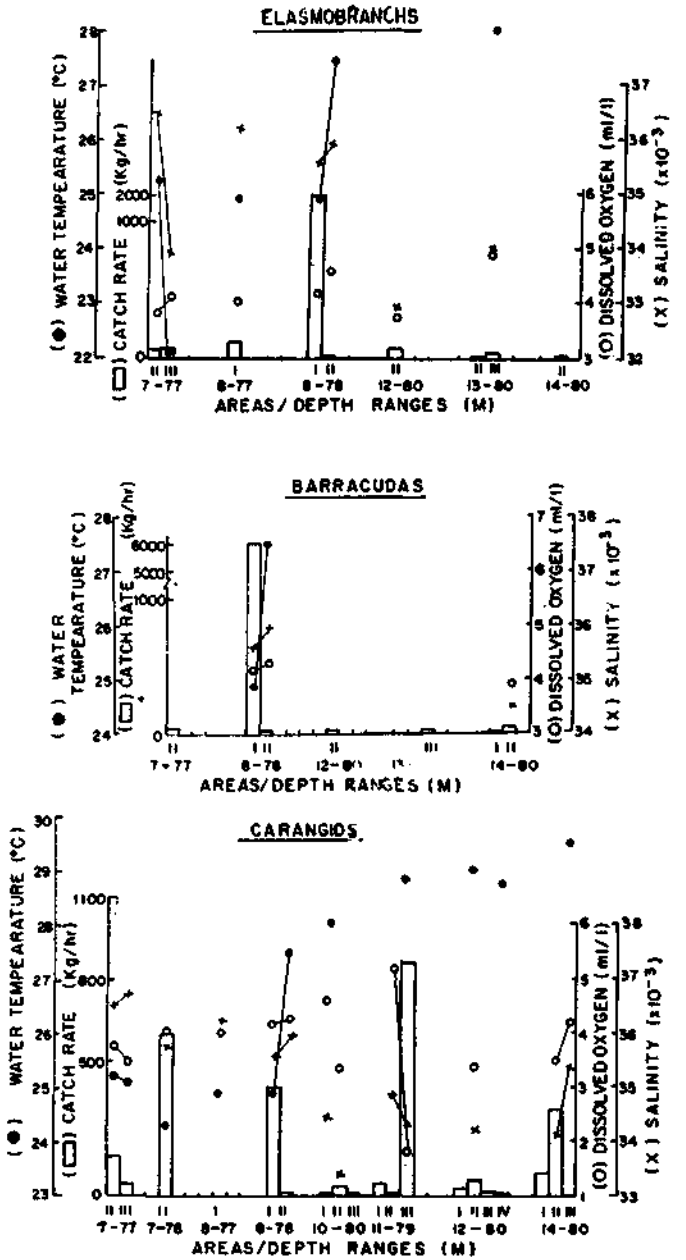

Fig. 2 — Catch rate (kg/hr) of elasmobranchs, barracudas and carangids caught in relation to water temperature, salinity and dissolved oxygen of the nearest fishing depth from the southeast coast of India

It may also be noticed that the catch rate is minimum during the northeast seaon (October-January). While the lesser coverage during the monsoon season cannot be ruled out, it may be pointed out that the standing crop of phytoplankton during the northeast monsoon season is several times less than that of southwest monsoon season (Subrahmanyan, 1973). Further it is reported that in region between 8° and 12° N, the waters were barren during the transition period of October-December period between the monsoons (Zernova & Ivanov, 1964). And the increase in catch rate observed during the postmonsoon period may be due to the reported upwelling occurring in the Bay of Bengal from January to June at different centres along the east coast (Varadachari & Sharma, 1967). It may therefore be surmised that fish production in Bay of Bengal is highly influenced by monsoon shifts as is also suggested by Steemann-Nielson & Jensen (1957) and an extensive investigation during different season is necessary in order to give a true picture.

Bathymetric distribution (Table 3) of major finfish resources as observed in the present study shows that maximum concentration is recorded in 60 -80 m depth range, with other depth ranges moderately populated. It is generally observed that productivity is more towards the shore decreasing seaward (Nair *et al.* 1973). But according to Radhakrishna *et al.* (1972), the shelf and slope waters are equally productive with less intensity in the offshore areas. However, being influenced by the various eco-biological factors such as temperature, light, availability of food etc., fish tend to move to and from the shallow and deeper waters and the behavioural pattern of fish may account for making both shelf and slope waters more or less equally distributed with fish.

A scrutiny of the catch particulars in the present study indicates that nemipterids and barracudas (*Sphyraena* spp) the most dominant groups caught were obtained from the Wadge Bank and Gulf of Mannar area respectively during July, the former being caught from 60-80 m depth range and the latter from shallow waters of 20 - 40 m depth range. It may also be noticed from the present results that deeper areas of Wadge Bank had cooler waters of high salinity, while Gulf of Mannar area had warmer waters of moderate salinity. Upwelling has been reported to be pronounced during July-September period along the southwest coast, which extends up to the Wadge Bank area off Cape Comorin (Banse, 1959,1968). The upwelled waters are rich in nutrients, with low temperature and dissolved oxygen and high salinity brought from the deeper areas. The hydrological variations in the waters of Wadge Bank and Gulf of Mannar may be due to the difference in the extent of upwelling in these areas and also due to the influence of fresh water discharge into the Bay of Bengal. The abundance of nemipterids in the Wadge Bank area may be due to their preference for cooler upwelled waters rich in nutrients. Further postulating a theory of correlation of nemipterid fishery with the hydrological conditions of the adjacent waters, Krishnamoorthy (1973) reported that the hydrological changes may have some effect too close to be casual on the benthic organisms on which nemipterids feed. It is also possible that the distribution of nemipterids may have some relation with their breeding grounds for these fishes are reported to breed in trawling grounds beyond 50 m depth (Murthy, 1984). Therefore there is scope to believe that food and spawning

exert some influence on the abundance of nemipterids in the trawling grounds (Appa Rao, 1989) which in turn are influenced by hydrological factors, for water temperature alone or in conjunction with salinity, regulates maturation of ova, buoyany of eggs, larval development and abundance of preferred food.

Likewise, barracudas which abound the shallow inshore waters were found to prefer warmer low saline waters of Gulf of Mannar. Here, it may be surmised that barracudas prefer the waters of Gulf of Mannar, since in the Bay of Bengal,the shelf waters are nearly isothermal without much fluctuation (Subrahmanyan, 1973).

James (1973) has observed the Gulf of Mannar area to be one of the rich grounds for elasmobranchs with skates and rays confined mostly to 15-37 m depth range. Moreover, the appearance of sharks along the east coast is very often noticed in association with the abundance of their food-fish such as sardines and mackerels (Devadoss *et al.* 1989), whose distribution in turn is influenced by fluctuations in hydrological factors such as water temperature and salinity within 20 m depth range (Ramana *et al.* 1991). Therefore, it may be concluded that the distribution of elasmobranchs in the Gulf of Mannar area may have some relation with the availability of their food fishes, whose distribution in turn is controlled by the prevailing hydrological characters.

Wadge Bank area was reported to be one of the richest perch (Kalava) grounds (Silas, 1969) with species like snappers (*Lutjanus* spp,) preferring high saline waters. These fishes are known to inhabit the crevices of rocky beds of varying depths, coming out occasionally in shoals for food from the nutrient rich upwelled waters (Menon *et al.* 1977). The distribution of species like *Epinephelus* spp, *Lethrinus* spp, *Lutianus* spp etc. in the Wadge Bank area may probably be related to their preference for suitable substratum and optimum hydrological conditions.

Carangids in the adult stage are reported to be piscivorous preferring *Stolephorus* spp (Sreenivasan, 1978; Sivakami, 1993). According to Narayana Pillai (1991) *Stolephorus* spp, avoiding unfavourable temperature in the Ratnagiri - Karwar region and further south , tend to migrate to the southeast coast between Cape Comorin and Tuticorin in dense congregations during June to October period. Nursery grounds of carangids are also being located in the central and southern shelf including Wadge Bank area (Rao *et al.* 1977). The distribution of carangids in the 7°-78°, 8°- 78° and 11°-79° areas, as observed in the present study may therefore be attributed to their feeding and breeding requirements.

The effect of low oxygen content in the upwelled water is a matter of concern. According to Banse (1959, 1968), the low oxygen content which goes even below 0.15 ml/l can adversely affect the distribution of demersal fishes. However according to Murthy (1992), the dwindling of fish catches may be caused by the toxic effect of bacterial load in the upwelled water. Narayana Pillai (1991) states that the upwelled water gets oxygenated within a short time due to contact with atmosphere and also due to wind action. In the present study, dissolved oxygen content in different depth ranges was generally within a range of 3.45 - 5.27 ml/l and did not exhibit any adverse

influence on the distribution of fish fauna. And the higher oxygen content of the waters of the Bay of Bengal may be due to lesser organic content (Subrahmanyan, 1973).

Movements of fish tend to be influenced by water movements and plankton bloom, with the water movement dependent on temperature, salinity gradient and wind action , and plankton production on the nutrient in the water (Subrahmanyan, 1973). While pelagic fishes such as sardine and mackerel, subsist on plankton, with the predators like elasmobranchs around, bottom feeding fishes thrive on benthic organisms which in turn subsist on the plankton-dead or alive,sinking to the bottom. Thus the distribution of pelagic and demersal fish is to a great extent influenced by the dynamic interactions of different trophic levels. In the present case, it is found that when the nutrient rich warmer upwelled waters of high salinity in the Wadge Bank harbours fish like nemipterids and other perches, pelagic forms such as *Sphyraena* spp, elasmobranchs and carangids form congregations in the Gulf of Mannar area, where their smaller food fishes like sardine, mackerel and whitebaits thrive favoured by the optimum water temperature and salinity conditions. It is therefore felt that for a thorough understanding of the distribution of different groups of fishes in time and space, it is imperative that the interaction of different trophic levels with the prevailing hydrological and meteorological conditions need be examined which can help a long way in locating and forecasting the fishing grounds and thus enhancing the fish production.

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REFERENCES

Appa Rao, T. 1989. Fishery of threadfin bream at Waltair with notes on some aspects of biology of *Nemipterus mesoprion* (Bleeker), *J. Mar. Biol. Ass. India.* 31 (1&2): 103 - 109.

Banse, K. 1959. On upwelling and bottom trawling off the south- west coast of India, *J. Mar. Biol. Ass. India.* 1 (1) : 33-48.

Banse, K. 1968. Hydrography of the Arabian Sea shelf of India and Pakistan and effects demersal fishes, *Deep-Sea Res.* 15: 45-79.

Devadoss, P., Kuthalingam, M.D.K. & Thiagarajan, R. 1989. The present status and future project of elasmobranch fishery in India, In: *Nat. Symp. On R & D in Marine Fisheries,* Part I : CMFRI, Bull. 44:188-198.

James, P.S.B.R. 1973. Sharks, rays and skates as a potential fishery resources off the east coast of India, In: *Proc. Symp. Mar. Liv. Res. Seas India.* Spl. Pubn. (CMFRI, Cochin) 483 - 494.

Krishnamoorthy, B. 1973. An assessment of nemipterus fishery off Andhra-Orissa coasts based on exploratory fishing, In: *Proc. Symp. Liv. Res. Seas India*: Spl. Pubn. (CMFRI, Cochin) 495 - 516.

Menon, M.D., Varghese C.P. & Haridas, C., 1977. Development of Trap fishing for rock cod off southwest coast of India, *Seafood Export J.* 9 (1): 5-14.

Misra, K.S. & Menon, M.A.S. 1955. On the distribution of the elasmobranchs and cheimaeras of the Indian region in relation to the mean annual isotherms, *Rec. Indian Mus.* 53 : 73-86.

Murthy, V.S.R. 1984. Observations on the fishery of threadfin breams (Nemipteridae) and on the biology of *Nemipterus japonicus* (Bloch) from Kakinada, *Indian J. Fish.* 31 : 1-18.

Murthy, A.V.S., Gopalakrishna Pillai, N. Zafar Khan, M. Sunil Kumar, K.U. & Alavandi, S.V. 1990. Variation in fish catches from the continental shelf between Quilon and Gulf of Mannar and its relation to oceanographic conditions during the southwest monsoon period, In : *Proc. Ist Workshop FORV Sagar Sampada,* edited by K. J. Mathew, (CMFRI, Cochin) 291 - 294.

Murthy, A.V.S. 1992. A critical study on the bad effects of upwelled waters on fisheries as exemplified by the situation of the Kerala-Karnataka region of the west coast of India, *J. Mar. Biol. Ass. India,* 34 (1 & 2): 246-252.

Nair, P. V. R. Samuel, S., Joseph, K.J. & Balachandran, V.K. 1973. Primary production and potential fishery resources in the seas around India, In: *Proc. Symp. Liv. Res. Seas India,* Spl. Pubn. (CMFRI, Cochin) 184-198.

Narayana Pillai, V. 1991. Salinity and thermal characteristics of the coastal waters off southwest coast of India and their relation to major pelagic fisheries of the region. *J. Mar. Biol. Ass. India,* 33 (1&2) : 115-133.

Radhakrishna, K., Bhattathiri, P.M.A. & Devassy, V.P. 1978. Primary productivity of the Bay of Bengal during August - September period, *Indian J. Mar. Sci.* 7: 94-98.

Ramana, T.V., Nathaniel D.E. & Reddy, M.P.M. 1991. Distribution of some oceanographic factors in the Arabian Sea off Manjeswar and their possible effect on oil sardine and mackerel fisheries in the area, *J. Mar. Biol. Ass. India,* 33 : 9-18.

Rao, K.V.N., Kumaran, M. & Sankarasubramanyan, J. 1977. Resources of horse mackerel off the southwest coast of India, *Seafood Export J.* 9 : 9-27.

Silas, E.G. 1990. Exploratory fishing by *R.V. Varuna, Bull. Cent. Mar. Fish. Res. Inst.* 12: pp. 86.

Sivakami, M.S. 1993. On the food habits of the fishes of the family Carangidae (Unpublished).

Sreenivasan, P.V. 1978. Observations on the fishery and biology of *Megalaspis cordyla* at Vizhinjam, *Indian J. Fish.* 25 (1&2) : 122-140.

Steeman-Nielson, E. & Jensen, E.A. 1957. Primary oceanic production. The autotrophic production of organic matter in the oceans, Galathia Repts. Copenhagen, I, 4: 49-136.

Subrahmanyan, R. 1973. Hydrology and plankton as indicators of marine resources, In : *Proc. Symp. Liv. Res. Seas. India. Spl. Pubn.* (CMFRI, Cochin) 199-228.

Sukhanova, I.N. 1964. The phytoplankton of the northeastern Part of the Indian Ocean in the season of the southwest monsoon, *Trud. Inst. Okeanol. Akad. Nauk. SSSR.* 65 : 24-31.

Varadachari, V.V.R. & Sharma, G.S. 1967. Circulation of the waters in the north Indian Ocean, *J. Indian Geoph. Uni.* 4 (2) : 61-63.

Virabhadra Rao, K. 1973. Distribution pattern of the major exploited marine fishery resources of India, In: *Proc. Symp. Liv. Res. Seas India* Spl. Pubn. (CMFRI, Cochin) 18 - 101.

Zernova, V.V. & Ivanov, A. 1964. On the distribution of phytoplankton as depending from hydrological conditions in the northern part of the Indian Ocean, *Trud. Inst. Okeanol. Akad. Nauk. SSSR.* 64: 257 - 264.

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