Marine Fisheries Research and Management

Editors
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2000

22 Carangid resources of India

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ABSTRACT

A review of the research work carried out so far on various aspects of the carangid resources has been made in this paper based mainly on the published contributions of Central Marine Fisheries research Institute. The fluctuations in the fishery since 1950 and its present status, in the light of the improved tackling devices and changed fishing patterns, have been analysed. A drastic increase in the landings was noticed since 1985 which was mainly due to the mechanization of the country crafts, the use of purse seine and ringseine, intensification of trawling and the introduction of multiday fishing. The studies on the food and feeding habits have revealed that almost all species of carangids are pelagic carnivores, feeding mainly on a variety of smaller crustaceans and fishes. The stock assessment studies conducted on certain commercially important species have shown that most of them are either optimally or under-exploited and hence there is scope for increasing the production without adverse effect on the sustainability of the stocks.

Introduction

The carangids are pelagic fishes widely distributed in the Indo-Pacific region and their importance in the Indian fishery is highly significant as they constitute nearly 7% of the annual marine fish landings in India in the current decade. The Family Carangidae includes horse-mackerels, queen fishes, scads, pompanos and darts and is represented by 140 species under 25 genera. They occur abundantly in shallow waters upto 60m depth along both the coasts supporting fisheries almost round the year particularly along Andhrapradesh, Tamil Nadu, Kerala and Karnataka. The commercial fishery is supported mainly by *Megalaspis cordyla, Decapterus russelli, Alepes djedaba, Atule mate, selar*

crumenophthalmus, *Selaroides leptolepis*, *Caranx* spp., *Carangoides* spp.,*Scomberoides* spp. and *Trachinotus* spp.

The carangid species are mostly schooling fishes (*Alectis* spp. are generally solitary) and some are largely continental in distribution and occur primarily in brackish environment (especially young ones) while others are oceanic pelagics. The larger species of *Trachinotus*, *Seriola* and *Caranx* are highly regarded as sport fish (FAO, 1984).

Earlier investigations on carangidae were restricted to a few species such as *Selaroides leptolepis*, *Caranx kalla*, *Megalaspis cordyla*, *Decapterus russelli* etc. All such studies pertain to systematics, species descriptions, distribution, occurrence, behaviour, and reports on new records (Tandon, 1959; Srinivasa Rao, 1966; Reuben, 1967, 1968b; Luther, 1968; Meenakshisundaram and Gnanamuthu, 1968; Murty, 1972; Sreenivasan, 1974 b; Raje, 1984; Nair and Pillai, 1987; Yohannan and Balasubramaniam, 1987; Joel et al. 1987; Sivakami and Seetha, 1990; Gopakumar and Thomas, 1991 and Sivakami *et al.*, 1996; Mahadevan, 1950; Tandon, 1960a; and Venkataraman and Ramanathan, 1982). Association of certain marine carangid species with other organisms, especially medusae, have been reported by Panikker and Prasad (1952), Jones (1960) and Noble (1963). Investigations on the eggs and larvae were conducted by Delsman (1926 a & b), Devanesan and Chidambaram (1941), Devanesan and Varadarajan (1942), Chidambaram (1943), Gopinath (1946), Bapat and Prasad (1952), Bapat (1955), Kuthalingam (1959), Basheeruddin and Nayar (1962), Rao (1963), Subrahmanyan (1964, 1966), Rao and Girijavallabhan (1973) and Premaletha (1988, 1991). Accounts on the fishery and biology have been published by Chacko and Mathew (1955), Tandon (1960b, 1962a,b), James (1964), Rao *etal.* (1977), Sreenivasan (1978a,b), Bapat *etal.* (1982), Kasim and Khan(1986), Premalatha (1993), Raje(1994), Sivakami *etal.* (1994) and Sivakami (1995). The food and feeding habits of carangids include the works of Datar (1954) on *Caranx rottleri* (Cuv. & Val); Kuthalingam (1955, 1959) on *Caranx djedaba* and *M. cordyla*; Tandon (1960b,c) on *S. leptolepis*; Kagwade (1967) on *C. kalla*; Reuben (1969) on *Carangoides malabaricus*; Sreenivasan (1974a, 1979) on *M. cordyla* and *D. dayi* and Hamsa and Kasim (1989) on *C. carangus*. Publications on length-weight relationships, age, growth and size at first maturity in carangid species include those of Tandon (1961a, 1961b, 1962c), Kagwade (1968 a), Radhakrishnan (1973) and Sreenivasan (1981a, 1982). Investigations on various aspects of the biology,

population dynamics and stock assessment of carangid species of Indian waters date back to 1962. The publications in this field are those of Tandon (1962c) on *S. leptolepis*, Banerji (1973) on carangid group in general, Rao *et al.* (1977) on the horse mackerel, Murty (1991) on *D. russelli*, Reuben *et al.* (1992) on a number of species, Dhulkhed and Annigiri (1994) on carangids of Karnataka coast and Kasim and Hamsa (1994) on *C. leptolepis* and *C. carangus*.

Data base

The catch statistics published in various issues of Marine Fisheries Information Service and other publications of the Central Marine Fisheries Research Institute, Cochin are used to describe the status of the carangid fishery in India. State-wise, gear-wise, species-wise data on estimated catch and effort during 1985-93 were provided by the NMLRDC of CMFRI. Available published information on the carangid resources of India contributed by the CMFRI and other Institutes/Universities formed the other main sources for the preparation of this review paper.

Status of the fishery

During the last five decades the carangid production in India has been showing annual fluctuations. The annual landings varied from 6122 tonnes in 1950 to 196871 tonnes in 1995 (Fig.1) at an annual average of 51899 tonnes, carangids constituted 1.06% (in 1950) to 8.25% (in 1992) of the total all India marine fish landings. The fishery showed a steady but slow progress

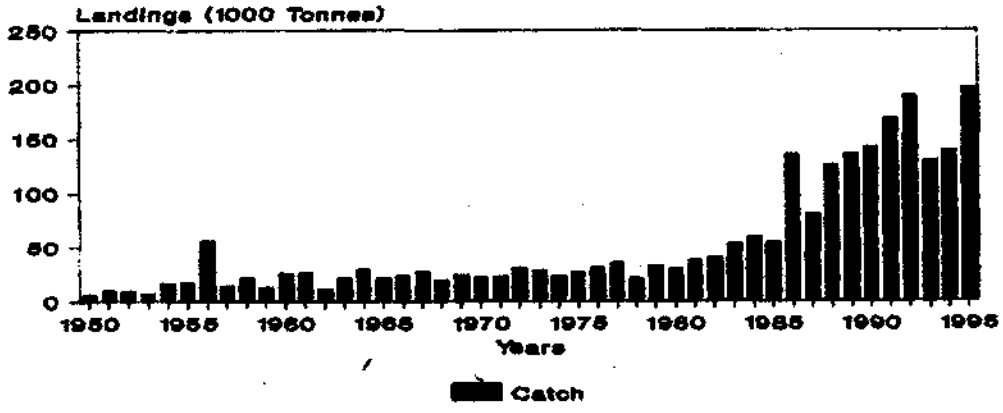


Fig.1. Annual Landings of Carangids During 1950 to 1995

till 1980 and thereafter it improved slightly. From 1986 onwards a marked increase in production could be noticed.

The average annual landings during 1950-55 and thereafter in different decades from 1956 to 1995 were worked out and the results indicate that during 1950-55 the average catch was 11262 tonnes. In the 1956-65 period it increased to 23885 tonnes, showing a 112% rise. During 1966-75 it increased to 24674 tonnes, which was 3.3% more than that of the previous decade. In 1976-85 and 1986-95 the increases were to the tune of 59.1% and 267.3% compared to their preceding decades and the average landings were 39247 and 144164 tonnes respectively. A tremendous increase in the fishery could be noticed since 1985 (Fig.1) and it could mainly be due to the mechanization of country crafts initiated in 1980s and the intensification of trawling operations including multi-day fishing being practiced subsequently. These factors enabled to extend the fishing areas to distant and hitherto unexploited grounds. The introduction of ringseine in the coastal fishery also could have helped in enhancing the production from this sector.

The west coast of India was the major contributor (69.6%) to the all-India average annual carangid catch. The contributions from the east coast and island territories were 29.6% and 0.7% respectively. The trend of the contribution by these regions to the fishery in different decades showed a decline for the east coast (from 52.9% in 1956-65 to 18.3% in 1986-95) and an increase for the west coast (from 47.1% in 1956-65 to 80.8% in 1986-95) and the island territories (from 0.3% in 1966-75 to 0.9% in 1986-95). A major portion of the production along the east coast (94.8%) came from the southern states comprising Andhra Pradesh, Pondichery and Tamil Nadu and 83.1% of the west coast production came from Kerala, Karnataka and Goa. (Table 1).

Table :1 Contribution by east and west coasts and island territories to the total carangid catch in different periods from 1956 to 1995 (Annual Average)

Periods	East coast		West coast		Island territoris		Total
	Catch (t)	%	Catch (t)	%	Catch (t)	%	Catch (t)
1950-55	0	0	0	0	0	0	11262
1956-65	12627	52.9	11257	47.1	0	0.0	23885

1966-75	12503	50.7	12085	49.0	86	0.3	2474
1976-85	17220	43.9	21701	55.3	326	0.8	39247
1986-95	26427	18.3	116442	80.8	1295	0.9	144164
Year Avg.	17194	29.6	40371	69.6	427	0.7	57992*

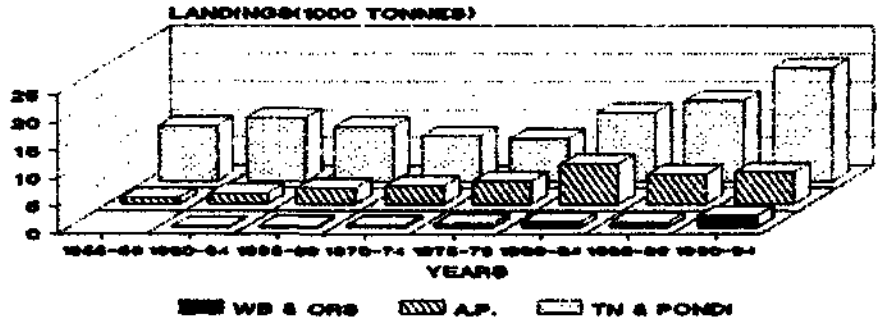
* Annual average for the period 1956-95. (1950-55 excluded)

Statewise-production: Kerala is the major contributor to the carangid catch in India. During 1956-94 period nearly 38% of the average annual catch was obtained from this state whereas the contributions of other states were 25.1% by Tamil Nadu, 11.1% by Karnataka, 8.1% by Maharashtra, 7.2% by Andhra Pradesh and 3.7% by Gujarat. A comparison of the statewise contribution during the last two decades of 1975-84 and 1985-94 shows that there has been a substantial increase in the catch in Kerala, from 29.2% (1975-84) to 43.8% (1985-94). Similarly progress was noticed in Karnataka and Maharashtra. In the case of Tamil Nadu, Goa, Andhra Pradesh, West Bengal (including Orissa) and Gujarat their contribution comparatively decreased in 1985-94. It may be concluded that in the past two decades, 64.3% during 1975-84 and 72.8% during 1985-94 were obtained from the southern states of Karnataka, Kerala and Tamil Nadu (including Pondichery). The State-wise average annual landings at 5 year intervals, starting from 1956 , are presented in Fig 2.

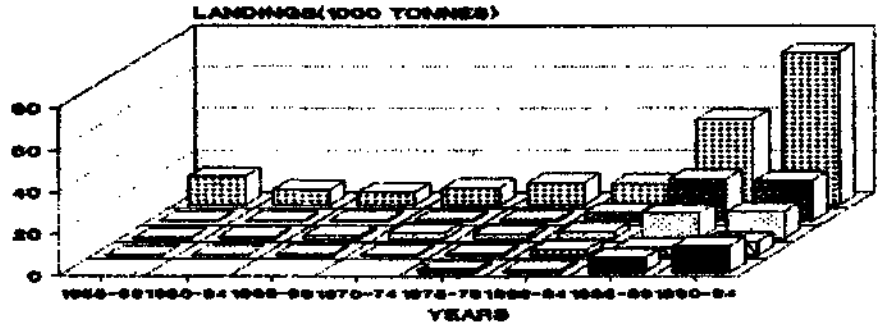
Craft and gears: Carangids are exploited using mechanized, motorized and non-motorized vessels of different types and sizes ranging from the dug-out canoes to large trawlers, including catamarans, plank-built boats and many sorts of canoes with or without inboard or outboard engines.

Almost all types of gears such as the trawl net, gillnet, hooks & line, boatseine, shoreseine, ringseine and purseseine are employed in the exploitation of this resource. Pelagic trawl, shrimp trawl, ring-seine and purse-seine are the most effective gears at present, especially for smaller and medium sized species. In the case of the larger species drift gillnets and hooks & line are the most popular gears. Carangids are also caught in smaller quantities in the traditional gears like boat-seine and shore-seine.

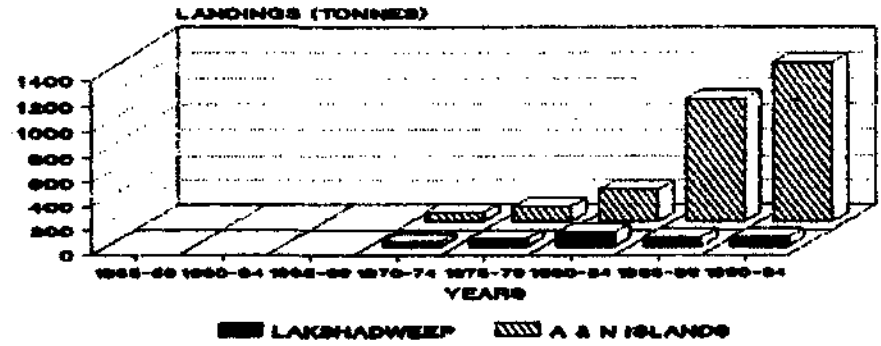
In Tamil Nadu, Kerala and Karnataka, which together contribute



A. EAST COAST



B. WEST COAST



C. ISLAND TERRITORIES

Fig.2. The average annual landings of carangids at different states (5 yearly average)

73% of the annual carangid catch, these fishes are landed both in mechanized (including motorized) and non-mechanized sectors. The production in the mechanized sector was 56.4% in Tamil Nadu, 91.9% in Kerala and 96.2% in Karnataka while in the non-mechanized sector it was 43.7%, 8.1% and 3.8% respectively. The gear-wise contribution to the fishery in three major states viz Tamil Nadu, Kerala and Karnataka shows that the trawl net is the major gear in Tamil Nadu (41.6%) and Kerala (37.6%) while it is the purse-seine in Karnataka (72.8%) with trawl net in the second position (20.9%). In Tamil Nadu and Kerala the second important gear was gillnet (16.6%) and ringseine (34.9%) respectively.

Seasonal abundance

The trend in seasonal abundance of carangids during 1985-93 period was analysed (Table 2) and the results are compared with an earlier period of 1956-68 (Table 3) inorder to know the change in the pattern of abundance over a period of time.

Table.2 Quarter-wise Average carangids catch in different states during 1985-93

States	Factors	I Qrt	II Qrt	III Qrt	IV Qrt	Total
West Bengal &	Catch	416	148	232	563	1359
Orissa	%	30.6	10.9	17.0	41.4	100
Andhra Pradesh	Catch	2312	1200	980	1055	5547
	%	41.7	21.6	17.7	19.0	100
Tamil Nadu &	Catch	3560	3683	5179	4004	16426
Pondichery	%	21.7	22.4	31.5	24.4	100
East Coast	Catch	6288	5031	6391	5622	23332
	%	27.0	21.6	27.4	24.1	100
Kerala	Catch	4686	8115	26985	16846	56632
	%	8.3	14.3	47.6	29.7	100
Karnataka &	Catch	4161	1728	7451	18490	31829
Goa	%	13.1	5.4	23.4	58.1	100

Maharashtra	Catch	2547	1699	871	6714	11831
	%	21.5	14.4	7.4	56.8	100
Gujarat	Catch	944	781	711	1974	4409
	%	21.4	17.7	16.1	44.8	100
West Coast	Catch	12338	12323	36018	44024	104701
	%	11.8	11.8	34.4	42.0	100
All India	Catch	18626	17354	42409	49646	128033
	%	14.5	13.6	33.1	38.8	100

Table:3 Quarter-wise average carangid catch in Different states During 1956-68

States	Factors	I Qrt	II Qrt	III Qrt	IV Qrt	Total
West Bengal & Orissa	Catch	26	43	41	81	191
	%	13.4	22.7	21.3	42.6	100
Andhra Pradesh	Catch	408	627	765	689	2489
	%	16.4	25.2	30.8	27.7	100
Tamil Naadu & Pondichery	Catch	2155	2723	3734	1739	10351
	%	20.8	26.3	36.1	16.8	100
East Coast	Catch	2589	3393	4540	2509	13031
	%	19.9	26.0	34.8	19.3	100
Kerala	Catch	431	464	3634	2701	7230
	%	6.0	6.4	50.3	37.3	100
Karnataka & Goa	Catch	248	37	74	331	690
	%	35.9	5.4	10.7	48.0	100
Maharashtra	Catch	165	89	127	453	834
	%	19.8	10.7	15.2	54.3	100

Gujarat	Catch	53	293	55	219	620
	%	9.6	9.4	41.5	39.5	100
West Coast	Catch	897	883	3890	3704	9374
	%	9.6	9.4	41.5	39.5	100
All India	Catach	3486	4276	8430	6213	22405
	%	15.6	19.1	37.6	27.7	100

Along the east coast, during 1985-93, the catch was almost uniformly spread throughout the year. The range in quarterly variations was only 5.8% with the contribution varying from 21.6% in the second quarter to 27.4% in the third quarter. In West Bengal and Orissa the maximum occurrence was in the 4th quarter (41.4%) followed by 1st quarter. In Andhra Pradesh it was the 1st and the 2nd quarters respectively. In Tamil Nadu and Pondichery the peak season was in the 3rd quarter followed by 4th quarter.

Along the west coast, the 4th quarter followed by the 3rd quarter emerged as the peak periods contributing 42% and 34.4% respectively. But in the different States the pattern varied. In Kerala it was abundant in 3rd quarter followed by 4th quarter but in Karnataka-Goa the 4th quarter was followed by the 3rd quarter. In Maharashtra and Gujarat the maximum landing was in the 4th quarter followed by the 1st quarter. In general the peak season for carangid fishery in India starts in June, extends for a period of 6 months, and ends in December.

In the earlier period, 1956-68 (Table 3), the fishery was at its peak in the 3rd and 4th quarters. Along both the east and the west coasts the maximum abundance was in the 3rd quarter, but the second dominance was noticed in the 2nd quarter along the east coast and in the 4th quarter along the west coast. A comparison of catch trend in these distantly placed time intervals indicates that the period from July to December continues to be the peak season for carangid fishery in India.

Species composition

For the compilation of fisheries statistics in India the carangids are broadly grouped under four heads, namely horse-mackerel, scads, queen fishes and 'other carangids'. During 1985-93 (Table 4) the all India carangid catch was constituted mainly by the scads (45.8%) closely followed by 'other carangids' (39.2%). Horse- mackerel and queen fishes constituted 11.2% and 3.8% respectively. The species composition along the west cost reflected the all India trend but along the east coast it varied (Table 4) and the 'other carangids' constituted the bulk (66.2%) with the scads (16.9%) occupying the second position. The horse-mackerel and the queen fishes formed only 5.5% and 8.7% respectively. The State-wise percentage composition of the major groups is presented in Fig.3

Table 4. Species Composition of Carangids during 1985-93 (Average Catch in tonnes)

States	Species				
	Horse-mackerel	Scads	Leather-Jackets	Other carangids	Total
West Bengal	59	0	136	38	233
%	25.3	0.00	58.4	16.3	100
Orissa	404	106	160	455	1125
%	35.9	9.4	14.2	40.5	100
Tamil Nadu & Pondichery	117	2782	1320	12207	16426
%	0.7	16.9	8.0	74.3	100
East Coast	1297	4571	2021	15442	23331
%	5.5	19.6	8.7	66.2	100
Kerala	3213	35987	352	17079	56631
%	5.7	63.5	0.6	30.2	100
Karnataka	2632	8170	548	9810	21160
%	12.4	38.6	2.6	46.4	100
Goa	1710	4562	85	3716	10073
%	17.0	45.3	0.8	36.9	100

Maharashtra	3313	4515	536	3466	11830
%	28.0	38.2	4.5	29.3	100
Gujarat	2030	88	1291	100	3509
%	57.9	2.5	36.8	2.8	100
West Coast	12898	53322	2812	34171	103203
%	12.5	51.7	2.7	33.1	100
All India	14195	57893	4833	49613	126534
%	11.2	45.8	3.8	39.2	100

Megalaspis cordyla, commonly known as the horse-mackerel, is one of the major commercially important species of carangid. Large resource of this species has been discovered along the northwest coast of India by Bapat et.al (1982) in a survey programme of M.T.MURENA. Another important group is the round scads, constituted by *Decapterus. russelli* (= *D. dayi*),*D. macrosoma*, *D. macarellus* and *D. kurroides*. The species of queen fishes include *Scomberoides tala*, *S.lysan*, *S. commersonianus* and *S.tol*. The 'other carangids' include the trevellies, jacks and pompanos. Some of the species that contribute to the fishery in India are *Alectis indicus*, *A. ciliaris*, *Alepes kalla*, *A. djedaba*, *Atropus atropus*, *Atule mate*, *Carangoides armatus*, *C. chrysophrys*, *C. ferdau*,

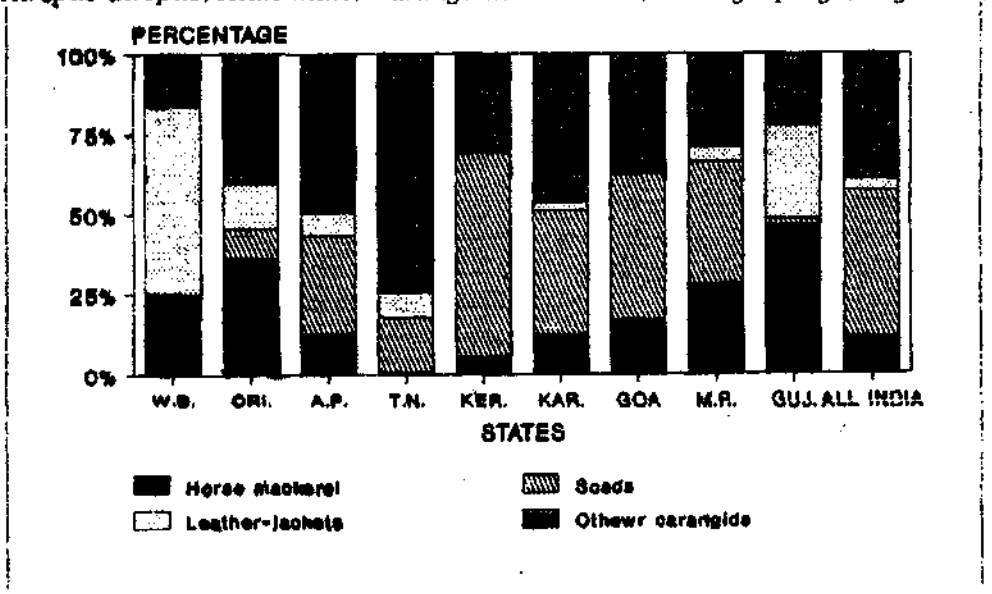


Fig.3. Percentage contintution of major carangid groups, state-wise and all India.

C. gymnostethus, C. malabaricus, C. oblongus, Caranx ignobilis, C. melampygus, C. carangus, C. sansun, C. sexfaciatus, C. sem, Elegatis bipinnulata, Gnathanodon specious, Selar crumenophthalmus, Selaroides leptolepis, Seriolina nigrofaciata, Trachinotus baillonii, T. blochii, Uraspis uraspis, Trachycentron canadus, and *Trachurus trachurus*. Among the 35 and odd common species occurring along the coast, a few like *M. cordyla, D. russelli, Alectis spp. Alepes djedaba, A. kalla, Atropus atropus, Carangoides malabaricus, C. chrysophrys, Atule mate, Selar crumenophthalmus, Selaroides leptolepis, Caranx carangus, C. ignobilis, C.malampygus* and *C. sexfaciatus* contribute significantly to the fishery with spatial and temporal variations. Some species of queenfishes and jacks attain large sizes whereas most others are moderate and medium sized and are abundant in large schools.

Migration

Information on the migration of carangid species is scanty. Since they are fast-moving shoaling fishes they are expected to undertake migratory movements. Rao *et al.* (1977) observed that species of horse-mackerel are fast swimmers, highly schooling and migratory. Their survey along the southwest cost of india has shown that good concentrations of these fishes shift northward from southern shelf to the central and northern shelf areas by September-October with maximum accumulations occurring in the northern area by May-June. Thereafter the migration of the stock from the central and northern area of the south west coast takes place both to oceanic area as well as southern latitudes. High level abundance of the horse-mackerel is available for a much longer period off the coasts of Kerala and southern Tamil Nadu and for a much shorter duration off Karnataka and southern Maharashtra. As these fishes grow bigger and older, they move to oceanic habitats and their inshore migration during post monsoon is mainly for the purpose of breeding and feeding. The horse-mackerel and scads also exhibit diurnal variation in the distribution pattern. Generally during the day these fishes are found as dense vertically extended schools at or near the bottom and at night they are found ascending to surface layers either in dispersal state or in schools. Meenakshisundaram and Gnanamuthu (1968) observed the shoreward migration of *Caranx sexfaciatus* during December along the Madras coast for feeding . The migration of *D. russelli* has been reported by Bapat *et.al.* (1982) and stated that the fish probably migrates to the deeper waters after attaining the penultimate stage of maturity. This is evidenced by

the availability of specimens in running stage in 91-125m depth area and in V stage in 55-90m depth area. Shore-ward migration of schools of *Selar crumenophthalmus* during December has been reported by Nair and Pillai (1987) from Vizhinjam.

Size distribution

The carangids show a wide range of sizes. The maximum size of the smallest species (*Caranx kalla*) is 16 cm fork length and that of the largest species (*Caranx ignobilis*) is 146 cm fork length (Smith-vaniz 1984). The length range of *M. cordyla* reported by Lipton *et al* (1988) seems to be unrealistically small (5-15 cm), as the maximum size reported is 80 cm total length. On the other hand the sizes of *C. chrysophrys* (36-85 cm), *C. malabaricus* (15-65 cm) and *S.leptolepis* (54-69 cm) reported by Bapat *etal.* (1982) also seem to be very high because the maximum sizes recorded for these species are only 38.5 cm, 24 cm and 18.5 cm fork length respectively. *D. russelli*, the most abundant species, has a length range of 3-27 cm total length with 12 to 23 cm constituting the commercial fishery.

Age and growth

Published accounts on age and growth of carangid species are very few. The earliest study is that of Tandon (1962c) on *S.leptolepis* based on length frequency analysis. He estimated that the species grows to a size of 123 mm at the end of one year. Kagwade (1968a) observed that *Caranx kalla* from Calicut area, attains a length of 82, 132 & 167 mm at the end of 1st, 2nd and 3rd year respectively. The growth parameters were $L\infty = 217$mm and K= 0.71. Sreenivasan (1978 b & 1982) studied the growth of *M.cordyla* and *D.dayi* respectively from Vizhinjam and estimated the growth parameters. Later Murty (1991) estimated the growth and mortality parameters of *D.russelli* from Kakinada and Reuben *et al* (1992) on a number of species from different regions along the coast of India. The findings of these investigations are presented in Table 5. The methodology followed in these studies is mainly the length frequency analysis. The ELEFAN I programme (Pauly and David. 1981) and Witheral method were also employed to estimate $L\infty$ and K. Similar studies were also conducted by Kasim and Hamsa (1994) on *C.leptolepis* and *C.carangus* from Tuticorin.

Table 5. Estimated Growth parameters of certain species of caramgids by different workers

Authors	Year	Species	Locality	length at age in mm	Growth parameters L∞	K/Yr	to
Tandon	1962	*Selaroids loptolepis*	Mandapam	I-year 123	202	0.82	-
Reuben et al	1992	*Selaroides leptolepis*	Pondichery		202	0.82	
Kasim & Hamsa	1994	*Caranx leptolepis*	Pondichery		213	1.43	-0.015
Kagwade	1968	*Caranx kalla*	Calicut	I-year 82 II-year 132 III-year 167	271	0.71	-
Sreenivasan	1978	*Megalaspis cordyla*	Vizhinjam	I-year 250 II-year 290 III-year 320 IV-year 330 (Fork length)	420 FL	0.131	-5.0099
Reuben et al	192	*Megalaspis cordyla*	East coast		410	0.52	
			North-west coast		525	0.82	
			South-west coast		394.4	0.60	
Sreenivasan	1982	*Decapterus dayi*	Vizhinjam	I-year 150 19months 184 (Fork length)	260FL	0.1858	0.50
Murty	1991	*Decapterus russelli*	Kakinada		232.3TL	1.08	-0.08
Reuben et al	1992	*Decapterus russelli*	East coast		221	0.71	
			North-west coast		299	0.45	
			South-west coast		248	0.78	
Reuben et al	1992	*Caranx carangus*	Tamil nadu & Pondichery		444	0.65	
Reuben et al	1992	*Atropus atropus*	North-west coast		440	0.65	
Reuben et al	1992	*Alepes djadaba*	Kerala coast		326	0.61	
Reuben et al	1992	*Atul mate*	Kerala coast		340	0.85	
Kasim & Hamsa	1994	*Caranx carangus*	Tuticorin		498	0.77	0.0455

Length-weight relationship

The earliest study on the length-weight relationship of a carangid species from Indian waters was that of Tandon (1962a) on *S.leptolepis*. He drew a common equation for both the sexes as there was no significant difference between the sexes in their regressions.

The studies on *D.dayi* by sreenivasan (1981) from Vizhinjam showed

that the 'b' values of males and females did not vary significantly, but a pooled value (2.9886) for both the sexes was significantly different from that of the indeterminates (3.1691). The estimate by Murty (1991) was slightly higher (3.4076) compared to the observations of Sreenivasan (1981) and Reuben *etal* (1992). The 'b' values of length-weight regression of *M.cordyla* obtained for different regions by Reuben *et al* (1992) and by Sivakami (1995) for Cochin were found to be less than 3. In *Atropus atropus* the'b' value calculated by Reuben *etal.* (1992) for the northwest coast (2.8570) was slightly higher than that observed by Raje (1994) from Veraval region (2.6133). In *Caranx carangus* the studies by Reuben *et al* (1992) and Kasim and Hamsa (1994) showed that the estimates of 'b' was almost identical and was less than 3. The length-weight relationship of *Alepes kalla* and *Atule mate* studied by Reuben *et. al* (1992) and the 'b' values estimated were 3.2443 and 3.0569 respectively. In all these studies significant difference in the 'b' values between sexes were not reported, but Sreenivasan (1981) observed that indeterminate and adults of *D.dayi* differed significantly at Vizhinjam.

Food and feeding

The studies conducted so far reveal that these fishes are generally pelagic carnivores feeding mainly on fishes and crustaceans. The account by Kuthalingam (1955) on the feeding habits of *Caranx djedaba* from Madras coast is the first of the kind on carangid species. He observed that these fishes feed less during the immature stages than when they are mature. But according to Sivakami (1990) it had lower stomach volume during breeding period and the fish within a length range of 150-199 and 240-319 mm showed preference for young fish while those in the 200-239 mm range relished ostracods and other crustaceans. According to Venkataraman (1960) crustaceans formed the major food of the species.

M.cordyla, according to Kuthalingam (1959), is a carnivore, feeding mostly on crustaceans. The early post-larva of this species begins on a diet of copepod nauplii and diatoms but gradually changes over to larger pelagic organisms as it grows and finally subsists on planktonic as well as nektonic organisms. Sreenivasan (1974) observed that the intensity of feeding decreased with the advancement of maturity and it was higher during night than by day. It has been generally accepted by all that this fish preferred fish items especially *Stolephorus* spp. though crustaceans were also found in the stomach.

Decapterus russelli is also a pelagic carnivore and according to Basheeruddin and Nayar (1962) the young ones of the size 4-12 cm feed mainly on crustaceans like *Acetes* and copepods. Sreenivasan (1979) noticed that the adults of this species prefer fishes like *Stolephorus* spp., *Leiognathus* spp. and *Sardinella* spp. while the small fishes preyed mostly upon crustaceans. He observed that at Vizhinjam this species was feeding actively during pre and post-monsoon months but poorly during monsoon and that neither the stage of maturity nor the time of the day had much influence on feeding.

According to Tandon (1960b,c) *S.leptolepis* is a carnivore feeding on crustaceans, fishes, algae and diatoms. Though there is no change in the food of this species in different stages of maturity it showed indications of cessation of feeding during night. Tandon (1960b) studied the food of *C.sexfaciatus* and *C.melampygus* also and compared it with that of *S.leptolepis*. According to him both these species devoured fishes and the former devoured *Anchoviella* spp. while the latter preferred *Leiognathus* spp. Meenakshisundaram and Gnanamuthu (1968) also noticed that *Anchoviella* spp. is the preferred food of *C.sexfaciatus*.

Caranx mate (=*Atule mate*) is another carnivorous carangid feeding chiefly on planktonic crustaceans. According to Kuthalingam (1959) this fish feeds throughout its life on planktonic crustacea though they also feed on numerous clupeoid larvae. Basheeruddin and nayar (1962) also observed the juveniles of *S.mate* of the size 2-12 cm feed mainly on crustaceans.

The feeding habits of *Alectis indicus*, *Carangoides armatus*, *C.malabaricus*, *Caranx carangus*, *Chorinemus tolu* and *Trachinotus blochii* were studied by Basheeruddin an Nayar (1962), who found that these are mainly carnivores feeding on crustaceans and juvenile fishes. According to Reuben (1968) *C.malabaricus* along Visakhapatnam is a carnivore and column feeder. Hamsa and Kasim (1989) noticed that the food of adult *C.carangus* above 150 mm is fish followed by crustaceans, but the young ones upto 149 mm sustained only on prawns. This was in agreement with the observation made by Basheeruddin and Nayar (1962) who noticed that the juveniles of *C.carangus* from Madras fed exclusively on stomatopod larvae, other crustaceans and tubiculous polychaetes. The food of *Chorinemus lysen*, according to James (1964), comprised *Lucifer* and juvenile fishes especially *Leiognathus* spp.

A detailed study on the food of *Caranx kalla* by Kagwade (1967) revealed

that the adult of the species is a plankton feeder (pelagic crustaceans and molluscan post-larvae) but the juveniles fed also on diatoms and dinoflagellates in addition to the zooplankton. He noticed that the rate of feeding is low during the peak breeding period. Similar behaviour was observed in *Atropus atropus*, a pelagic carnivore, by Raje (1994) along Veraval coast. According to Venkataraman (1960) prawns and copepods comprised the main food of *C.kalla*.

All these studies clearly indicate that the carangids are generally pelagic carnivores feeding mainly on pelagic crustaceans, small fishes, molluscan larvae, etc. Occasional occurrence of plant material was also noticed in the diet of a few species. Carangids are generally continuous feeders but diurnal and seasonal variations in the feeding habits do occur in certain species.

Size and age of maturity

The sizes at first maturity of a few species of carangids have been worked out. It includes *C.kalla, M.cordyla, D.dayi, S.leptolepis, A.djedaba, C.carangus, A.mate and A.atropus*. The results of these studies by different authors are presented in Table 6.

Kagwade (1968 b) observed that in *C.kalla* 50% of the females matured first at the size of 124 mm total length and the condition factor recorded the minimum value at a length of 122 mm for the females and 117 mm for the males when they are considered mature for the first time. The size of first maturity of this species noticed by Reuben *et al* (1992) is slightly higher (129 mm) than that observed by Kagwade (1968 b) and it attains the age of 1.7 years at this time.

In the case of *M.cordyla*, Sreenivasan (1978) observed that both the sexes attain maturity at a minimum length of 250 mm and 50% become mature at 270 mm when it attains 1 year of age. But according to Reuben *et al* (1992) the size and age of first maturity are 250 mm and 1.8 years respectively.

According to Murty (1991) *D.russelli* attains first maturity at 150 mm when the fish is 0.88 year of age whereas Reuben *et al* (1992) are of opinion that the fish matures at the size of 137 mm when it is 1.36 years old along the east coast and the northwest coasts indicating a slower growth rate, and 1.03 years along the southwest coast.

Tandon (1961 b) observed that in *S.leptolepis* the males mature slightly earlier than the females and all the males and females above 110 mm were mature. But according to Reuben *et al* (1992) this fish matures at a still smaller size of 88-101 mm when the age is 0.72-0.85 year.

Spawning and recruitment

The spawning habits and seasons of some common species of carangids occurring along the coast of India have been studied by different workers based on the gonadial maturity, ovadiametre distribution, larval occurrence and recruitment size and seasons. The results are tabulated in Table 6.

It could be noticed that most of the carangids spawn twice in a prolonged spawning season. Restricted spawning was noticed in *A.atropus* by Reuben *et al* (1992). Raje (1994) observed that the ripe speciemens of A.atropus are available for the major part of the year at Veraval, which suggest that the species has a prolonged spawning season with two peaks, but admits that further investigations are needed in this regard.

The workers on *S.leptolepis* agree that the species spawns twice in a year, during January-March and July-October. According to Reuben *et al* (1992) the intensive spawning is in October and another less intensive one in July. Tandon (1962 a) observed that the females dominated generally but during spawning season they mix almost equally (M:F=1:1).

It is generally accepted that *M.cordyla* has a prolonged spawning season but the individual fish breeds only once. Sreenivasan (1978) found that at Vizhinjam it spawns intensely during the monsoon, beyond 5 km from the fishery belt and the probable time of spawning is night. Bapat *et al* (1982) also agree that the fish had a prolonged spawning season but the peak spawning takes place during winter (December-February). They also noticed that the males generally dominated in January-May, August and November; females in July & December and the sexes were equal in June. According to Sivakami (1995) the overall dominance of females in the population was evident at Cochin area. While studying the fish larvae in the plankton along the south-west coast of India Premaletha (1993) noticed that the larval concentration of the species was maximum along the shelf edge off Calicut area, followed by Karwar, Cochin and Quilon areas, indicating these as the spawning grounds. The probable breeding ground of the species, according to Sivakami (1995), is towards the northern belt near Calicut with moderate

intensity at Kochi.

A prolonged spawning season extending from February to November was observed in the case of *D.dayi* by Sreenivasan (1981) at Vizhinjam but at Kakinada, Murty (1991) noticed that the fish spawns twice in a season. Reuben *et al* (1992) also observed that the individuals of the species released the eggs in two spurts. Premalatha (1993) opined that males were dominant in the catch and the concentration of larvae were more from Quilon to Capecomerin region and their occurrence was maximum during May to November. Sreenivasan (1981) expressed the view that at Vizhinjam the species spawns at night in the inshore waters.

In the case of *C.kalla* , Kagwade (1968b) observed that the individual fish has one short spawning period, but the species as a whole was found to spawn all round the year with two peaks, the major one during December-January and a minor one during May-June. Reuben *et al.* (1992) also observed similar behaviour along the south-west coast but the peaks noticed were slightly different, the pronounced one being slightly earlier (October) and the less pronounced one slightly late (July). Kagwade (1968b) observed that the females were dominant in smaller size-groups and males in the higher size groups. However it was nearly 50:50 during the months of June, August and October of some years.

A.djedaba has a prolonged breeding season from July to November and releases two batches of eggs during the period (Sivakami. 1990). Reuben *et al* . (1992) also observed two peaks, a major one in December followed by a less pronounced one in September. The species showed predominance of males in most of the months at Cochin (Sivakami 1990).

Two spawning periods were observed in *A.mate* (Reuben *et al.* 1992) and *Chorinemus lysan* (James 1964). In the latter species the sexes were found to be equally distributed in the commercial catch.

The recruitment periods of the species studied by Reuben *et al* (1992) are presented in Table 6.

Fecundity

The fecundity of *S.leptolepis* (Tandon, 1962a), *Chorinemus lysan* (James 1964), *C.kalla* (Kagwade, 1968b), *M.cordyla* (Sreenivasan, 1978, Sivakami,

1995), *D.dayi* (Sreenivasan, 1981) and *A.atropus* (Raje, 1994) were studied and the results are tabulated in Table 6.

Table : 6 Spawning biology of some carangid species

Author	Species and Locality	Spawining season	Recruitment period	Size & age at first maturity	Fecundity
1	2	3	4	5	6
Sreenivasan (1978)	***Megalaspis Cordyla***	Apr.-Feb.	-	270mm	91854 to
	vizhinjam	Peak:May to Aug.-		1.0 Year	324292
Bapat et al. (1987)	***Megalaspis cordyla***	Aug. to Apr./May	-	-	
	North-west coast	Peak : Dec.-Feb.			
Reuben et al. (1992)	***Megalaspis Cordyla***				
	East coast	Mar.-May	Apr.-May	250mm	-
	North-west coast	July	Jan.-Oct.	1.8 Year	-
	South-west coast	Jan.	Jul.-Apr.		-
Premalatha (1993)	***Megalaspis Cordyla***	Apr. to May &	-	-	-
	South-west coast	Oct.-Nov.			
Sivakami(1995)	***Megalaspis Cordyla***	Apr.-Feb.	-	251-260mm	91854 to
	Cochin	Peak:May-Aug.			324292
Sreenivasan (1981)	***Decapterus dayi***	Feb.-Nov.	-	130-139mm	16388 to
	Vizhinjam	Peak:Feb.-Apr.		107640	
Murty (1991)	***Decapterus russelli***	Dec. to Aug.-	150mm	-	
	Kakinda				
Reuben et al. (1992)	***Decapterus russelli***				
	East coast	Apr. & Aug.	Jul.-Nov.	137mm	-
	North-west coast	Dec. & Aug.	Jun. & Jan.	1.36 year	-
	South-west coast	Dec. &Sep.	Jan. &July.	1.03 year	-
Premalatha (1993)	***Decapterus russelli***	May	-	-	-
	South-west cost				
Bapat et.al. (1987)	***Trachurus trachurus***	Jan.	-	-	-
	Gujarat				
James (1964)	***Chorinemus lysan***	Apr. to Aug.,	-	-	8-35 lakhs

	Rameswaram				eggs
Kagwade (1968)	***Caranx kalla*** Calicut	Dec.-Jan. & May. to June	Dec.-Jan. Jul-Aug	124mm	30000 to 75000 eggs
1	2	3	4	5	6
Reuben et al. (1992)	*Alepes kalla* South-west coast	Oct.-Jul.	Apr.-Jan.	129mm 1.7 year	-
Prabhu (1956)	***Selaroides leptolepis*** Mandapam	Feb. and Jul. to Aug.	-	139mm	-
Tandon (1962)	***Selaroides leptolepis*** Mandapam	Jan.-Mar. & Jul.-Oct.	-	101mm	373750
Reben et al (1992)	***Selaroides leptolepis*** Tamil Nadu	Oct.-Jul.	Jan. & Oct.	88-101mm 0.72-0.85 Year	--
Reuben et al (1992)	***Atropus atropus*** North-west coast	Nov.-Dec.	Apr.	210mm	0.65 year
Raje (1994)	***Atropus atropus*** veraval	Prolonged with tow peaks	--	210 mm	31432 to 372344
Reuben et al. (1992)	***Caranx carangus*** Tamil Nadu	Nov. & Apr.	Feb.-Mar. & Sep.	220mm 1.05 year	--
Sivakami (1990)	***Alepes djadaba*** Cochin	Jun. to Nov.	--	180-189mm	--
Reuben et al. (1992)	***Alepes djadaba*** Kerala	Dec. & Sep.	Jun. & Mar.	180-189mm	--
Reuben et al. (1992) --	***Atule mate*** Kerala	Apr.-May &Jun.-Feb.		Jul. & Oct. 0.83 year	172mm

Eggs and larval studies

The eggs, larvae and juvenile stages of some carangid species from Indian waters have been described by earlier workers. The species studied are *C.kalla* (Bapat and Prasad, 1952), *C.leptolepis* and *Caranx* spp. (Bapat, 1955), *M.cordyla* (Kuthalingam, 1959 and Premalatha, 1988), *C.mate* (Kuthalingam, 1959), *C.malabaricus*, *C.carangus* (Rao and Girijavallabhan, 1973), *Alectis ciliaris*, *A.indicus* and *Atropus Atropus* (Premalatha, 1991). These studies were

based on the plankton samples and the characteristics of eggs and larvae of different sizes/ages that have been described. The species, area of collection and the size/age of larvae described are presented in Table 7.

Bapat and Prasad (1952) collected young ones of *S.leptolepis* which schools round large medusae. Kuthalingam (1959) collected larvae from plankton, reared them to the identifiable size. He also studied their diet habits. The descriptions by Premalatha (1988) were based on the plankton collections of UNDP/FAO/Pelagic Fisheries Project during 1971-75 period along the south-west coast of India.

Table 7: Descriptions available on the larvae of carangid species

Author	Species	Locality	Stages described
1	2	3	4
Bapat and Prasad	*Caranx kalla*	Palk Bay	Larvae of the sizes 8.23mm, 11.75mm, 13.5mm, 21mm, 31.0mm & 55.0mm.
Bupat (1955)	*Caranx leptolepis*	Gulf of Mannar & Palk Bay	Egg, newly hatched larvae, one day, tow day & three day old larvae.
"	*Caranx sp.*	"	Egg, newly hatched larvae.
Kuthalingam (1959)	*Megalaspis cordyla*	Madras coast	Egg, just hatched larvae, 24 Hrs., 48 Hrs, 54 Hrs., 4th day, 7th day, 10th day, 14th day & 33rd day old larvae and juveniles.
Premalatha (1959)	*Megalaspis* cordyla	South-west coast	Larvae of the sizes 2.2, 3.7, 5.1, 7, 8, 10.3, 14 and 19mm; seasonal abundance and distribution of larvae described.
Kuthalingam (1959)	*Caranx mate*	Madras coast	Egg, just hatched larvae, 24 Hrs., 48 Hrs., 72 Hrs 13th day, 18th day, 27th day, and 38th day old larvae juveniles.
Premalatha (1991)	*Alectis ciliaris*	South-west coast	Larvae of sizes 4.3., 5,6,6.8 & 15mm are described.
"	*Alectis indicus*	"	Lavae of the sizes 2.7, 3.4,7 & 15mm are described.
"	*Atropus atropus*	"	Larvae of the sizes 4, 6.8 & 10.2 mm described
Rao and Girija-vallabhan (1973)	*Carangoides malabaricus*	Madras (Plankton)	Egg, newly hatched larvae, 1-day, 2-day and 3-day old pro-larvae described.
"	*Caranx carangus*	"	Egg, newly hatched larvae, 1-day and 2-day old pro-larvae described.

Population dynamics and stock assessment

Studies on the population dynamics and stock assessment of carangid species are very few and are limited to those by Murty (1991) on *D.russelli* from Kakinada; Reuben *et al* (1992) on 8 species namely *M.cordyla, D.russelli* (both from 3 regions viz. east, north-west & south-west); *C.carangus, S.leptolepis* (from Tamil Nadu and Pondichery region), *A.atropus* (from north-west coast); *A.kalla* (from south-west coast), and *A.djedaba* and *A.mate* (from Kerala coast); Kasim and Hamsa (1994) on *C.leptolepis* and *C.carangus* (from Tuticorin). The growth and mortality parameters estimated for the species are presented in Table 8 along with the MSY and exploitation levels.

Table:8 Estimated Mortality Parameters and status of the exploited stocks of certain carangid species by different workers

Authors	year	Species	Locality	Annual mortality rates			MSY (T)	Level of exploitation
				Total (Z)	Natural (M)	Fishing (F)		
Murty	1991	*Decapterus russelli*	Kakinada	6.65	1.90	4.75		
Reuben et al.	1992	*Decapterus russell*	East coast	2.83	1.35	1.48	2800	Optimum
			North-west coast	2.85	0.83	2.02	3500	Optimum
			South-west coast	3.88	1.26	2.62	22200	Optimum
Reuben et al.	1992	*Megalaspis cordyla*	East coast	3.08	0.84	2.24	1060	Optimum
			North-west coast	5.12	1.04	4.08	4727	Optimum
			South-west coast	2.85	0.93	1.92	8400	Optimum
Reuben et al.	1992	*Caranx carangus*	Tamil nadu & Pondichery	4.51	0.95	3.56	2600	Over
Reuben et al.	1992	*Atropus atropus*	North-west coast	6.84	1.26	5.58	953	Over
Reuben et al.	1992	*Alepes kalla*	Sout-west coast	3.08	1.40	1.60	14500	Under
Reuben et al.	1992	*Alepes djadaba*	Kerala coast	5.15	0.99	4.16	7800	Over
Reuben et al.	1992	*Atul mate*	Kerala coast	3.53	1.22	2.31	4300	Optimum
Reuben et al.	1992	*Selaroides leptolepis*	Tamil nadu & Pondichery	4.88	1.35	3.53	6600	Over
Kasim&Hamsa	1994	*Caqranx leptolepis*	Tuticorin	6.10	2.19	3.91		
Kasim&Hamsa	1994	*Caranx carangus*	Tuticorin	6.54	1.18	5.36		

The yield per recruit analysis of *D.russelli* by Murty (1991) from the trawl landings at Kakinada showed that with t_c above 0.6 the Y_w/R increased with increased effort (F), but does not reach the maximum. The highest Y_w/R, however is obtained with t_c at 0.6 only. According to him the length at first capture (l_c) estimated and time of capture (t_c) calculated were 158 mm and 0.98 year.

The mortality parameters of *C.leptolepis* and *C.carangus* of the Tuticorin area were estimated by Kasim and Hamsa (1994). They observed that the former species is not exposed to higher fishing pressure as in the case of the latter by trawl net and opined that the effort of trawl net may be increased further, whereas in the case of *C.carangus* further increase in trawl net effort may not be favorable unless the age at first capture is increased by increasing the cod-end mesh size, which is not practical. However, exploitation of this species by drift gillnet is recommended, provided the mesh size is increased to enhance the age at first capture.

Banerji (1973) assessed the stock of carangids in Indian waters and stated that the then fishing intensity in all the states was exerting pressure on the coastal stocks of carangids. It was estimated that the expected potential sustainable yield for the whole of the country was not more than 25000 tonnes.

Rao *et al* (1977) studied the stock of horse- mackerel comprising the true horse- mackerel (*M.cordyla*), the scads (*Decapterus* spp.) and the trevellies (*Caranx* spp.) by conducting resource survey along the coast from Retnagiri to the Gulf of Mannar during the 1972-75 period. They are of opinion that the average standing stock along the project area was of the magnitude of 141000 tonnes which was considerably higher than the then all India yield. The average standing stock was estimated to be in the order of 140000 tonnes. They also observed that the average stock was the highest along the Kerala coast (70259 tonnes) followed by southern Tamil Nadu (56246 tonnes), Karnataka (20202 tonnes) and southern Maharashtra (12852 tonnes).

The studies by Reuben *et al.* (1992) showed that *M.cordyla* along the east and northwest coasts; *D.russelli* along the north-west coast, and *C.carangus* and *S.leptolepis* along the Tamil Nadu coast are being exploited expending much more effort than required to realize the MSY. But *D.russelli* along the east and the south-west coasts and *A.kalla* and *A. djedaba* along the Kerala coast can be exploited with increased effort of trawl net to enhance their production to MSY level. A similar condition is exhibited by *M.cordyla* along south-west coast for drift gillnet and *A.mate* along Kerala coast for hooks & line. Sivakami *et al.* (1996) reported that the potential yield of carangid along the EEZ of India is around 94971 tonnes.

All these studies, except that of Banerji (1973), positively indicate that most of the carangid species are either under exploited or optimally exploited

and hence there is scope for increasing the production especially along the south-west coast and the Gulf of Mannar, as stated by Rao *et al* (1977).

Conservation and management

The available information on the population characteristics and stock assessment on some commercially important species have shown that most of them are optimally or under-exploited. Over exploitation exists only in the case of *S.leptolepis* and *C.carangus* along Tamil Nadu coast; *A.atropus* along the north-west coast and *A.djedaba* along the Kerala coast. Otherwise, the carangids as a whole is an under exploited resource with great potential. Regulation of gillnet effort and mesh size has been recommended for the horse mackerel fishery as it exerts heavy fishing pressure on fishes of higher size groups, especially above 240 mm size.

Acknowledgments

The author is grateful to Dr. M. Devaraj, Director, Central Marine Fisheries Research Institute, Cochin and to Dr. N.G.K.Pillai, Head, Pelagic Fisheries Division, CMFRI, Cochin, for their encouragement and to Dr. P.P.Pillai, Principal Scientist, and Shri A.A. Jayaprakash, Senior Scientist, CMFRI, Cochin for their help and valuable suggestions for the improvement of the manuscript.

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