

Finfish diversity in the trawl fisheries of southern Kerala

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Among the maritime states of India, Kerala with a coastline of 590 km and 39,139 sq km of continental shelf area enjoys the distinction of being the foremost marine producer and exporter. The potential yield of the area up to 200 m depth has been estimated to be about 8 lakh tonnes.

Kerala records an average production of 5,74,984 t of fish annually (1995-2004). The estimated marine fish landing of Kerala during 2006 was 5.92 lakh tonnes which highlights an enhanced rate of over 10% caught in 2005 against the total production of 2.71 million tonnes recorded in India during 2006. Normally the catch is harvested by a variety of craft and gear combinations. Marine fishing using artisanal gears is an age-old tradition and in Kerala there are 9,522 such units in operation.

Motorisation with the outboard engines was the next phase of development and it played a vital role in the process of progress in fisheries. There are 14,151 units operating at present in Kerala. The next phase is mechanisation with inboard engines and there are 5,504 boats engaged in fishing. The trawlers constitute 72% (3,982) of the mechanised boats in Kerala.

The value of the annual marine fish catch in the domestic market realised at primary level (landing centre) is Rs.2,901 crores and at secondary level Rs. 4,855 crores. During the year 2006, India earned 1,479 million US \$ (Rs.6, 647 crores) as foreign exchange by exporting 4, 61,229 mt of marine products and Kerala contributed 17% (87,378 mt) in terms of 257million US \$ (Rs. 1,158 crores).

The fisherfolk population of the state is 6,02,234 living in 1,20,486 families spread over 222 fishing villages, of which 3,04,308 are males and 2,97,926 are females. The literacy rate among the population is 73% as per the Marine Census 2005. There are 178 fish landing centers in Kerala. A total of 1,24,103 fishers are engaged in fishing full time; 10,488 part time and 5,631 as occasional workers.

Marine fish catches of southern Kerala are mainly landed at Cochin and Sakthikulangara-Neendakara fisheries harbours. Apart from these two, there are a number of small harbours where mechanised boats land their catch such as Munambam, Azhikkal, Ponnani and Beypore. Other than these, there are 178 fish landing centers and many small landing jetties used by the mechanised boats to land their catch.

The marine fishery of Kerala is dominated by trawls. The trawl fishery contributes to the major share of the marine fish catch and the landing is composed of more fish varieties when compared to any other fishing gear. Trawl landings are concentrated at Quilon, Ernakulam and Calicut districts due to the availability of harbour facilities.

Due to the ever increasing pressure to maximize their returns trawl operators have recently, expanded their trawl fishing grounds to deeper areas by equipping their vessels with electronic fishing aids such as fish finders and Global Positioning Systems.

Craft and gear

Trawl net is the most effective gear to exploit demersal resources. Mostly medium sized vessels (8-20 m with 100-120 HP engines) operate trawl net to exploit the marine crustaceans, cephalopods and demersal finfishes from inshore to deeper sea grounds in Kerala. Generally, the trawlers use two-seam and four-seam trawl net with the head rope of 30-40 m length and 3-5 m vertical opening, with the cod end mesh size of 18-30 mm. Right from the mid-eighties, most of the trawl units switched over to multiday fishing operations, extending up to 80-120 m depth to exploit the mid-shelf grounds and the operational cost is reduced to a certain extent by using a combination of both day and night fishing.

Since the year 2000, the fishermen of Kerala have been engaged in deep sea trawling up to 450 m depth employing vessels of 14-19 m overall

length (OAL) equipped with 100-180 HP engines. The winch drum has been changed to accommodate up to 1,800 m of wire rope. The thickness of the wire rope has been increased to about 10 mm and the head rope length to 40 m. By minimizing the number of floats on the head rope and by reducing the trawling speed, these vessels are able to operate the net at greater depths.

Generally, 6-8 crew members go for fishing in each trip which lasts up to 2-3 days in the beginning of the season. As the season advances, the fishing vessels stay away from the harbours even up to 5-6 days. Some of the small sized vessels still conduct single day fishing.

Fishing areas

The trawlers conduct targeted fishery for prawns off Kanyakumari in the south and Beypore (Calicut) in the north during peak prawn season (November to March) up to 400 m. The rest of the period they do trawling in the coastal inshore and offshore waters up to the depth zone of 200 m.

The trawlers from Neendakara area generally do the fishing in the grounds lying between Kayamkulam and Anjuthengu and off Cape Comorin region.

Quilon Bank

The more productive fishing area in the south-west coast is the "Quilon Bank" lying between 08° N and 09° N lat. in the depth range of 275-375 m off Quilon- Alappuzha, covering an area of 3,300 sq. km. The depth zones off Kerala coast are shown in Fig. 1.

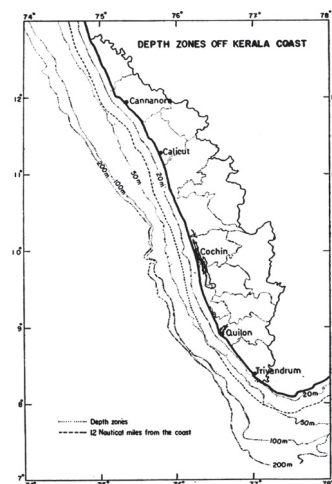


Fig. 1. Depth zones off Kerala coast (CMFRI, 1986)

Wadge Bank

The existence of good fishing ground in the "Wadge Bank" off Cape Comorin coast is well known to the fishermen of Kerala.

Perch grounds

The productive fishing ground for Kalava (Perches) is observed towards the north-west of Cochin off Chettuwa and Ponnani in the depth zone of 70-200 m.

Fishing season

The trawl fishery usually commences by September or October immediately after the south-west monsoon and extends throughout the year except during the mandatory fishing ban period.

Methodology

The present study was conducted for one year (*i.e.*, from January to December, 2006) in four major trawl landing centres *viz.*, Cochin, Munambam, Kalamukku and Neendakara along the south-west coast of India. Fortnightly field observations were made to collect species composition of finfishes landed by trawlers and monthly and annual estimates of total landings were following the Stratified Multi-stage Random Sampling Technique formulated by Central Marine Fisheries Research Institute (Sreenath *et al.*, 2005).

The diversity of finfishes was calculated following Shannon-Weiner (J1) and Pielou's evenness indices (J'). Since individual size of fish species differed greatly, the indices were expressed in terms of biomass and not in terms of number of individuals. Hill's abundance (N2) was used to examine the variation in the number of dominant species. Species richness was calculated following Margalef's index (d). The similarity in species composition was studied by calculating the Bray-Curtis Coefficient (Cluster analysis). The taxonomic distinctness (TD) was calculated for total species from presence/absence data. As these indices are helpful in finding out statistical deviation in biodiversity between the four centres, these were calculated for plotting 95% funnel and ellipse plots. However, all the diversity indices were done using the PRIMER V.5 analytical package developed by Plymouth marine Laboratory, UK.

Finfish catch from the trawl landing centers

The trawl landings of finfishes related to the in-house Project of the Marine Biodiversity Division, Code No. MBD/02 "Species diversity of the exploited marine finfish resources along the Indian coasts" were collected and the diversity studies were conducted mainly from four fish landing centers of southern Kerala, Sakthikulangara, Neendakara, Cochin and Munambam fisheries harbours and Kalamukku landing centre. The major fish landing centers of Kerala are marked in Fig. 2.



Fig. 2. Major fish landing centers of Kerala (CMFRI, 2007)

During the year 2006, the trawlers operated in the four centers landed a total catch of 70,788 t, of which the finfish resources constituted 81.6% (57,785 t). The Sakthikulangara- Neendakara centre landed 44.4% (25,635 t) of finfish catch followed by Munambam 28.3% (16,332 t), Kalamukku 16.1% (9,293 t) and Cochin 11.3% (6525 t).

Month-wise finfish catch in all the centers showed that finfishes were abundant during September-October (29.3%) and April-May (29.3%). The month-wise landings of finfishes are showed in Fig. 3.

Finfish family-wise distribution

The family Nemipteridae formed the major catch constituting 20.4% (11,801 t) followed by Carangidae 18.9% (10914 t), Trichiuridae 17.0% (9795 t), Engraulidae 10.2% (5903 t), Synodontidae 7.7% (4457 t). Other families contributing to over 1000 t are Cynoglossidae, Scombridae, Sciaenidae, Serranidae, Sphyraenidae, Clupeidae, Elasmobranchs

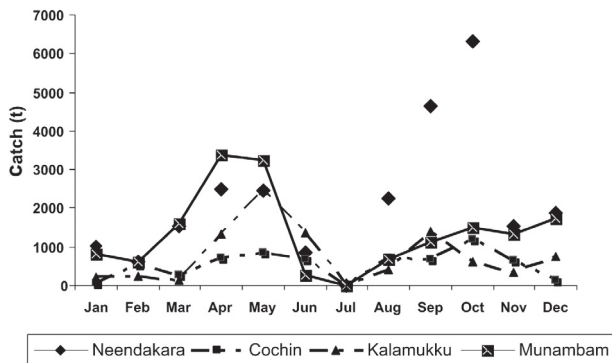


Fig. 3. Monthly catch of finfish in tonnes from four trawl landing centers of southern Kerala

and Leiognathidae. The family-wise catch is depicted in Fig. 4, 5a and 5b.

Center-wise trawl net catch composition

Finfishes from the trawl catches of Munambam were mainly composed of 12 families constituting 97.2% of the total. Nemipteridae formed 27.4% followed by Carangidae (19.5%), Engraulidae

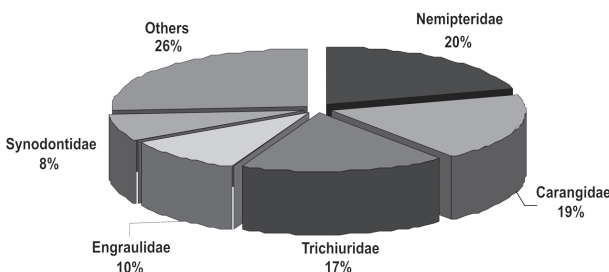


Fig. 4. Abundance of dominant families in the trawl landings

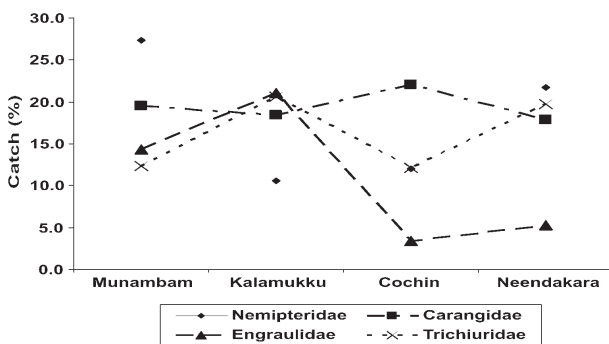


Fig. 5a. Catch percentage of major families in the four trawl landing centers

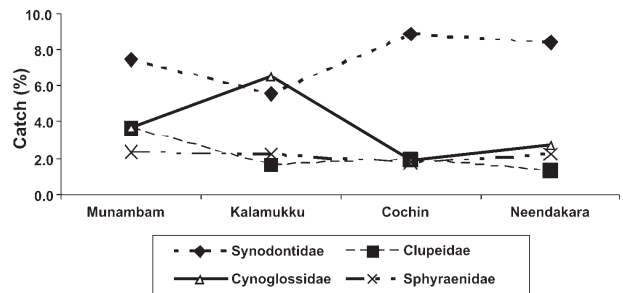


Fig. 5b. Catch percentage of major families in the four trawl landing centers

(14.4%), Trichiuridae (12.4%) and Scombridae (7.4 %) and the rest by other families.

Engraulidae, Trichiuridae, Carangidae and Nemipteridae were the four families, which contributed to 70% of the catch of Kalamukku. The other families such as Cynoglossidae, Synodontidae, Scombridae, Sciaenidae, Serranidae, Clupeidae and Leiognathidae formed more than 1% of the total finfish catch landed.

At Cochin Fisheries Harbour, 13 families constituted 83% of the total finfish catch in the trawl landings. Members of Carangidae contributed to (22.0%) followed by Trichiuridae and Scombridae (12.2% each) and Nemipteridae (12.0%) while the rest of the landings were by other families.

The major catch (73%) of Neendakara was formed by 5 families namely, Nemipteridae (21.7%), Trichiuridae (19.8%), Carangidae (17.8%), Synodontidae (8.4%) and Engraulidae (5.3%). Elasmobranchs and other 11 families were also significant in the trawl landings.

Diversity of finfish species

Finfishes landed by the trawlers in the four landing centers showed a wide diversity with 301 species belonging to 96 families. Neendakara exhibited the highest diversity with 223 species spread out in 81 families.

The highest number of species was represented in the family Carangidae with 28 species followed by Serranidae (17), Engraulidae (12), Leiognathidae (12), Lutjanidae (10) Sciaenidae (9), Nemipteridae (8), Bothidae (7) and Soleidae (7), Six families were recorded with 6 species each in Cynoglossidae, Gerreidae,

Mullidae, Platycephalidae and Scombridae. An equal number of 5 species was present in Dasyatidae, Rhinobatidae, Callionymidae and Clupeidae. Similarly, 4 species each in six families, 3 species in 12 families and 1 or 2 species in the rest of the families were observed.

Species diversity at Munambam was found to be higher in the family Carangidae with 21 species. Engraulidae and Sciaenidae were represented by 9 species each; Leiognathidae with 8, Serranidae with 7 and Nemipteridae with 6 species. The families with 4 species were Clupeidae, Mullidae and Scombridae. Three species each occurred in 5 families, 2 species in 12 families and only a single species in 33 families.

The number of species observed at Kalamukku was higher in the family Carangidae with 19 species followed by Engraulidae (11 species); Leiognathidae (8 species); Cynoglossidae (6 species), Clupeidae and Sciaenidae (5 species each). The families represented by 4 species were Nemipteridae, Platycephalidae and Scombridae. Three species each occurred in 5 families, 2 species in 12 families and only a single species was encountered in 34 families.

At Cochin Fisheries Harbour, species diversity was observed to be higher in the family Carangidae with 18 species; Engraulidae 10 species; Lutjanidae, Scombridae and Serranidae with 7 species each and Nemipteridae with 6 species. The families represented by 5 species were Clupeidae, Leiognathidae, Platycephalidae and Sciaenidae while Rhinobatidae was composed of 4 species. Three species of each was recorded in 8 families, 2 species in 12 families and only a single species in 20 families.

At Neendakara, species diversity was higher in the Family Carangidae with 15 species followed by Engraulidae and Serranidae with 10 species each; 9 species per family in Leiognathidae and Lutjanidae and 8 species in Nemipteridae. The families with 6 species were Mullidae and Soleidae. There were 5 families each with 5 species and 2 families by 4 species. Three species were encountered in 15 families and 2 species each by twenty one families followed by a single species in 30 families (Fig. 6).

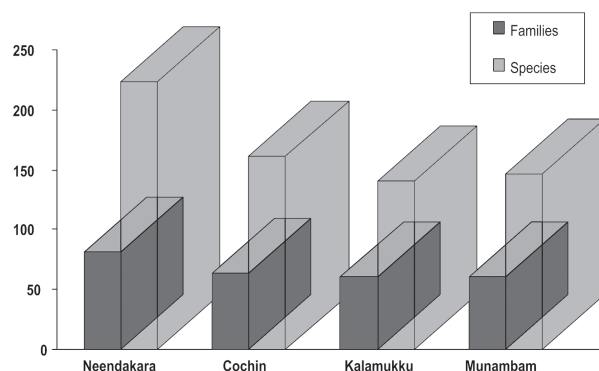


Fig. 6. Species diversity of finfish landed by trawlers in four trawl landing centers

Dominant species

In the trawl fishery the major species occurred were *Nemipterus randalli* with a catch of 9,729 t followed by *Lepturacanthus savala* with 8,277 t and *Decapterus russelli* with 8,083 t. Among dominant species, those which recorded catches of 500 t and above are given in Table 1. The species which occurred sporadically in the catches are listed in Table 2.

Table 1. Dominant species and their catches from trawl landing centers

Species	Catch (t)	%
<i>Nemipterus randalli</i> , Russell, 1986	9729	16.8
<i>Lepturacanthus savala</i> (Cuvier, 1829)	8277	14.3
<i>Decapterus russelli</i> (Rupell, 1830)	8083	14.0
<i>Saurida tumbil</i> (Bloch, 1795)	2519	4.4
<i>Nemipterus japonicus</i> (Bloch, 1791)	2045	3.5
<i>Saurida undosquamis</i> (Richardson, 1848)	1927	3.3
<i>Cynoglossus macrostomus</i> Norman, 1928	1782	3.1
<i>Trichiurus lepturus</i> Linnaeus, 1758	1518	2.6
<i>Epinephelus diacanthus</i> (Valenciennes, 1828)	1387	2.4
<i>Sardinella longiceps</i> Valenciennes, 1847	1157	2.0
<i>Stolephorus commersonii</i> , (Lacepède, 1803)	1107	1.9
<i>Stolephorus indicus</i> (van Hasselt, 1823)	977	1.7
<i>Encrasicholina devisi</i> (Whitley, 1940)	951	1.6
<i>Stolephorus waitei</i> Jordan & Seale, 1926	947	1.6
<i>Priacanthus hamrur</i> (Forsskål, 1775)	946	1.6
<i>Stolephorus insularis</i> Hardenberg, 1933	896	1.6
<i>Rastrelliger kanagurta</i> (Cuvier, 1816)	832	1.4
<i>Sphyræna obtusata</i> Cuvier, 1829	795	1.4
<i>Selar crumenophthalmus</i> (Bloch, 1793)	653	1.1
<i>Megalaspis cordyla</i> (Linnaeus, 1758)	644	1.1
Other tunnies	635	1.1
<i>Leiognathus daura</i> (Cuvier, 1829)	584	1.0
<i>Thryssa mystax</i> (Bloch & Schneider, 1801)	536	0.9
<i>Johnius glaucus</i> (Day, 1876)	500	0.9

Table 2. Occurrence of species sporadically or rarely in the catches

<i>Neoharriotta pinnata</i> (Schnakenbeck, 1931)	<i>Cynoglossus puncticeps</i> (Richardson, 1846)
<i>Rhina ancylostoma</i> Bloch & Schneider, 1801	<i>Paraplagusia</i> sp.
<i>Rhinobatos annandalei</i> Norman, 1926	<i>Dactyloptena orientalis</i> (Cuvier, 1829)
<i>Torpedo marmorata</i> Risso, 1810	<i>Dactyloptena peterseni</i> (Nyström, 1887)
<i>Centrophorus granulosus</i> (Bloch & Schneider, 1801)	<i>Drepane punctata</i> (Linnaeus, 1758)
<i>Acanthurus</i> sp.	<i>Echeneis naucrates</i> Linnaeus, 1758
<i>Apistus</i> sp.	<i>Stolephorus baganensis</i> Hardenberg, 1933
<i>Apistus carinatus</i> (Bloch & Schneider, 1801)	<i>Thryssa dussumieri</i> (Valenciennes, 1848)
<i>Erisphex pottii</i> (Steindachner, 1896)	<i>Emmelichthys nitidus nitidus</i> Richardson, 1845
<i>Apogon kiensis</i> Jordan and Snyder 1901	<i>Erythrocles schlegelii</i> (Richardson, 1846)
<i>Apogon quadrifasciatus</i> Cuvier, 1828	<i>Platax teira</i> (Forsskål, 1775)
<i>Arius thalassinus</i> (Rüppell, 1837)	<i>Platax orbicularis</i> (Forsskål, 1775)
<i>Arius subrostratus</i> Valenciennes, 1840	<i>Cypselurus poecilopterus</i> (Valenciennes, 1847)
<i>Arius jello</i> Day, 1877	<i>Fistularia petimba</i> Lacepède, 1803
<i>Sufflamen fraenatus</i> (Latreille, 1804)	<i>Fistularia commersonii</i> Rüppell, 1838
<i>Sufflamen</i> sp.	<i>Neoepinnula orientalis</i> (Gilchrist and von Bonde, 1924)
<i>Odonus niger</i> (Ruppell, 1840)	<i>Rexea prometheoides</i> (Bleeker, 1856)
<i>Chascanopsetta lugubris</i> Alcock, 1894	<i>Gerres limbatus</i> Cuvier, 1830
<i>Bothus pantherinus</i> (Rüppell, 1830)	<i>Gerres oyena</i> (Forsskål, 1775)
<i>Pseudorhombus natalensis</i> Gilchrist, 1904	<i>Gerres longirostris</i> (Lacepède, 1801)
<i>Bregmaceros mccllellandi</i> Thompson, 1840	<i>Pentaprion longimanus</i> (Cantor, 1849)
<i>Dipterygonotus balteatus</i> (Valenciennes, 1830)	<i>Caffrogobius</i> sp.
<i>Callionymus gardineri</i> Regan, 1908	<i>Taenioides cirratus</i> (Blyth, 1860)
<i>Callionymus marleyi</i> Regan, 1919	<i>Plectorhinchus albovittatus</i> (Rüppell, 1838)
<i>Callionymus beniteguri</i> Jordan & Snyder, 1900	<i>Sargocentron melanospilos</i> (Bleeker, 1858)
<i>Callionymus</i> sp.	<i>Sargocentron rubrum</i> (Forsskål, 1775)
<i>Callionymus carebares</i> Alcock, 1890	<i>Hologymnosus annulatus</i> (Lacepède, 1801)
<i>Atule mate</i> (Cuvier, 1833)	<i>Xyrichtys pentadactylus</i> (Linnaeus, 1758)
<i>Carangoides uii</i> / <i>Carangoides coeruleopinnatus</i> (Rüppell, 1830)	<i>Leiognathus leuciscus</i> (Gunther, 1860)
<i>Carangoides armatus</i> (Rüppell, 1830)	<i>Lobotes surinamensis</i> (Bloch, 1790)
<i>Carangoides ferdau</i> (Forsskål, 1775)	<i>Lophiodes mutilus</i> (Alcock, 1894)
<i>Carangoides talamparoides</i> (Bleeker, 1852)	<i>Lutjanus johnii</i> (Bloch, 1792)
<i>Ulua mentalis</i> (Cuvier, 1833)	<i>Lutjanus kasmira</i> (Forsskål, 1775)
<i>Uraspis secunda</i> (Poey, 1860)	<i>Pinjalo pinjalo</i> (Bleeker, 1850)
<i>Trachinotus mookalee</i> Cuvier, 1832	<i>Lipocheilus carnolabrum</i> (Chan, 1970)
<i>Psenopsis cyanea</i> (Alcock, 1890)	<i>Lutjanus lutjanus</i> Bloch, 1790
<i>Carangoides coeruleopinnatus</i> (Rüppell, 1830)	<i>Megalops cyprinoides</i> (Broussonet, 1782)
<i>Acanthocephala limbata</i> (Valenciennes, 1835)	<i>Gymnothorax enigmaticus</i> Mc Coster & Randall, 1982
<i>Chaetodon modestus</i> Temminck & Schlegel, 1844	<i>Scolopsis vosmeri</i> (Bloch, 1792)
<i>Chaetodon marleyi</i> Regan, 1921	<i>Scolopsis bimaculatus</i> Rüppell, 1828
<i>Heniochus diphreutes</i> Jordan, 1903	<i>Scolopsis aurata</i> (Park, 1797)
<i>Chlorophthalmus punctatus</i> Gilchrist, 1904	<i>Pisodonophis cancrivorus</i> (Richardson, 1848)
<i>Chlorophthalmus agassizi</i> Bonaparte, 1840	<i>Brotula multibarbata</i> Temminck & Schlegel, 1846
<i>Chlorophthalmus bicornis</i> Norman, 1939	<i>Pseudorhombus elevatus</i> Ogilby, 1912
<i>Cirrhitis</i> sp.	<i>Histiopterus typus</i> Temminck & Schlegel, 1844
<i>Sardinella gibbosa</i> (Bleeker, 1849)	<i>Chrionema chlorotaenia</i> McKay, 1971
<i>Conger cinereus</i> Rüppell, 1830	<i>Satyrichthys adeni</i> (Lloyd, 1907)
	<i>Parapercis nebulosa</i> (Quoy & Gaimard, 1825)
	<i>Parapercis punctulata</i> (Cuvier, 1829)

Parapercis robinsoni Fowler, 1929
Parapercis hexophthalma (Cuvier, 1829)
Cociella crocodila (Tilesius, 1812)
Plotosus canius Hamilton, 1822
Plotosus lineatus (Thunberg, 1787)
Neopomacentrus nemurus (Bleeker, 1857)
Pristigenys nipponia (Cuvier, 1829)/
Pronotogrammus multifasciatus Gill, 1863
Pellona ditchela(Valenciennes, 1847)
Samaris cristatus Gray, 1831
Samaris macrolepis Norman, 1927
Samaris sp.
Johnius carutta Bloch, 1793
Johnius aneus (Bloch, 1793)
Umbrina canariensis Valenciennes, 1843
Otolithoides biauritus (Cantor, 1849)
Dendrochirus zebra (Cuvier, 1829)
Dendrochirus brachypterus (Cuvier, 1829)
Scorpaena neglecta Temminck & Schlegel, 1843
Pterois sp.
Epinephelus bleekeri (Vaillant, 1878)
Epinephelus chlorostigma (Valenciennes, 1828)
Epinephelus longispinis (Kner, 1864)
Epinephelus undulosus (Quoy and Gaimard, 1824)
Epinephelus quoyanus (Valenciennes, 1830)
Holanthias rhodopeplus (Gunther, 1872)
Pseudanthias fasciatus (Kamohara, 1954)
Pseudanthias sp.
Sacura boulengeri (Heemstra, 1973)
Anthias sp.
Variola louti (Forsskål, 1775)
Brachirus annularis Fowler, 1934
Aesopia cornuta Kaup, 1858
Solea bleekeri Boulenger, 1898
Minous monodactylus (Bloch & Schneider, 1801)
Terapon puta Cuvier, 1829
Pelates quadrilineatus (Bloch, 1790)
Lagocephalus inermis (Temminck & Schlegel, 1850)
Lagocephalus lagocephalus lagocephalus (Linnaeus, 1758)
Lagocephalus lunaris (Bloch & Schneider, 1801)
Chelonodon laticeps Smith, 1948
Triacanthus biaculeatus (Bloch, 1786)
Triacanthus nieuhofii Bleeker, 1852
Pseudotriacanthus strigilifer (Cantor, 1849)
Uranoscopus archionema Regan, 1921
Zanclus cornutus (Linnaeus, 1758)
Zenopsis conchifera (Lowe, 1852)

Diversity indices

The results of various diversity indices calculated are given in Table 3, 4 and 5. In line with the higher number of species and their abundance, Shannon diversity ($H'(\log_e)$) was more in Cochin (3.31) than in Munambam (2.91). Therefore, the Shannon–Weiner diversity, which is widely used for comparing diversity between various habitats, clearly showed the diverse nature of these centres (2.9-3.3). Similarly, the evenness (J') of species was also more in Cochin (0.70). However, Margalef's species richness (d) showed clear differences between the centres. Further, the variations in taxonomic distinctness ($\phi+$) and in the number of dominant species (N_2) were more in Cochin. The dendrogram (Fig. 7) drawn, clearly revealed the separate grouping of these centres with Munambam and Kalamukku forming a distinct group. The similarity in species composition and abundance among centres was in the range 55.88-72.34 (Table 5). The 95% confidence funnel generated for the variation in taxonomic distinctness values of all centres is shown in Fig. 8 and 9. This reveals that the centres *viz.*, Kalamukku and Munambam fell within the confidence funnel showing no deviation from normal distribution while Cochin and Neendakara with exploitation of more numbers of species have shown deviation from the normal distribution. The ellipse plot also has clearly shown significant departure of centres such as Munambam and Kalamukku from those at Neendakara and Cochin. Therefore, samples of Cochin and Neendakara fell away from 95% contours, showing significant statistical deviations. The 95% funnel drawn and the ellipse plot also clearly separated the samples of Cochin and Neendakara from the Munambam and Kalamukku group.

As per the Marine Fisheries Census 2005, the number of trawlers operated off Quilon area is 1259.

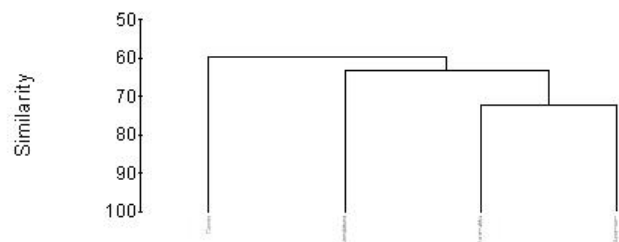


Fig. 7. Dendrogram of finfishes recorded in various trawl landing centres of Kerala showing grouping of centres.

Table 3. Month-wise diversity indices of finfish in different trawl landing centres of Kerala during 2006

Munambam

Month	Species	Quantity	Species richness d	Pielou's evenness J'	Shannon H'	Simpson 1-Lambda'	Hill's abundance	
	S	N					N1	N2
Jan	39	803	5.68	0.80	2.93	0.91	18.65	11.39
Feb	22	630	3.26	0.72	2.22	0.84	9.23	6.15
Mar	32	1593	4.20	0.74	2.55	0.87	12.86	7.45
Apr	35	3385	4.18	0.68	2.43	0.85	11.36	6.64
May	37	3252	4.45	0.57	2.05	0.73	7.77	3.76
Jun	14	280	2.31	0.60	1.59	0.68	4.93	3.09
Aug	9	683	1.23	0.39	0.86	0.40	2.36	1.66
Sep	11	1117	1.42	0.61	1.46	0.73	4.29	3.66
Oct	30	1507	3.96	0.38	1.30	0.53	3.65	2.13
Nov	40	1339	5.42	0.72	2.65	0.90	14.22	9.93
Dec	55	1741	7.24	0.66	2.66	0.85	14.34	6.58

Kalamukku

Month	Species	Quantity	Species richness d	Pielou's evenness J'	Shannon H'	Simpson 1-Lambda'	Hill's abundance	
	S	N					N1	N2
Jan	28	248	4.90	0.85	2.83	0.92	17.03	11.74
Feb	35	228.6	6.26	0.66	2.33	0.83	10.28	5.87
Mar	32	128.3	6.39	0.73	2.54	0.88	12.65	8.01
Apr	33	1329	4.45	0.56	1.97	0.68	7.20	3.08
May	44	2452	5.51	0.70	2.65	0.88	14.13	8.47
Jun	23	1379	3.04	0.61	1.91	0.76	6.78	4.22
Aug	11	426	1.65	0.49	1.18	0.55	3.24	2.21
Sep	18	1414.5	2.34	0.14	0.42	0.16	1.52	1.19
Oct	31	612	4.68	0.54	1.87	0.71	6.48	3.47
Nov	41	339.5	6.86	0.77	2.86	0.91	17.49	10.74
Dec	37	736	5.45	0.75	2.69	0.86	14.73	6.99

Cochin Fisheries Harbour

Month	Species	Quantity	Species richness d	Pielou's evenness J'	Shannon H'	Simpson 1-Lambda'	Hill's abundance	
	S	N					N1	N2
Jan	31	73.8	6.97	0.76	2.59	0.91	13.39	9.35
Feb	37	549.5	5.71	0.77	2.76	0.91	15.85	11.34
Mar	41	262.7	7.18	0.76	2.81	0.90	16.62	9.52
Apr	62	713.6	9.28	0.64	2.66	0.81	14.24	5.26
May	49	853.45	7.11	0.57	2.23	0.81	9.28	5.36
Jun	48	671	7.22	0.65	2.52	0.79	12.40	4.72
Aug	19	723	2.73	0.57	1.67	0.68	5.31	3.10
Sep	31	692.5	4.59	0.53	1.83	0.65	6.25	2.83
Oct	47	1201	6.49	0.73	2.80	0.89	16.37	8.90
Nov	46	644.5	6.96	0.68	2.60	0.84	13.48	6.31
Dec	51	138	10.15	0.83	3.27	0.94	26.26	16.10

Neendakara

Month	Species		Species richness d	Pielou's evenness J'	Shannon H'	Simpson 1-Lambda'	Hill's abundance	
	S	N					N1	N2
Jan	44	1011	6.22	0.70	2.66	0.87	14.28	7.68
Feb	50	631	7.60	0.78	3.06	0.90	21.29	10.17
Mar	57	1528.2	7.64	0.74	2.99	0.91	19.93	10.77
Apr	61	2486	7.67	0.72	2.96	0.92	19.22	12.14
May	58	2459.5	7.30	0.69	2.79	0.88	16.25	8.57
Jun	45	864.2	6.51	0.68	2.58	0.84	13.15	6.10
Aug	22	2240	2.72	0.56	1.74	0.72	5.72	3.58
Sep	39	4658	4.50	0.54	1.99	0.70	7.35	3.37
Oct	59	6315	6.63	0.69	2.81	0.89	16.58	8.81
Nov	50	1550	6.67	0.83	3.26	0.95	26.13	18.41
Dec	52	1888	6.76	0.82	3.22	0.94	25.13	15.80

Table 4. Diversity indices of finfish in various trawl landing centres of Kerala

Centre	Species		Species richness d	Pielou's evenness J'	Shannon H'(loge)	Simpson 1-Lambda'	Hill's abundance	
	S	N					N1	N2
Neendakara	131	25633.7	12.8057	0.6550	3.1936	0.9126	24.3763	11.4473
Cochin	108	6220	12.2488	0.7082	3.3159	0.9326	27.5484	14.8169
Kalamukku	80	9299	8.6455	0.6835	2.9951	0.9105	19.9881	11.1693
Munambam	87	16330	8.86528	0.6528	2.9156	0.9006	18.4612	10.0574

Table 5. Bray - Curtis similarity for finfish collected from different trawl centres in Kerala

	Neendakara	Cochin	Kalamukku	Munambam
Neendakara	0	0	0	0
Cochin	55.88106264	0	0	0
Kalamukku	58.86174983	63.32622	0	0
Munambam	67.57236321	59.95855	72.34073281	0

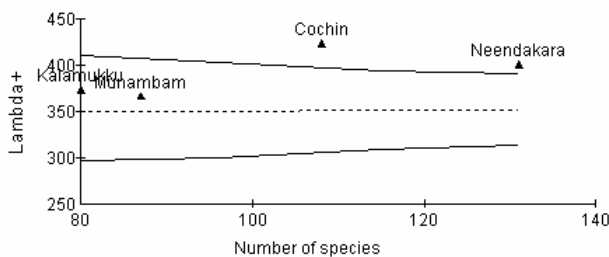


Fig. 8. The 95% confidence funnel for variation in taxonomic distinctness values (lambda +) showing diversity of finfishes and deviation from normal distribution.

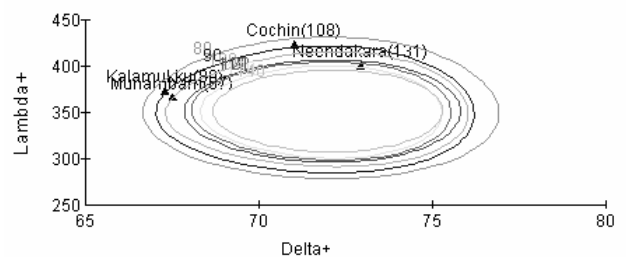


Fig. 9. 95% probability contour of average taxonomic distinctness (delta+) and variation in taxonomic distinctness (lambda+), showing statistically significant deviation in fish diversity between centres.

The number of trawl nets stationed at Neendakara is 166 and in Sakthikulangara 178. During 2005, the number of MDT trawlers landed from August to September alone changed from 17 to 68 per day

and the highest number of 68 observed was on 22nd August. Usually the observations were made for a day from 0600 to 1200 hrs in the morning and 1200 to 1800 h in the afternoon. The depth of operation

varied from 60 to 284 m and the approximate fishing hours estimated were 10-70. Single day trawl operations were very high during August constituting 189-192 per day and the largest number 192 was landed on 29th August. Trawl fishing was done in a depth zone ranging from 20 to 96 m for an average duration of 4-10 h. It is observed that the capacity of the MDTN is approximately, 6000-7000 kg while that of the MTN is 1000 kg (Table 6).

320 m. In the year 2006, the trawlers employed were comparatively more at CFH, from 20 to 63 per day. The landing from the MDTN of the other centers remained more or less the same recording 4 - 20 and 10 - 28 respectively for a similar depth range of 24-320 m.

The present findings agree with the resource characteristics of the major groups of finfishes reported from the bottom trawling operations

Table 6. Trawlers landed at the main centres

Details	Landing centres			
	NDK	CFH	KAL	MBM
No. of trawlers	1,259		—1,403 —	
No. of trawl operations per day	160-200	About 100	Below 100	Above 100
Main fishing grounds –Depth (m)	MDTN - 40-284 MTN - 16-100	24-300 -	30-320 10-22	40-270 12-22
Storage capacity (kg)	MDTN – 6,000-7,000 kg. MTN - 1,000 kg.	—7000 kg. —	—1000 kg.—	
Range of HP	MDTN – 9-160 MTN - 90-160	100-16 90	00-120 190	100-120 90

The number of trawl operations was entirely different in 2006 with the highest number of 134 multiday trawlers landed per day in September (8th Sept. 2006) and the number fluctuated from 14 per day to over 130. In the case of single day trawlers, the biggest number 152 was recorded in August (23rd August) from a mere total of 33 per day observed during the second week of September. The depth of operation for multiday trawlers varied from 40 to 256 m and the duration showed approximately 8 to 48 h. While in the case of single day trawlers, the depth zone never went beyond 20 to 100 m for a fishing duration of 4 to 10 hrs. However, it is very significant to note that a staggering number of 221 trawlers comprising of both MDTN and MTN were landed on a single day in September 2006 (26th Sept. 2006: 89 MDTN + 132 MTN) at Neendakara. The number of trawlers landed showed a change from 49 per day onwards.

At Cochin Fisheries Harbour, during 2005 the number of MDTN operated in the fishing grounds off Cochin varied from 4 to 81 at CFH, 2-17 at Munambam and 3-35 at Kalamukku landing centres per day and the average depth zone of fishing varied from a shallow region of 30 m upto a deeper zone of

conducted along the south-west coast of India in terms of seasonality and abundance of the species. The resource appraisal surveys off Kerala shows the predominance of threadfin breams in the depth zone of 100-200 m between December and April, however, the stocks move into the areas below 100 m during July-October in great abundance resulting in high catch and catch rates (Nair and Jayaprakash, 1986; Murty *et al.*, 1992; Nair *et al.*, 1996). Commercially exploitable demersal resources including lizard fishes are confined mainly to the continental shelf region within 100 m (James, 1989). High concentration of Carangidae is observed during monsoon from July/August onwards especially along the Kerala/SW coast (Rao *et al.*, 1977; Sivakami *et al.*, 1996). Lazarus *et al.* (1992) and Nair *et al.* (1996) reported the peak period of occurrence for ribbon fishes as the monsoon season along the coast. Movements of fish as observed previously are influenced by water movements dependent on temperature, salinity gradient, plankton blooms and wind action rather than dissolved oxygen.

It has been observed that certain species *Nemipterus randalli*, Russell, 1986, *Lepturacanthus savala* (Cuvier, 1829) and *Decapterus russelli*

(Rupell, 1830) are found dominant along with the emergence of a few rare species and new records indicating the presence of the unexploited and unexplored marine finfish resources along the southern Kerala coast. Perhaps the mechanisation of the fishing crafts, with the use of modern equipments, high enduring capacity as well as catching efficiency achieved by the gears would have brought in the rare and new resources. Some of the new records to the Indian seas like *Pristigenys nipponia* (Cuvier, 1829), *Brachirus annularis*, *Apogon kiensis*, *Callionymus gardineri* and *Sacura boulengeri* are the added features of this investigation. The full

details of all the new records are yet to be confirmed waiting for further literature. Juveniles of *E. diacanthus* were observed in large numbers during the post-monsoon season at Kalamukku and Cochin Fisheries Harbour. Among the by-catches of finfishes from the four trawling centres, Callionymidae was the dominant family apart from Leiognathidae and Gobidae. The species of Callionymidae are reported infrequently from the west coast especially, Kerala. *C. carebares* and *C. marleyi* are found more in numbers along the Kerala coast, particularly from Neendakara, though they were not reported earlier.