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Diversity of reef fishes in trap fishery at Keelakarai, Gulf of Mannar, south-east coast of India

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ABSTRACT

The diversity of finfishes caught in traps at Keelakarai, Gulf of Mannar was assessed quantitatively and qualitatively for a period of six years from July 2006 to June 2012. Average landing during the period was 109 t per year with maximum of 137 t during 2008-09. Among the 98 species of reef fishes landed, *Siganus canaliculatus* dominated (28%), followed by *Scarus ghobban* (21%). During the first two years of the study, *S. ghobban* dominated over *S. canaliculatus* and later the trend reversed. Family-wise, maximum contribution was by Siganidae (36%) followed by Scaridae (21%). Seasonally, the major peak was recorded during post-monsoon of 2009. The Shannon index of diversity was maximum during 2007-08. Cluster analysis indicated the highest similarity in species composition between 2010-11 and 2011-12. SIMPER analysis identified 26 species as most significant in creating the observed pattern of similarity for 90% cut off contributions. Ellipse plot showed statistically significant deviation in fish diversity between years. Reef fish landings showed an increasing trend from 2006-07 to 2008-09, a decline afterwards and then almost steady condition prevailed during the last two years of the study which implies that there is no scope for further increase in landings by trap fishery at Keelakarai.

Keywords: Diversity, Gulf of Mannar, Keelakarai, Reef fishes, South-east India, Trap fishery

Introduction

Trap fishing is one of the indigenous methods of fishing prevalent in the Gulf of Mannar. Traps are easy to deploy, relatively less expensive to fabricate and suitable to operate in areas with rocks and coral reefs. This may be the reason for the development of an organised trap fishery at Keelakarai where such areas are available in plenty. Several ornamental fish species are also caught in traps along with food fishes. Attractive ornamental fishes collected in live condition fetch good price, thereby forming an additional income to the fisherfolk in this area. Several researchers have studied various aspects of trap fishery operated at Keelakarai, located in Gulf of Mannar. Prabhu (1954) gave an account of the perch fishery by special traps and the different methods of operation in the Gulf of Mannar and Palk Bay around Mandapam. Lal Mohan (1985) described the changing trend in the traditional trap fishery of Keelakarai and Rameswaram. Varghese *et al.* (2008) gave an account of trap fishing in the Gulf of Mannar and Palk Bay. Murugan and Durgekar (2008) have touched upon the seasonal abundance of coral reef associated fishes at Keelakarai while describing the status of fisheries in Tamil Nadu. Kalaiarasan *et al.* (2014) gave a brief account on trap fishery during 2011-12, but emphasis was given to types of traps and qualitative aspects of fishery. Kalaiarasan *et al.* (2015) compared the performance of three types of traps *viz.,* experimental traditional trap, Norwegian collapsible trap and modified Norwegian collapsible trap. Murugan *et al.* (2014) studied the diversity, occurrence and socio-economic aspects of snappers and job fish fisheries from Gulf of Mannar region. However, there are no recent studies describing the trap fishery in the Gulf of Mannar from Keelakarai area. Hence, an attempt was made to study the species diversity and the monthly, seasonal and yearly abundance of different species in the trap fishery at Keelakarai in Gulf of Mannar.

Materials and methods

Fortnightly samplings were done to estimate the diversity of finfishes landed by traps operated at Keelakarai (09^{0} 14' N; 78^{0} 47' E) in Gulf of Mannar, for a period of six years from July 2006 to June 2012. Trap fishery in Keelakarai covers an area of about 1000 ha. The reef fish species in the landings were identified using FAO identification sheets (Fischer and Bianchi, 1984), Smith and Heemstra (1986) and Munro (2000). Species-wise, family-wise, month-wise, season-wise and year-wise catch data were generated and analysed using MS-Excel. The seasons considered for the study were pre-monsoon (July-September), monsoon (October-December), post-monsoon (January-March) and summer (April-June) as described by Rajasegar and Sendhilkumar (2009), as the study site was located on the south-east coast of India. Each year was taken as the twelve month period from July to June. Conventional diversity indices like Shannon diversity index H'($\log_2$) (Shannon and Wiener, 1963); Margalef's richness index d (Margalef, 1958) and Pielous evenness index J' (Pielou, 1975) were applied to compare the fish diversity between years. New diversity indices have statistical support to compare the biodiversity within different years and can be derived using average taxonomic distinctness index Δ^{+}; total phylogenetic diversity index sPhi+ and taxonomic diversity index Δ (Clarke and Warwick, 2001). To compare the diversity between years, dominance plot was drawn (Lambshead *et al*., 1983; Clarke and Warwick, 2001) by ranking the species in decreasing order of abundance. The data were fourth root transformed before analysis for diversity indices, similarity and cluster analyses. Similarity in species composition was studied by calculating the Bray-Curtis coefficient (Clarke, 1999). Similarity matrices were constructed using the Bray-Curtis similarity measure on non-standardised logarithmic transformed data. The similarity is taken as 100% when the two samples are totally similar and as 0 when the two samples are totally dissimilar. In cluster analysis, hierarchical agglomerative clustering and in the non-metric multidimensional scaling (MDS), the Bray-Curtis similarity was used to construct the map (Clarke and Warwick, 2001). SIMPER analysis was carried out to find out the contribution of each species to the observed similarity or dissimilarity between the years. To find out the deviation from normal distribution and to test the variance between samples, Δ+ and λ^{+} values were used for plotting the 95% ellipse plots. All the univariate and multivariate analyses for the diversity profile were done using PRIMER (Plymouth Routines in Multivariate Ecological Research) v.6 package developed by the Plymouth Marine Laboratory, UK (Clarke and Gorley, 2001), following Khan and Lyla (2005).

Results and discussion

Quantitative abundance

A total of 654.46 t of reef fishes were landed by traps at Keelakarai fish landing centre during the six-year period from July 2006 to June 2012, with an average landing of 109 t per year. This yearly average was much higher than that recorded (10.45 t $year^{-1}$) by Prabhu (1954) from Gulf of Mannar. Of the total landings, maximum contribution (21%) was during 2008-09 and minimum (10%) was during 2006-07 (Fig. 1).

The landings were found to increase from 2006-07 to 2008-09 and then showed a decreasing trend.

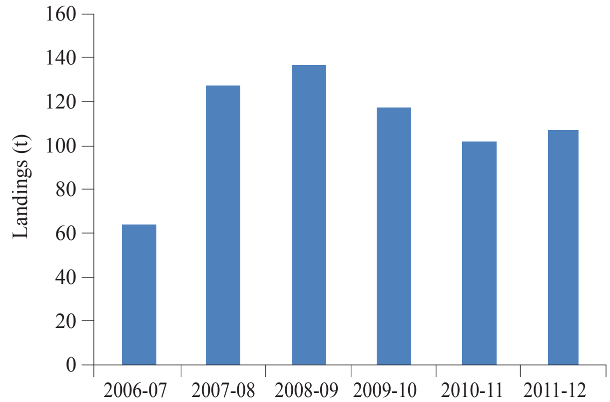
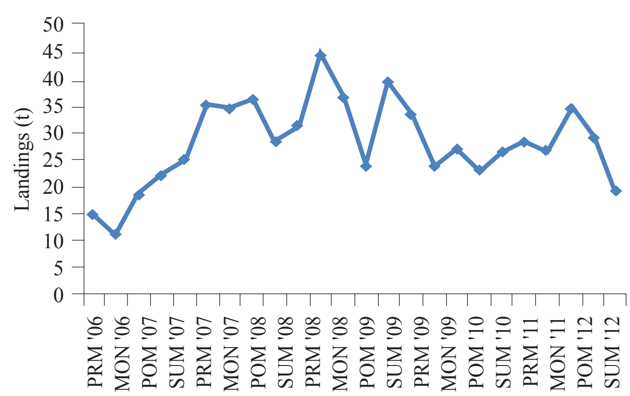


Fig. 1. Year-wise reef fish landings at Keelakarai by traps during July 2006 - June 2012

Season-wise study indicated a major peak in the fishery during post-monsoon in 2009 followed by a minor peak during monsoon of 2009 (Fig. 2). According to Kalaiarasan *et al*. (2014), the peak season for trap fishing at Keelakarai was from September to February based on a study for one year. Also, Murugan and Durgekar (2008) recorded monsoon season as the peak catching period. In the present study also, the seasonal peaks were observed during October-March in most of the years, which closely agrees with the above findings. As early as 1985, Lal Mohan also observed peak fishing season from December to April. A gradual increase was recorded in landings from monsoon 2006 to monsoon 2007. Then, a setback was noticed in the fishery till monsoon 2008 and it revived during the post-monsoon of 2009. During post-monsoon of 2009, the highest of 18.1 t was landed in the month of March.

The average catch per day was found to be 349 kg. The catch per trap showed a fluctuating trend till summer 2010 and then the catch per trap was almost steady.



PRM: Pre-monsoon, MON: Monsoon, POM: Post-monsoon, SUM: Summer

Fig. 2. Season-wise reef fish landings at Keelakarai by traps during July 2006 - June 2012

Average catch per trap was 1.59 kg. Prabhu (1954) reported the catch rate per trap as 0.14 kg in Gulf of Mannar while Lal Mohan (1985) estimated the catch per trap as 0.48 kg. Thus, an improvement in the catch rate was evident over the years. In case of catch per month also, there was an increase from 2844 kg (Lal Mohan, 1985) to 9089 kg during the present study. This increase in catch may be due to the different types of baits used, size and types of traps employed and change in the area of operation of the traps.

Qualitative abundance

A total of 98 species of reef fishes belonging to 27 families were recorded from the landings by traps at Keelakarai during the present study period (Table 1).

Table 1. List of reef fishes landed by traps at Keelakarai during July 2006 - June 2012

Species	Family	Common name
Acanthurus gahhm	Acanthuridae	Black surgeonfish
A. lineatus	Acanthuridae	Lined surgeonfish
A. mata	Acanthuridae	Elongate surgeonfish
A. nigricauda	Acanthuridae	Epaulette surgeonfish
A. triostegus	Acanthuridae	Convict surgeonfish
A. xanthopterus	Acanthuridae	Yellowfin surgeonfish
Zebrasoma velifer	Acanthuridae	Sailfin tang
Balistoides viridescens	Balistidae	Titan triggerfish
Abalistes stellaris	Balistidae	Starry triggerfish
Caesio cuning	Caesionidae	Redbelly yellowtail fusilier
Caranx heberi	Carangidae	Blacktip trevally
Chaetodon decussatus	Chaetodontidae	Indian vagabond butterflyfish
C. octofasciatus	Chaetodontidae	Eightband butterflyfish
C. plebeius	Chaetodontidae	Blueblotch butterflyfish
C. trifascialis	Chaetodontidae	Chevron butterflyfish
C. vagabundus	Chaetodontidae	Vagabond butterflyfish
C. xanthocephalus	Chaetodontidae	Yellowhead butterflyfish
C. auriga	Chaetodontidae	Threadfin butterflyfish
C. collare	Chaetodontidae	Redtail butterflyfish
Heniochus acuminatus	Chaetodontidae	Pennant coralfish
Platax teira	Ephippidae	Longfin batfish
Neotrygon kuhlii	Dasyatidae	Blue-spotted stingray
Plectorhinchus diagrammus	Haemulidae	Striped sweetlips
P. pictus	Haemulidae	Trout sweetlips
P. schotaf	Haemulidae	Minstrel sweetlips
Diagramma picta	Haemulidae	Painted sweetlips
Sargocentron rubrum	Holocentridae	Redcoat
S. melanospilos	Holocentridae	Blackblotch squirrelfish
Kyphosus cinerascens	Kyphosidae	Blue sea chub
Cheilinus chlorourus	Labridae	Floral wrasse
C. undulatus	Labridae	Humphead wrasse
Halichoeres hortulanus	Labridae	Checkerboard wrasse
H. nigrescens	Labridae	Bubblefin wrasse
H. zeylonicus	Labridae	Goldstripe wrasse
Hemigymnus melapterus	Labridae	Blackeye thicklip
Thalassoma lunare	Labridae	Moon wrasse
Psammoperca waigiensis	Latidae	Waigieu seaperch
Lethrinus harak	Lethrinidae	Thumbprint emperor
L. nebulosus	Lethrinidae	Spangled emperor
L. microdon	Lethrinidae	Smalltooth emperor
L. miniatus	Lethrinidae	Trumpet emperor
L. ornatus	Lethrinidae	Ornate emperor
L. variegatus	Lethrinidae	Slender emperor
Lutjanus argentimaculatus	Lutjanidae	Mangrove red snapper
L. bohar	Lutjanidae	Two-spot red snapper
L. decussatus	Lutjanidae	Checkered snapper
L. fulviflamma	Lutjanidae	Dory snapper
L. fulvus	Lutjanidae	Blacktail snapper
L. gibbus	Lutjanidae	Humpback red snapper
L. kasmira	Lutjanidae	Common bluestripe snapper
L. lemniscatus	Lutjanidae	Yellowstreaked snapper
L. lutjanus	Lutjanidae	Bigeye snapper
L. quinquelineatus	Lutjanidae	Five-lined snapper
L. rivulatus	Lutjanidae	Blubberlip snapper
L. russellii	Lutjanidae	Russell's snapper
L. vitta	Lutjanidae	Brownstripe red snapper
Parupeneus barberinus	Mullidae	Dash-and-dot goatfish
P. heptacanthus	Mullidae	Cinnabar goatfish
P. indicus	Mullidae	Indian goatfish
Upeneus tragula	Mullidae	Freckled goatfish
Gymnothorax favagineus	Muraenidae	Laced moray
G. punctatus	Muraenidae	Red Sea whitespotted moray
Scolopsis bimaculata	Nemipteridae	Thumbprint monocle bream
Lactoria cornuta	Ostraciidae	Longhorn cowfish
Ostracion cubicus	Ostraciidae	Yellow boxfish
Pempheris molucca	Pempheridae	Moluccan sweeper
Pomacanthus semicirculatus	Pomacanthidae	Semicircle angelfish
P. annularis	Pomacanthidae	Bluering angelfish
Abudefduf bengalensis	Pomacentridae	Bengal sergeant
A. septemfasciatus	Pomacentridae	Banded sergeant
A. vaigiensis	Pomacentridae	Indo-Pacific sergeant
Neoglyphidodon melas	Pomacentridae	Bowtie damselfish
Bolbometopon muricatum	Scaridae	Green humphead parrotfish
Scarus ghobban	Scaridae	Blue-barred parrotfish
S. psittacus	Scaridae	Common parrotfish
Chlorurus sordidus	Scaridae	Daisy parrotfish
Pterois russelli	Scorpaenidae	Plaintai turkeyfish
P. volitans	Scorpaenidae	Red lionfish
Cephalopholis argus	Serranidae	Peacock hind
C. boenak	Serranidae	Chocolate hind
C. formosa	Serranidae	Bluelined hind
Epinephelus bleekeri	Serranidae	Duskytail grouper
E. chlorostigma	Serranidae	Brownspotted grouper
E. coeruleopunctatus	Serranidae	Whitespotted grouper
E. longispinis	Serranidae	Longspine grouper
E. diacanthus	Serranidae	Spinycheek grouper
E. flavocaeruleus	Serranidae	Blue-and-yellow grouper
E. malabaricus	Serranidae	Malabar grouper
E. merra	Serranidae	Honeycomb grouper
E. polyphekadion	Serranidae	Camouflage grouper
E. tauvina	Serranidae	Greasy grouper
Siganus canaliculatus	Siganidae	White-spotted spinefoot
S. javus	Siganidae	Streaked spinefoot
S. lineatus	Siganidae	Golden-lined spinefoot
S. spinus	Siganidae	Little spinefoot
Arothron hispidus	Tetraodontidae	White-spotted puffer
A. stellatus	Tetraodontidae	Stellate puffer
Zanclus cornutus	Zanclidae	Moorish idol

(Cont...)

Kalaiarasan *et al*. (2014) observed fishes of 24 families in landings from traps at Keelakarai and the higher number of families recorded during the present study may be due to the long duration of the study period. The family-wise distribution of landings is given in Fig. 3 (families forming less than 1% of landings are not included).

Family-wise estimates showed that Siganidae formed maximum (36%) of the landings by traps during the period under study, followed by Scaridae (21%), Lethrinidae (11%), Serranidae (8%) and Mullidae (7%).

Among the species landed, *Cheilinus undulatus* categorised as 'Endangered' in the IUCN Red List, was also observed. Ninety-eight species of reef fishes were landed during the present study, whereas 92 species were recorded by Murugan and Durgekar (2008) from traps employed in Keelakarai. Species composition of fish landings at Keelakarai by traps is depicted in Fig. 4.

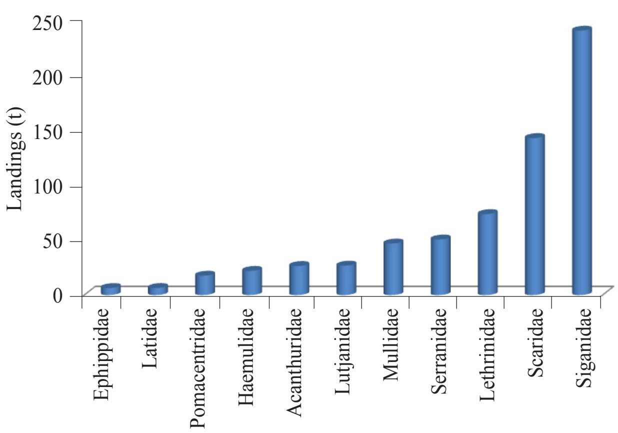


Fig. 3. Family-wise reef fish landings at Keelakarai fish landing centre by traps during July 2006 - June 2012

Siganus canaliculatus contributed maximum and formed 28% of the landings. This was followed by *Scarus ghobban* (21%). *Lethrinus nebulosus* and *Siganus javus* formed 8% each, *Parupeneus indicus* contributed 7% and rest of the species formed only less than 5% each. As early as 1954, Prabhu observed that *L. nebulosus* and *S. ghobban* formed 56.8 and 25.9% of the trap landings in Gulf of Mannar whereas Lal Mohan (1985) noticed that the trap fishery in Gulf of Mannar depended mainly on *L. nebulosus, S. canaliculatus* and *S. ghobban,* which formed 45, 26.2 and 10% respectively. The above studies indicate that there exists a temporal shift in the abundance of species in trap landings in Gulf of Mannar. Season-wise abundance of dominant species recorded during the present study is indicated in Fig. 5.

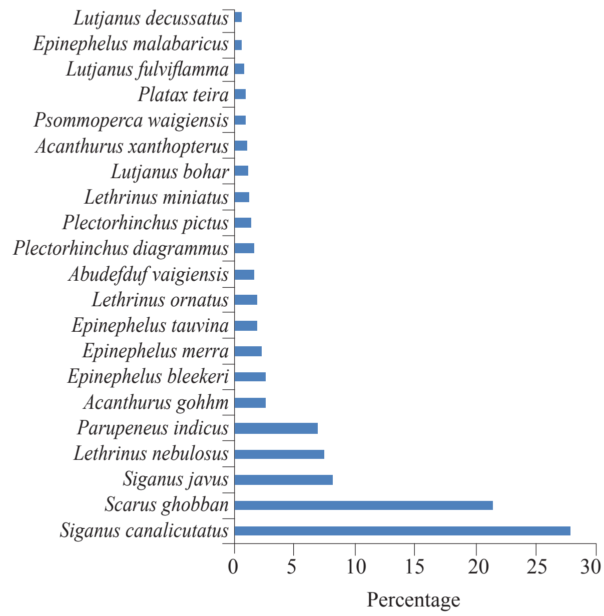


Fig. 4. Species-wise dominance (%) among total reef fishes landed at Keelakarai by traps during July 2006 - June 2012

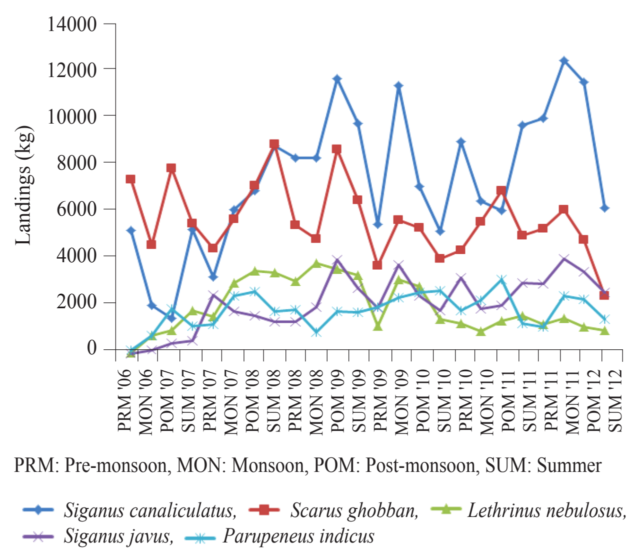


Fig. 5. Season-wise landings of dominant species by traps at Keelakarai during July 2006 - June 2012.

The most dominant species, *S. canaliculatus* showed a fluctuating trend and reached the major peak in the monsoon of 2011. In general, *S. canaliculatus* and *S. javus* were found to increase while *S. ghobban* and *L. nebulosus* showed a decreasing trend during the period of study. There was a clear shift in the abundance of *S. ghobban* and *S. canaliculatus.* Upto summer season of 2008, *S. ghobban* dominated over *S. canaliculatus* but afterwards the trend was reversed. The size of *S. ghobban* was also found to decrease substantially after the initial period. This decline in the abundance of *S. ghobban* may be due to overexploitation, and increase in the abundance of *S. canaliculatus* may be attributed to the use of more of shrimp head, shrimp peelings and jelly fishes as bait in the trap.

Biodiversity

A community diversity analysis to discern the species status for the different years was carried out (Table 2). Margalef's richness (d) and Fisher's alpha showed highest values in 2006-07 (4.16 and 4.82 respectively) whereas lowest were observed during 2011-12 (2.26 and 2.50 respectively). Another major component of diversity *i.e.*, Pielou's evenness or equitability J' was the highest in 2007-08 (0.65) and the lowest was during 2006-07 (0.50). The Simpson index (1-lambda) provided information on dominance of species and it was found to be high in 2007-08 (0.87) and low in 2011-12 (0.70). Shannon index of diversity H' ($\log_2$) which is a more realistic estimate of biodiversity was found to be the highest in 2007-08 (3.76) and the lowest was found to be observed in 2011-12 (2.58). In the present investigation, the Shannon indices of diversity were medium varying from 2.58 to 3.76. Seasonally, the maximum diversity (H') was recorded during monsoon of 2007 and diversity was found to be higher during monsoon or post-monsoon seasons in most of the years during the study period.

Table 2. Diversity indices of fishes during different years

Year	S	N	d	J'	Fisher	H '($\log_2$)	1-Lambda'	Delta	Delta+	Lambda+	sPhi+
2006-07	55	434928	4.16	0.50	4.82	2.87	0.76	32.20	43.85	72.82	1485.71
2007-08	56	959819	3.99	0.65	4.57	3.76	0.87	35.28	43.96	106.79	1600.00
2008-09	37	1086684	2.59	0.62	2.88	3.23	0.80	31.70	41.01	82.40	1028.57
2009-10	44	908738	3.13	0.62	3.53	3.36	0.82	32.56	42.77	80.68	1285.71
2010-11	34	818010	2.42	0.57	2.69	2.89	0.76	29.10	40.49	60.96	928.57
2011-12	32	900577	2.26	0.52	2.50	2.58	0.70	25.28	40.78	54.13	928.57

The conventional indices can only be used with quantitative data as they are much influenced by the sampling effort and evenness property. The newly introduced biodiversity indices have additional statistical framework for comparison of one sample with another. The taxonomic diversity index was more in 2007-08 (35.28) and less in 2011-12 (25.28). The total phylogenetic diversity index was also more in 2007-08 (1600) and it was less in 2010-11 and 2011-12 (928.57). The average taxonomic distinctness index was more in 2007-08 (43.96) and less in 2010-11 (40.49). The results revealed that the biodiversity rich year of 2007-08, had more stability and less variation than other periods, where the variation in taxonomic diversity index was comparatively low.

The dominance plot or K- dominance curve was constructed on the data sets to find out the biodiversity pattern (Fig. 6). The curve for the year 2007-08, which lies on the lower side, extends further and rises slowly due to presence of more number of species. As the percentage contribution of each species is added, the curve extends horizontally (species number is evident from the *x*-axis), before reaching the cumulative 100%. In the typical undisturbed ecosystem, the K-dominance curve is S-shaped and Fig. 6 clearly shows curve wih a gentle slope and medium starting point indicating medium diversity.

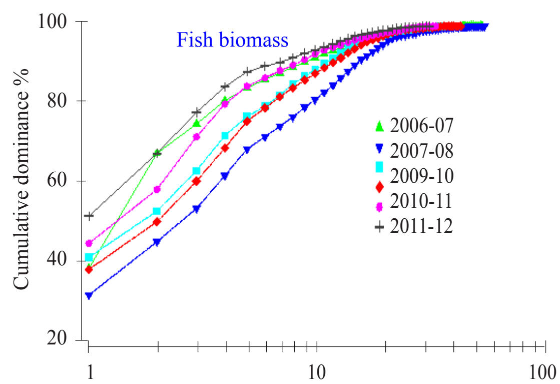


Fig. 6. Dominance plot for fishes landed by traps at Keelakarai during July 2006 - June 2012

Table 3. Bray–Curtis similarity for fishes collected from different years

Year	2006-07	2007-08	2008-09	2009-10	2010-11	2011-12
2006-07						
2007-08	66.62					
2008-09	59.08	75.26				
2009-10	61.20	71.42	78.26			
2010-11	60.01	69.27	79.54	80.75		
2011-12	56.95	67.71	78.25	76.33	90.29	

The Bray-Curtis similarity coefficient (Table 3) is extensively used to find out the degree of relationship in species composition and abundance between samples collected from various places. This coefficient varies from 0 to 100%, with the ends of the range representing the extreme possibilities. The similarity is 100% if the two samples are totally similar and it is 0 if the two samples are totally dissimilar. The highest similarity was found between the year 2010-11 and 2011-12 with 90.29% similarity among themselves and low similarity was found between 2006-07 and 2011-12 (56.95%).

Cluster analysis (dendrogram) revealed grouping of years with respect to species composition in the area (Fig. 7). The year 2010-11 and 2011-12 formed a group with the maximum similarity percentage of 90.

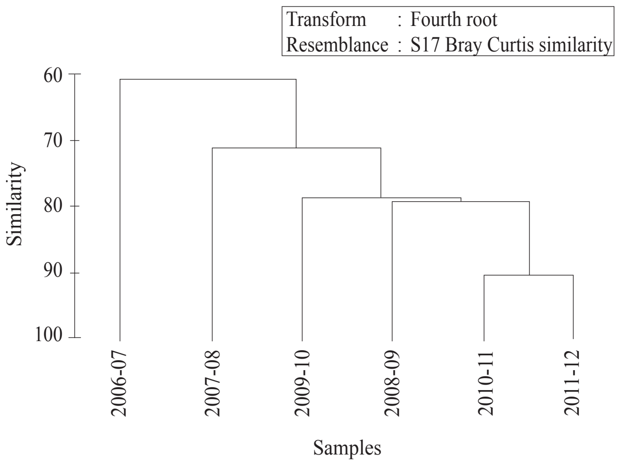


Fig. 7. Dendrogram of fishes recorded in various years

In the MDS bubble plot, the abundance of species and dissimilarity between the years were superimposed as circles of different sizes. The bubble plots give the abundance of discriminating species which is evident from the size of the bubble, greater the bubble size, higher the abundance of the fish species. Bubble plot of *S. canaliculatus,* the most dominant species is given in Fig. 8.

The results of SIMPER analysis are given in Table 4. The term 'average abundance' represents the average abundance (by numbers) in each year. The 'average contribution' represents the average contribution of each year to the average dissimilarity between the years.

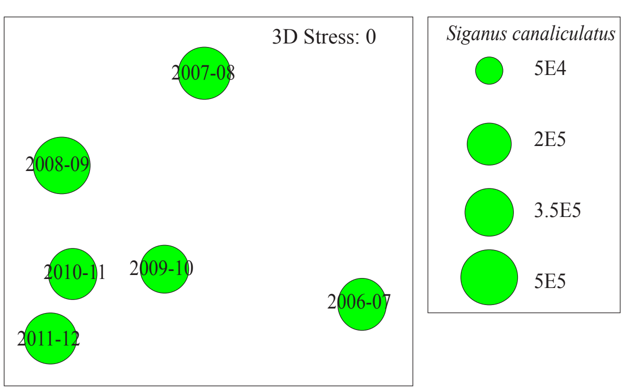


Fig. 8. Bubble plot for *Siganus canaliculatus*

The ratio indicates average contribution to the standard deviation between the years. The higher-contributing species was taken wherein the species contributing a small amount to the similarity and dissimilarity are dropped. The cut off for low contributions given was 90% and rare species after the cumulative percentage cut off point are ignored.

Twenty six higher-contributing species (Table 4) were taken out of ninetyeight species for the 90% cut off contributions. The identified 26 species were the most important in creating the observed pattern of similarity. The average similarity between group members, based on the Bray-Curtis similarity measure, is 71.40%. *S. canaliculatus* contributes about 23.82% (with average similarity of 6.61%) to the total similarity followed by *S. ghobban* contributing about 18.46% (with average similarity of 5.28%) and *S. javus* contributing about 17.12% (with average similarity of 4.54%).

The fitted 95% probability contours of average taxonomic distinctness (delta+) and variation in taxonomic distinctness (lambda+), showing statistically significant deviation in fish diversity between the years are depicted in Fig. 9. In the ellipse plot of the average taxonomic distinctness and variation in taxonomic distinctness, the values show statistically significant departure from the ellipse for all the observation years.

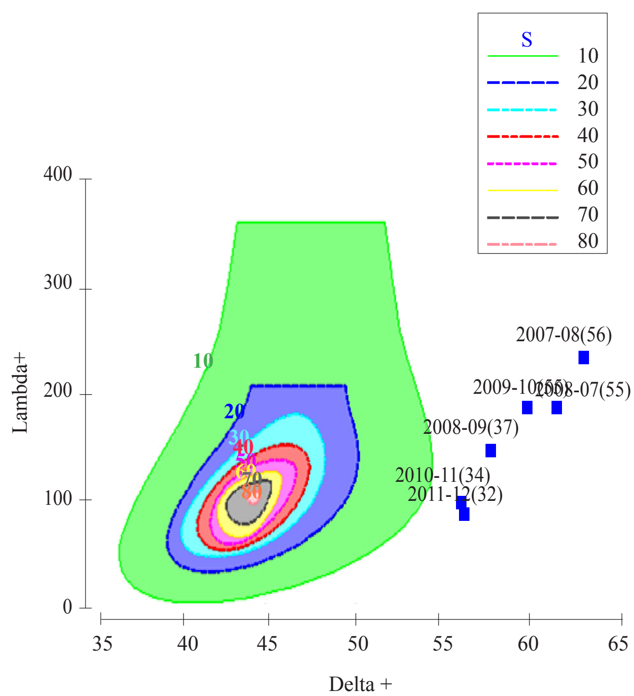


Fig. 9. The 95% probability contours of average taxonomic distinctness (delta+) and variation in taxonomic distinctness (lambda+), showing statistically significant deviation in fish diversity between the years

Table 4. SIMPER analysis of dissimilarity between years

Species	Average abundance (%)	Average similarity (%)	Ratio	Average contribution (%)	Cumulative contribution (%)
Siganus canaliculatus	23.82	6.61	7.49	9.26	9.26
Scarus ghobban	18.46	5.28	10.6	7.4	16.65
Siganus javus	17.12	4.54	4.24	6.35	23
Parupeneus indicus	15.6	4.37	9.29	6.12	29.12
Lethrinus nebulosus	15.18	4.07	12.26	5.7	34.82
Abudefduf vaigiensis	11.35	3.02	7.93	4.23	39.05
Lethrinus ornatus	11.06	2.92	7.51	4.09	43.14
Acanthurus gahhm	10.96	2.79	7.01	3.9	47.05
Lethrinus miniatus	9.74	2.57	4.52	3.61	50.65
Epinephelus merra	9.57	2.44	6.73	3.42	54.07
Psammoperca waigiensis	9.22	2.25	5.67	3.16	57.23
Epinephelus tauvina	8	2.25	10.99	3.15	60.38
Plectorhinchus pictus	7.99	2.16	5.91	3.02	63.4
Abudefduf septemfasciatus	8.43	2.07	5.66	2.9	66.3
Lutjanus fulviflamma	8.55	2.02	4.89	2.84	69.14
Plectorhinchus diagrammus	7.93	1.96	3.39	2.75	71.88
Epinephelus bleekeri	9.29	1.95	1.36	2.73	74.61
Lutjanus bohar	8	1.71	1.35	2.4	77.01
Platax teira	7.13	1.41	1.06	1.97	78.98
Abudefduf bengalensis	7.68	1.37	1.32	1.92	80.89
Caesio cuning	5.77	1.36	3.17	1.91	82.8
Acanthurus xanthopterus	6.72	1.17	1.29	1.64	84.44
Plectorhinchus schotaf	5.06	1.17	1.34	1.64	86.08
Acanthurus mata	4.84	1	1.27	1.41	87.49
Lutjanus lutjanus	5.11	1	1.3	1.39	88.88
Epinephelus malabaricus	4.87	0.94	1.11	1.31	90.2

The present investigation indicated that the reef fish landings by traps at Keelakarai increased from 2006-07 to 2008-09 and then showed a decline and the landings were almost steady during 2010-11 and 2011-12. Highest similarity was found between 2010-11 and 2011-12 (90.29%). The catch per trap was also found to be steady after 2010. This indicates that the exploitation level of resources in the trap fishery at Keelakarai might have attained its maximum level.

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