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Finfish Bycatch Diversity of Trawl Fishery of Nagapattinam Coast, Tamil Nadu, South India

S. Santhoshkumar[1], P. Jawahar[2], A. Srinivasan[2], N. Jayakumar[1], A. Subburaj[1]

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ABSTRACT

Background: The present study was undertaken to analyse the monthly and seasonal finfish bycatch diversity of trawler fishery of Nagapattinam coast situated in the state of Tamil Nadu, South India from January 2017 to August 2019.

Methods: Samples of finfish bycatch were collected fortnightly from the commercial shrimp trawlers operating in the coastal waters off Nagapattinam. The collected bycatch of finfish species was identified and month-wise and season-wise trawl finfish bycatch occurrence data collected were subjected to univariate and multivariate analysis using PRIMER Version 6.1.7. software.

Result: In this study, the annual average total landing was estimated at 15,414.41 tonnes with an annual average fishing effort of 9327 boat days. Of this total landing, commercial catch constituted 70.75% (10,905.78 tonnes), whereas finfish bycatch formed 21.12% (3,256.14 tonnes) and rest by other groups. The peak fishing effort was observed in every March during the study period. A total of 210 finfish species belonging to 15 orders, 79 families and 153 genera were recorded, in which the order, Perciformes alone shared 53.81% of the total number of species. The monthly univariate analysis revealed that bycatch diversity was the highest in every September and the lowest in every June during the study period, while the season-wise analysis revealed the highest diversity during monsoon seasons. Likewise, the month-wise multivariate analysis performed through cluster analysis divulged the highest similarity between September'17 and September'18, while the season-wise analysis revealed the highest similarity between postmonsoon'17 and postmonsoon'18. Further, the K dominance plot divulged that the highest density of finfish species was in every September and in monsoon seasons during the study period.

Key words: Bycatch, Diversity, Multivariate, Trawl, Univariate.

INTRODUCTION

Nagapattinam is blessed with a coastal length of 187.9 km which lies along the coast of Coromandel and Palk Bay on the shore of the Bay of Bengal, between the latitude of 10.7906°N and longitude of 79.8428°E. Trawl is the dominant fishing gear operated by the trawling boats along the coast of Nagapattinam. Among 13 coastal districts of Tamil Nadu, Nagapattinam region contributed 13% of the total marine capture fisheries production next to Kanyakumari (28.4%) and Ramanathapuram (20.8%) regions during 2018 (CMFRI, 2019). The impact of rapid technological changes in fishery cannot be ignored. The increase in the catch along the Indian coast in the last two decades is essentially due to increase in efficiency of craft and gear and spatial extension of fishing to offshore regions. Mechanized and motorized boats have shown an incredible tendency to expand their engine power and also size in the recent times. Their unbridled expansion is a matter of serious concern for all and proper regulation of these boats is very important. Further, it is an alarming fact that bycatch is also increasing day by day. Bycatch is the major concern in the trawler fishery due to its non-selective nature. The changing perspective of bycatch itself offers the greatest challenge, as yesterday's bycatch becomes today's target catch (Boyce, 1996). Hence, efforts need to be taken to reduce the bycatch particularly the catch of juveniles and sub-adult fishes.

Though the studies on trawler bycatch were attempted by various researchers in India (Boopendranath, 2009; George *et al.*, 1981; Gibinkumar and Boopendranath, 2008; Gordon, 1991; Kumar and Deepthi, 2006; Kurup *et al.*, 2003; Pravin and Manohardoss, 1996; Rao, 1998; Sujatha, 1995, 1996 and 2005), studies on the trawler bycatch diversity in Tamil Nadu, particularly in Nagapattinam coastal area is very limited. In this context, the paper attempted to provide information on the diversity of trawl finfish bycatch along the Nagapattinam coast.

MATERIALS AND METHODS

Samples of finfish bycatch were collected from the commercial shrimp trawlers operating in the coastal waters

[1]Dr. MGR Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Thalainayeru-614 712, Nagapattinam, Tamil Nadu, India.
[2]Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Nagapattinam-611 001, Tamil Nadu, India.

Corresponding Author: S. Santhoshkumar, Dr. MGR Fisheries College and Research Institute, Tamil Nadu Dr. J. Jayalalithaa Fisheries University, Thalainayeru-614 712, Nagapattinam, Tamil Nadu, India. Email: s.santhoshkumar@tnfu.ac.in

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off Nagapattinam from January 2017 to August 2019 (Fig 1). Trawlers operated in the Nagapattinam region have 18 - 20 meters overall length (OAL) and are made of steel. A total of 430 registered trawlers are operated from Nagapattinam Fishing Harbour and have the fishing characteristics of multi-fleet, multi-day with multi-fishing gear fishery. The trawlers are operated at the depth of 15-90 m with a distance of 40-80 nm from the shore. The multiday fishing pattern usually operates 3 hauls/day and spends about 3-3.5 hours/haul, which are further subjected to various factors. Trawlers usually operate with a cod-end mesh size of 25 mm. The bycatch finfish sampling was done fortnightly except during the trawl ban period *i.e*., from 15th April to 14th June. During sampling, the number of individuals of each finfish species was recorded and their weight was measured nearest to 1 gram. The bycatch of finfish species were identified based on the available taxonomic literature (Day, 1876; Lindberg, 1973; Fischer and Whitehead, 1974; Fischer and Bianchi, 1984; Gon and Randall, 2003). Month-wise and season-wise trawl finfish bycatch data collected were subjected to univariate analysis to estimate the Shannon Weiner Diversity Index (H$^{'}$), Pielou's evenness (J$^{'}$), Species richness (S), Margalef's species richness (d), Taxonomic diversity (Δ) and Total phylogenetic diversity (sPhi+) in the finfish bycatch population using PRIMER Version 6.1.7 software. Multivariate analysis was employed to assess the similarities that exist in the distribution and abundance of the population during different months and seasons using cluster analysis and K-dominance plot from January 2017 to August 2019.

RESULTS AND DISCUSSION

The present study is based on the finfish catch and bycatch data collected from the commercial trawlers operated along the coast of Nagapattinam from January 2017 to August 2019.

Estimated annual landings and finfish bycatch of trawl fishery

The estimated annual average landing of trawl catch was 15,414.41 tonnes with an annual average fishing effort of 9,327 boat-days. In the annual average landings, commercial catch shared 70.75% (10,905.78 tonnes) and annual finfish bycatch formed 21.12% (3,256.14 tonnes). Furthermore, juveniles of finfish constituted 56.88% (1851.94 tonnes) of the annual bycatch landing. The peak fishing effort was observed in March 2017 (1975) followed by March 2019 (1694), March 2018 (1660) and it was observed to be the lowest in February 2018 (140), followed by September 2018 (192), September 2017 (207) with the fishing effort ranging from 140 (February 2018) to 1975 boat-days (March 2017) during the study period (Table 1) and monthwise estimated landing of total catch, commercial catch, finfish bycatch and low value juvenile finfish bycatch are illustrated in Fig 2.

Taxonomical identification of finfish bycatch

Along the coast of Nagapattinam, 210 species of finfishes belonging to 15 orders, 79 families and 153 genera were collected from the bycatch of trawl fishing from January 2017 to August 2019. Finfish order-wise contribution of bycatch along the Nagapattinam region are showed in Fig 3. Additionally, 12 species of deep-sea fishes such as *Neoharriotta pinnata*, *Harpadon nehereus*, *Hoplostethus mediterraneus*, *Psenopsis cyanea*, *Neoepinnula orientalis*, *Lepidocybium flavobrunneum*, *Sphagemacrurus pumiliceps*, *Physiculus roseus*, *Alepocephalus bicolor*, *Lophiodes mutilus, Chascanopsetta lugubris* and *Ectreposebastes imus* and 9 finfish species of rare groups including *Mola mola, Bregmaceros mcclellandi, Atherinomorus lacunosus, Ptarmus jubatus, Satyrichthys laticeps, Pterygotrigla hemisticta, Opistognathus nigromarginatus, Bleekeria kallolepis* and *Bleekeria murtii* were also recorded.

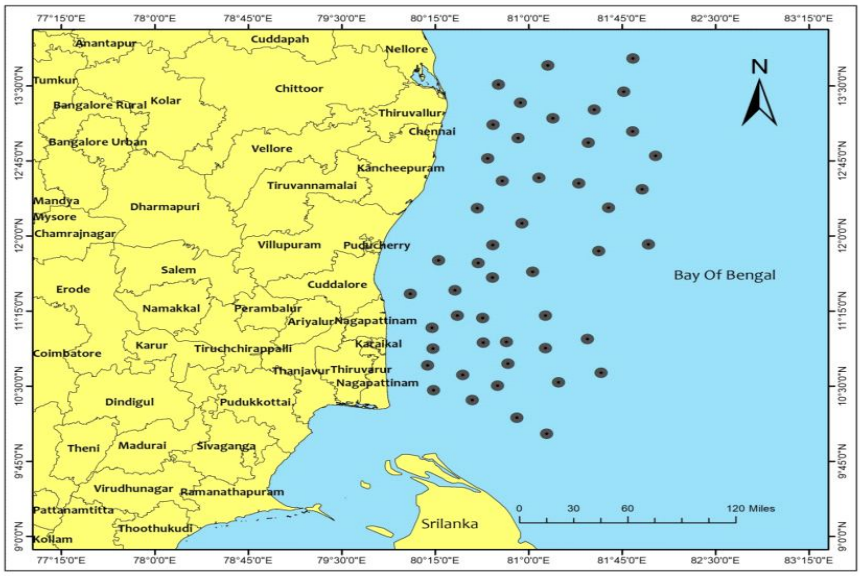

Fig 1: Trawling grounds of Nagapattinam coast.

Univariate analysis of monthly diversity

Monthly values of species richness (S) was recorded maximum during September 2017 (134) and minimum during June 2018 (53) and Margalef's Species richness (d) value was recorded high in September 2017 (19.25) and low in June 2018 (8.18). The Species richness and diversity are indicative of the stability of a community, (2014). Shannon-Wiener's diversity index (H') was the highest in September 2017 (6.5479) and the lowest in June 2018 (4.9144). The range of the indices in the trawl fishing indicated the diverse nature of bycatch finfish species. Shannon Weiner Index (H') value was estimated to be low during June which may be due to the non-operation of trawlers due to trawl ban enforced between between 15th April and 14th June. During the study period, the H' value was found to be low during December 2017 (5.2870), followed by June 2018 (4.9144), January 2019 (5.2043) which may be due to the dominance of one or few finfish species (Clupeid group during December 2017, Leiognathid group during June 2018, grunters and Leiognathid groups during January 2019). Similar H' values of trawl finfish bycatch ranging from 5.6266 to 4.5265 (Kodeeswaran, 2019) and crustacean bycatch from 5.53 to 3.13 (Pillai, 2014) were reported along the Chennai Coast. Species evenness (J') value was found to be high in September 2018 (0.939) and low in June 2019 (0.852), revealing that finfish species were evenly distributed over the months and there was not much difference in the species distribution along the coast of Nagapattinam. It is a well-known fact that the species diversity is found maximum if all species are equally

Table 1: Estimated total catch, finfish bycatch, bycatch other than finfish and juvenile finfish catch of trawlers of Nagapattinam coast during Jan 2017- Aug 2019.

Month of sampling	Total effort /month	Estimated total catch (Tonnes)	Estimated commercial catch (Tonnes)	Estimated finfish by catch (Tonnes)	Estimated by catch other than finfish (Tonnes)	Low value Juvenile catch (Tonnes)
Jan-2017	1290	1395.25	1018.53	255.89	120.83	99.09
Feb-2017	1260	1461.90	1081.81	305.83	74.26	130.27
Mar-2017	1975	1457.46	1020.22	326.32	110.91	131.12
Apr-2017	450	1113.83	846.51	212.41	54.91	91.50
Jun-2017	510	1155.30	820.26	236.84	98.20	172.65
Jul-2017	1209	1306.38	914.46	302.82	89.09	238.21
Aug-2017	1147	1279.72	857.41	321.59	100.71	221.03
Sep-2017	207	1223.43	868.64	267.81	86.99	130.30
Oct-2017	1200	1438.20	1035.50	311.37	91.33	162.37
Nov-2017	1110	1454.49	1018.15	334.53	101.81	160.62
Dec-2017	217	1525.59	1098.42	305.73	121.44	166.81
Jan-2018	279	1267.96	887.57	222.15	158.24	104.05
Feb-2018	140	1388.64	1013.71	275.23	99.70	123.24
Mar-2018	1660	1260.51	970.59	268.49	21.43	133.76
Apr-2018	420	1086.18	792.91	197.68	95.58	91.99
Jun-2018	510	1343.94	940.76	231.16	172.02	153.42
Jul-2018	1147	1884.80	1262.81	414.66	207.33	295.44
Aug-2018	1044	1656.83	1126.65	394.33	135.86	279.37
Sep-2018	192	1567.44	1050.18	319.76	197.50	232.98
Oct-2018	1248	1472.08	1030.46	348.59	93.04	213.04
Nov-2018	1080	742.00	504.56	152.85	84.59	88.53
Dec-2018	232	566.18	407.65	110.12	48.41	51.85
Jan-2019	783	1514.07	1090.13	290.70	133.24	123.07
Feb-2019	728	1520.60	1064.42	308.68	147.50	148.82
Mar-2019	1694	1538.57	1138.54	352.33	47.70	171.70
Apr-2019	390	1340.94	965.48	264.16	111.30	117.01
Jun-2019	255	1538.57	1030.84	280.02	227.71	183.36
Jul-2019	1110	1989.36	1412.44	493.36	83.55	344.80
Aug-2019	1102	2147.79	1481.97	478.96	186.86	321.98
Total	24589	40638.01	28751.58	8584.37	3302.04	4882.38
Annual average with standard deviation	9327±517	15414.41±316.26	10905.78±215.34	3256.14±83.69	1252.50±49.60	1851.94±74.36

abundant in the community. The Species richness (d) was found to be high in September 2017 (19.25) and low in June 2018 (8.18), giving an idea of variation in the species richness between different months during 2017-2019 in Nagapattinam coast. The species richness and evenness might be high and low in certain months which may be due to the migration of fish species influenced by the water temperature. When water temperature increases there is a coincidental increase in plankton biomass resulting in a high diversity level (Pillai, 2014). The monthly taxonomic diversity (Δ) was recorded high in August 2018 (92.99), followed by September 2017 (91.39) and low in June 2018 (77.86). The monthly total phylogenetic diversity was observed high in September 2017 (7425) and low in June 2018 (3175). The values of taxonomic diversity and phylogenetic diversity are supportive and useful to understand the monthly diversity of finfish bycatch. The univariate analysis of monthly diversity is tabulated in Table 2.

Multivariate analysis of monthly diversity

The multivariate analysis performed through cluster analysis revealed the similarity in finfish bycatch diversity between months and seasons. Like-wise, the K-dominance plot was drawn used to illustrate the abundance of different finfish bycatch species in different months and seasons during the study period. The cluster analysis of trawl finfish bycatch

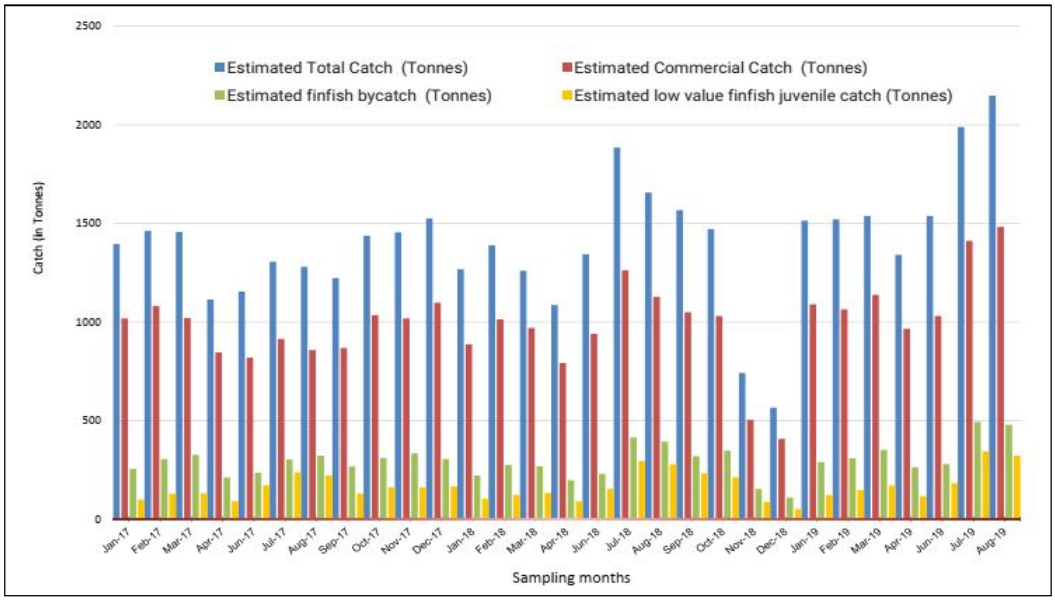

Fig 2: Estimated total catch, commercial catch, finfish bycatch and low value finfish juvenile catch of Nagapattinam coast.

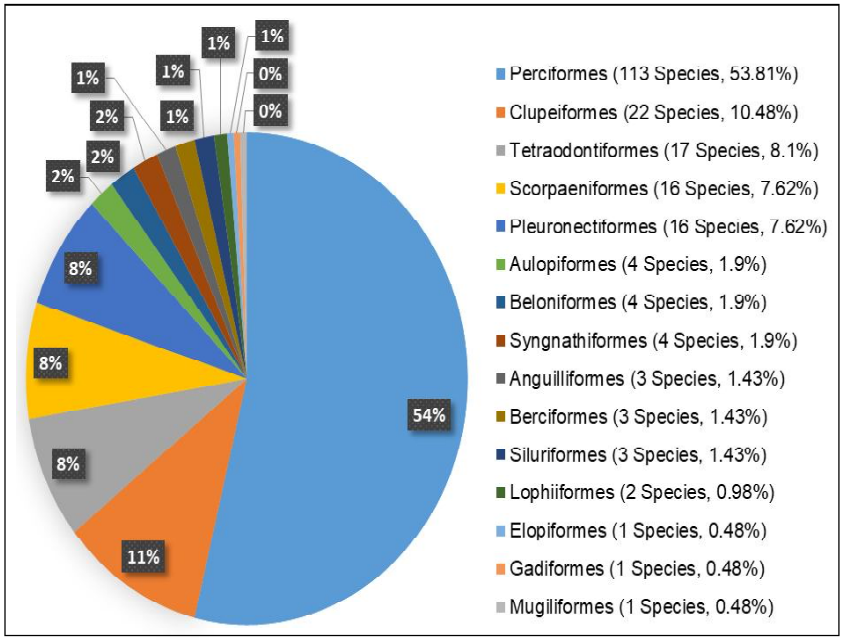

Fig 3: Finfish order-wise contribution of trawlers bycatch of Nagapattinam coast.

showed the highest similarity (66.68%) between September 2018 and September 2017 and the lowest similarity (30.21%) between February 2019 and June 2018. The results of cluster analysis showed the presence of finfish species over different months (Fig 4). The study revealed that finfish bycatch landed in the trawl fishery of Nagapattinam coast are diverse in nature (6.5479-4.9144) and species assemblages are in a parallel manner across the months. The abundant diversity of bycatch species is a common phenomenon in trawler fisheries (Pillai, 2014; Saila, 1983).

The K-dominance curve was obtained by plotting percentage cumulative abundance against species rank (K) on a logarithmic scale and the curve provides an undisturbed ecosystem exposed with an S-shaped curve. In the Nagapattinam coast, the plot showed that the curve for September 2017 and November 2018, which lie on the lower side, extended further and rose slowly due to the high intensity of species in this month. The dominance plot showed that the density of finfish bycatch species was high in September 2017 and November 2018 and proved that the number of species (richness) was more when compared to other months (Fig 5). Similar findings of abundant high diversity were observed along Chennai coast in December (Kodeeswaran, 2019), Thoothukudi coast in September (Ranjith, 2015) and Mangalore coast in October (Kumar *et al.*, 2015; Sonwal *et al.*, 2019).

Univariate analysis of seasonal diversity

A year was divided into four seasons namely summer (April, May, June), pre-monsoon (July, August, September), monsoon (October, November, December) and post-monsoon months (January, February, March) to assess the seasonal diversity (Pillai, 2014). Season-wise univariate analysis revealed that the species richness (S) ranged from 183 (monsoon 2017) to 123 (post-monsoon 2017) and Margalef's species richness (d) value ranged from 23.3575 (monsoon 2017) to 17.4877 (post-monsoon 2017). Similarly, species evenness (J′) ranged from 0.9266 (monsoon 2018) to 0.8434 (premonsoon 2019). The estimated Shannon - Weiner index was found to be within the range of 6.9241 (post-monsoon 2017) - 6.0386 (premonsoon 2019) whereas, taxonomic diversity (Δ) ranged from 90.92 (summer 2018) to 84.38 (post-monsoon 2019) and phylogenetic index ranged from 9775 (monsoon 2017) to 7025 (post-monsoon 2017). Upon comparing the different seasons of the study period, the monsoon seasons showed the maximum diversity (Table 3).

Multivariate analysis of seasonal diversity

The dendrogram of cluster analysis showed higher similarity (80.62%) between postmonsoon seasons of 2017 and 2018 and lower similarity (49.21%) between summer 2018 and monsoon 2019 (Fig 6). The seasonal K dominance curve indicated the high density of species during premonsoon 2017 and monsoon 2018 (Fig 7). In the present study, the highest seasonal similarity was found during post-monsoon, indicating that there was good recruitment to the fishery

Table 2: Month-wise univariate diversity indices of finfish bycatch of trawlers of Nagapattinam coast during Jan 2017 - Aug 2019.

Month	2017					2018					2019				
	S	d	J′	H′	Δ	sPhi +	S	d	J′	H′	Δ	sPhi +	S	d	J′	H′	Δ	sPhi +
January	84	13.44	0.904	5.7809	86.24	4825	95	14.82	0.914	6.0055	84.28	5450	56	9.41	0.896	5.2043	81.52	3275
February	86	13.32	0.903	5.8011	85.32	5000	127	19.06	0.916	6.3986	86.08	7075	95	14.17	0.917	6.0263	83.61	5100
March	97	14.66	0.921	6.0813	90.29	5575	110	16.65	0.911	6.1749	91.02	6225	108	18.12	0.924	6.2407	90.96	5825
April	114	16.71	0.924	6.3115	89.87	6600	104	16.14	0.904	6.0540	89.64	6150	103	17.46	0.931	6.2219	89.71	5575
June	89	13.53	0.922	5.9680	84.86	5000	53	8.18	0.858	4.9144	77.86	3175	78	12.22	0.852	5.3552	88.76	4700
July	85	13.31	0.923	5.9136	84.13	5075	83	12.99	0.853	5.4381	79.39	4800	112	17.17	0.877	5.9705	87.71	6125
August	90	14.56	0.905	5.8773	88.11	5325	113	16.54	0.934	6.3686	92.99	6425	76	11.73	0.872	5.4467	87.21	4375
September	134	19.25	0.927	6.5479	91.39	7425	108	15.83	0.939	6.3431	90.91	6100						
October	107	15.91	0.917	6.1812	84.04	6025	105	15.48	0.908	6.0953	86.84	5850						
November	113	17.35	0.922	6.2916	87.15	6500	119	17.74	0.935	6.4498	87.28	6700						
December	62	9.50	0.888	5.2870	84.79	3550	106	16.21	0.865	5.8163	80.51	5550						

immediately after the monsoon season along the coast of Nagapattinam. The similarity findings of Nagapattinam region in the present study were in conformity with the findings of Kodeeswaran (2019), Purusothaman *et al.* (2016), Kumar *et al.* (2015), Ranjith (2015), Karuppasamy *et al.* (2020) and Saroj *et al.* (2020). Additionally, high species abundance was reported in the premonsoon season which could be attributed to the trawl ban season.

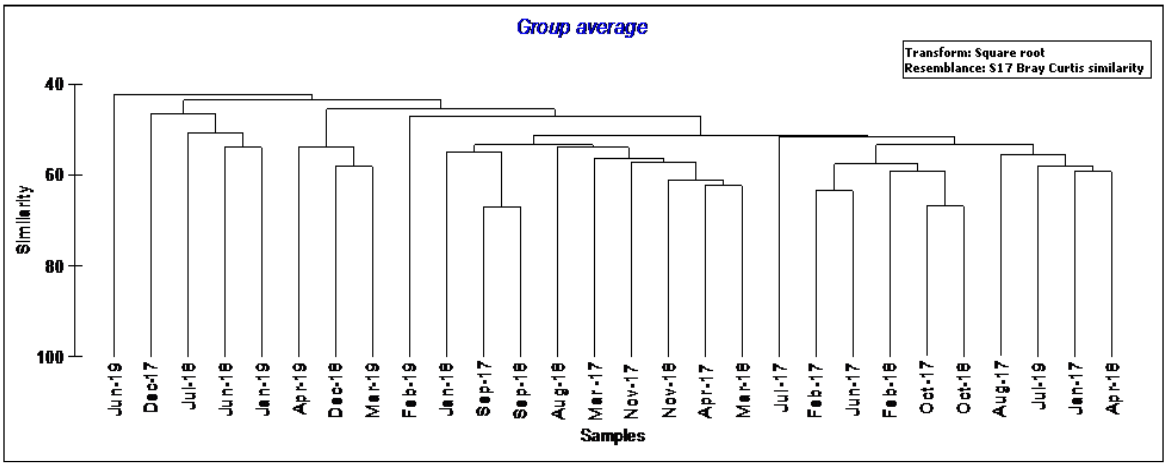

Fig 4: Month-wise dendrogram of finfish bycatch of trawlers of Nagapattinam coast from Jan'2017 to Aug'2019.

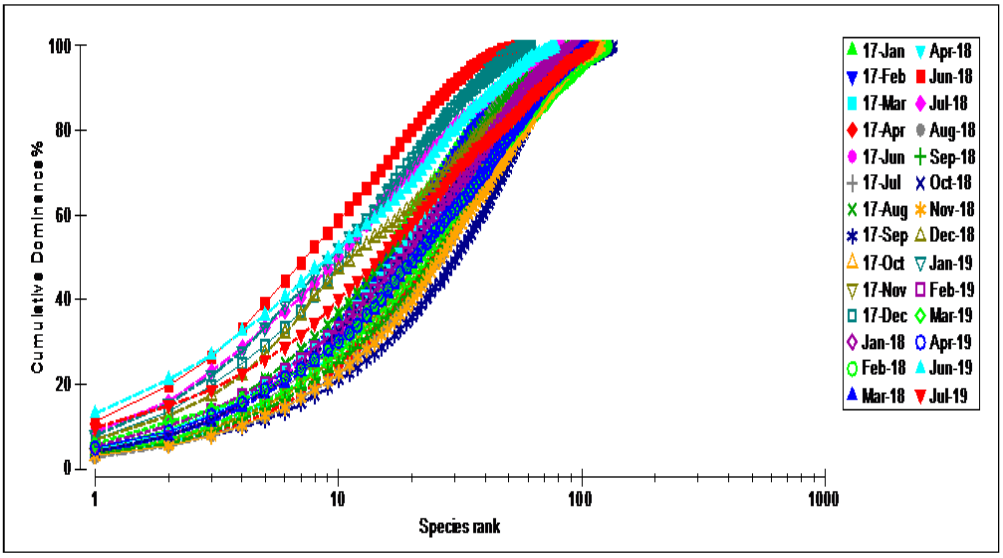

Fig 5: Month-wise K-dominance plot of finfish species bycatch of trawlers of Nagapattinam coast from Jan'2017 to Aug'2019.

Table 3: Season-wise univariate diversity indices of finfish bycatch of trawlers of Nagapattinam coast during Jan 2017-Aug 2019.

Season	S	d	J′	H′	Δ	sPhi+
Post monsoon 2017	123	17.4877	0.8876	6.1622	86.18	7025
Summer 2017	148	19.9899	0.9096	6.5577	90.46	8200
Pre monsoon 2017	145	19.4086	0.9007	6.4670	86.29	8125
Monsoon 2017	183	23.3575	0.9213	6.9241	89.04	9775
Post monsoon 2018	166	21.8162	0.8954	6.6037	86.67	8925
Summer 2018	149	20.6702	0.8902	6.4264	90.92	8225
Pre monsoon 2018	148	19.3347	0.8932	6.4395	87.90	8125
Monsoon 2018	173	22.0243	0.9266	6.8893	89.56	9325
Post monsoon 2019	150	19.9489	0.9091	6.5715	84.38	7875
Summer 2019	144	21.7719	0.9207	6.6014	90.79	7700
Pre monsoon 2019	143	18.9686	0.8434	6.0386	89.37	7850

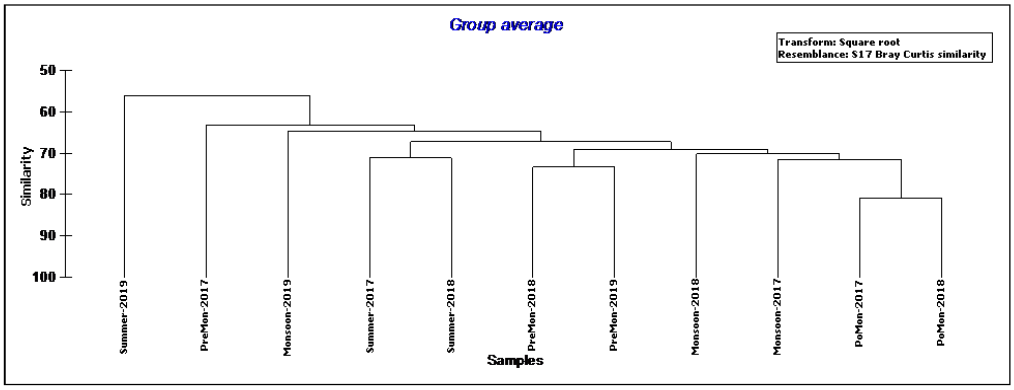

Fig 6: Season-wise dendrogram of finfish bycatch of trawlers of Nagapattinam coast from Jan'2017 to Aug'2019.

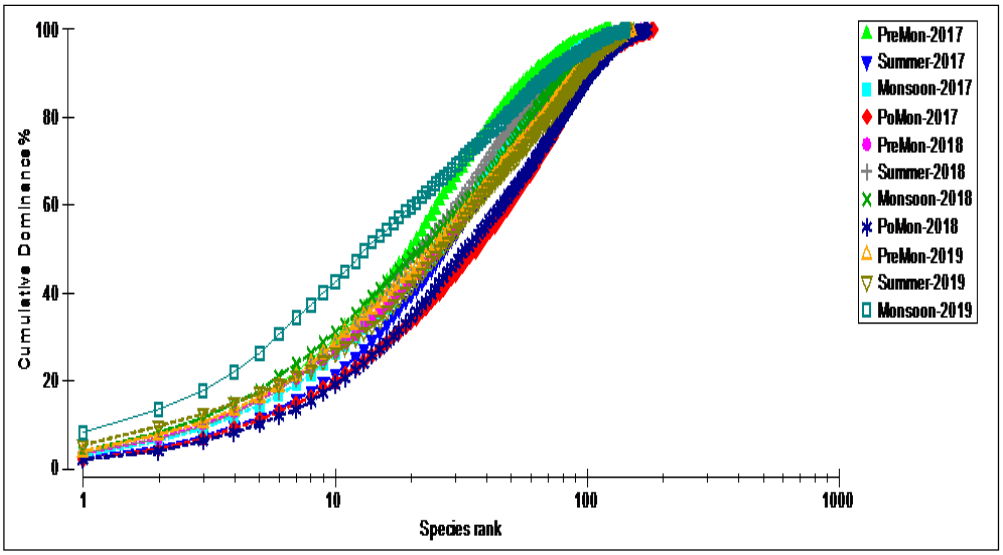

Fig 7: Season-wise K-dominance plot of finfish species of trawlers of Nagapattinam coast from Jan'2017 to Aug'2019.

CONCLUSION

Species diversity and abundance are indicators of a healthy ecosystem. In the present study, 210 species of finfish and 9 rare species of finfish were reported as trawl bycatch and the diversity was found to be high during monsoon season along the Nagapattinam coast. The species abundance and diversity indices provide baseline data information which will be very much useful for further studies on bycatch management in trawl fishery, impact of bottom trawling and conservation and management of fisheries resources along this coast.

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