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RESEARCH ARTICLE

SPATIAL TEMPORAL ASSEMBLAGE STRUCTURE OF FISHERY RESOURCES IN RELATION WITH ENVIRONMENTAL VARIABLES ALONG THE MANGROVE CREEKS OF SOUTH ANDAMAN

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ABSTRACT

The spatial and temporal pattern in the fishery assemblage structure of mangrove habitats along South Andaman Islands coast was studied in relation to environmental variables. Exploitation level was found to be low compared to mainland as fishing was carried out mainly for own consumption and less for commercial purpose. Fishery data were collected on weekly basis from artisanal fishermen at eight sampling stations and later sorted seasonally. Fifty five commercially important species were recorded during the study and sorted out into thirteen major groups for better understanding. Cluster analysis confirmed three seasons, of which season-I receiving highest rainfall recorded maximum fishery (45%) followed by season-II receiving moderate rainfall (35%) and least in season-III receiving least rainfall (20%). While spatially, the fishery was highest in Shoal Bay (40%) and lowest in Beodanabad (4%). *Scylla serata* (15.1%) dominated the catches followed by *Penaeus (Fenneropenaeus) indicus* (6.3%), *Penaeus (Fenneropenaeus) merguiensis* (5.3%), *Plotosus canius* (5.2%), *Oreochromis mossambicus* (4.1%) and *Scylla tranquebarica* (3.7%). Furthermore shrimps formed the major group that contributed 21.9% of the fishery followed by Mud Crabs (17.2%), Mullets (11.8%) and Silver-biddies (7.13%). Canonical Correspondence Analysis (CCA) indicated rainfall as the major factor influencing seasons and water temperature and salinity as the variables affecting the fish catch. Similarly BEST analysis also confirmed that water temperature, salinity and BOD as parameters affecting the fishery of South Andaman mangrove regions.

INTRODUCTION

Mangrove ecosystem is worldwide known for its various physiological and ecological functions. These coastal forests are among the most productive ecosystems of the world which makes them suitable as shelter to various organisms. They not only support diverse marine, freshwater and terrestrial flora and fauna but are also important to adjacent ecosystem such as coral reefs and sea grass beds (Shunula and Whittick, 1996; Macintosh & Ashton 2002). In addition they provide various commercial products to local communities (Bandaranayake 2002).

Andaman and Nicobar Islands (6°45' and 13°41' North latitude and 92°12' and 92°57' East longitude) are one of the union territories of India and are 1,200 km from mainland India. These islands are known for its luxuriant mangrove coverage of 1190 Sq.km (20%) which is third in the country next to Sunderban and Gujarat (Venkataraman and Wafar, 2005; Mandal and Naskar, 2008). Naskar and Mandal (1999) explained favourable climatic conditions such as short dry season and high tidal fluctuation and heavy amount of rainfall as the reason for tall dense mangrove forest in these islands. Many researchers have studied the islands mangrove flora starting from 1902 to till date, to mention a few are (Kloss, 1902; Parkinson 1923; Thothathri 1981; Mal *et al*. 1985; Dagar and Singh 1999, Debnath 2004, Dam roy *et al*. 2009; Ragavan *et al*. 2014). A total of 34 mangrove species under 17 genera belonging to 13 families has been reported from the island by Dagar *et al*. (1991). However recently Ragavan *et al*. (2015) updated the list to 38 mangrove species (4 hybrids and 34 species) belonging to 12 families and 19 genera. Nevertheless studies on mangrove icthyofauna are very few and restricted to works on diversity (Gopinathan and Rajagopalan; Das and Dev Roy, 1989; Dam Roy, 1999; Dam Roy, 2003; Rajan *et al*. 2003 and Devi and Rao, 2007). Moreover the Island ecosystem in Andaman and Nicobar Islands is very unique where all the major marine ecosystems viz. Mangrove, coral, rocky and sandy co-exists. Hence the present study was carried out for the

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first time to give an idea of how fishery behaves during different seasons in relation to the fluctuations in the habitat variables in an Island ecosystem.

MATERIALS AND METHOD

Study area

Eight mangrove areas viz. Carbyn's Cove, Beodanabad, Manjery, Sipighat, Chouldary, Ograbranch, Kadakachand and Shoal Bay of South Andaman district of Andaman and Nicobar Islands were selected for the present study (Figure 1). The climate of the Islands can be defined as tropical, with coastal hot and humid uniform climate due to its geographical location, humidity is high with average being 80%, and the temperature ranges and 21º to 33º C. The Bay Islands receive rainfall of about 3000 mm per annum and extremes of summer and winter are practically unknown (Meteorological statistics of Andaman and Nicobar Islands 2014, http://andssw1.and.nic.in/ecostat/bas).The south-west monsoon visits the islands roughly between mid May and early October, and north-west monsoon between November and December (lonelyplant.com). Based on the rainfall and Temperature data, three Seasons were proposed during the study period that is Season – I (May to September) when the rainfall is highest and temperature is low due to heavy rainfall, Season - II (October to January) when the rainfall is moderate and temperature is medium due to moderate rainfall and commencing of winter Season though winter Season cannot be sharply differentiated and Season – III (February to April) when there is negligible or least rainfall and temperature is high due to least rainfall and commencing of summer Season though it is not sharply differentiated.

Fishery resources

Station wise catch (Kg) was recorded weekly during the period from October 2012 to September 2013 from the 8 stations and later compiled monthly to find the annual catch (Kathiresan and Rajendran, 2002; Nandan *et al*., 2012). The resources recorded from the study area were sorted into 13 economically important groups after identifying the individual species (Fischer and Bianchi, 1984; Rao *et al*., 2000; Devi and Rao, 2007 and www.niobioinformatics.in/crab) viz. Mullets (*Liza* spp. and *Valamugil* spp. - Family Mugilidae), Silverbellies (Leiognathidae), Half beaks (Hemiramphidae), Trevally (Carangidae), Anchovies (Engraulidae), Sardines (*Sardinella* spp Clupeidae), Snappers (*Lutjanus* spp. - Lutjanidae), Silver-biddies (*Gerres* spp. - Gerridae), Grunts (*Siganus* spp.- Siganidae), Catfish (*Plotosus* spp. - Plotosidae), Tilapia (*Oreochromis mossambicus* - Cichilidae), Shrimps (Penaeidae) and Mud Crab (*Scylla* spp.- Portunidae). Seasonal catch were estimated for each group separately for each station (Nandan *et al*., 2012). The environmental parameters viz. water temperature, air temperature, Dissolved oxygen (Winkler's method), Biological oxygen demand (Grasshoff *et al*., 1983; Saravankumar *et al*., 2009), salinity (refractometer) and pH (pH meter) were collected monthly. Whereas rainfall data was obtained from meteorological department (http://andssw1.and.nic.in/ecostat/basic_statistics1112.php)

Statistical analysis

Multivariate analysis was carried out to identify the fishery assemblage structure in the study area using PRIMER v 6 (Clarke and Gorley, 2006). The raw environmental data was overall transformed (Log (x-1)), normalised and MDS (Non-Metric-Multi-Dimensional Scaling) analysis was performed. Similarly for Fishery overall transformation (square-root) of raw data was done for performing cluster analysis and MDS, to find out the additional insights about the monthly variations in the assemblages structure of fishery (Rueda and Defeo, 2003).

RELATE routine analysis within the PRIMER was performed to scrutinize the relationship between the fish catch and environmental parameters and similarity matrix was compared with spearman rank correlation coefficients (q), with q = 1 indicating a perfect match (Rueda and Defeo, 2003 and Clarke and Gorley, 2006). In addition, relationship between the fish catch and environmental parameters (water temperature, air temperature, salinity, pH, Dissolved oxygen, Biological oxygen demand) was also compared performing canonical correspondence analysis (CCA) using PAST software, version 2.16 (Ter Braak, 1986, Araujo *et al*., 1999 and Hammer *et. al*., 2001).

To study seasonal and spatial variation in communities as well as to detect relation between species and environmental parameters (ter Braak and Prentice, 1988; ter Braak and Verdonschot, 1995 and Mansoor *et al*., 2012). Where CCA plot illustrate environmental parameters by vectors, for which direction and length are determined by the correlation of the environmental variable with the ordination axes and by the eigenvalues of the axes (Bouchereau *et al*., 2008).

RESULTS

The present study has made an effort to ascertain the fluctuations in fishing activity in the selected mangrove regions of South Andaman in relation to the environmental parameters. It could be found that the exploitation level in general was low compared to the mainland India (Kathiresan and Rajendran, 2002; Bhatta and Panda, 2008 and Nandan *et al*., 2012) and in contrast and the mainland; the rainy season has shown high landings in the study area.

Environmental parameters

The air temperature ranged between 26.5 to 32˚C and the lowest was recorded in Shoal Bay during the Season- I (26.5˚C) and highest (32˚C) in Manjery and Ograbranch during the Season- III (Table 1). Water temperature ranged between 25 to 30.5˚C, lowest water temperature was recorded in Shoal Bay (25˚C) during the Season – I and highest in Ograbranch (30.5˚C) in Season- III The season wise analysis of rainfall data from South Andaman Islands have shown Season- I with highest rainfall (447.15 mm), Season- II with average rainfall (140.65 mm) and Season- III with lowest rainfall (10.7 mm) (http://andssw1.and.nic.in/ecostat/basic_statistics1112.php).

Table1 Station wise range and mean values of environmental parameters

Stations		AT			WT			pH			Salinity			DO			BOD		
		S -I	S -II	S -III	S -I	S -II	S -III	S -I	S -II	S -III	S -I	S -II	S -III	S -I	S -II	S -III	S -I	S -II	S -III
CC	Min	27	28	29	25	27	28	6.8	6.6	6.7	10	14	27	3.7	3.1	3	0.6	0.8	0.9
	Max	29	30	32	28	28	30	7.4	6.9	6.8	20	23	33	4.1	3.5	3.3	0.7	1.2	1.4
	Mean	28	29	31	27	28	29	7.1	6.8	6.8	15	19	30	3.9	3.3	3.2	0.7	1	1.2
BB	Min	27	29	30	26	29	30	7.1	6.3	6.6	10	12	21	3.2	2.7	2.5	0.3	0.3	0.3
	Max	31	31	31	27	31	31	7.5	6.6	6.8	15	16	30	3.8	3.9	3.3	0.4	0.4	0.5
	Mean	29	30	31	27	30	31	7.3	6.5	6.7	13	14	26	3.5	3.3	2.9	0.4	0.4	0.4
MR	Min	28	29	31	26	27	28	7.2	6.9	7.2	28	29	35	3.3	3.9	3.1	0.5	0.5	0.6
	Max	30	31	33	28	29	30	7.7	7.6	7.5	30	31	37	3.9	4.5	3.3	0.6	0.6	0.8
	Mean	29	30	32	27	28	29	7.5	7.3	7.4	29	30	36	3.6	4.2	3.2	0.6	0.6	0.7
SG	Min	27	28	30	25	26	26	6.1	5.8	6.3	25	28	32	3.5	3.9	3	0.5	0.6	0.7
	Max	29	30	32	28	28	29	6.7	6.1	6.7	32	31	34	4.6	4.6	3.3	0.7	0.8	0.8
	Mean	28	29	31	27	27	28	6.4	6	6.5	29	30	33	4.1	4.3	3.2	0.6	0.7	0.8
CR	Min	28	29	30	26	25	29	6.9	6.8	7.1	12	15	30	6.4	4.2	3.1	0.5	0.7	0.6
	Max	30	30	32	27	27	30	7.4	7.6	7.6	19	21	31	6.9	4.9	3.4	0.8	0.9	0.9
	Mean	29	30	31	27	26	30	7.2	7.2	7.4	16	18	31	6.7	4.6	3.3	0.7	0.8	0.8
OB	Min	28	29	31	26	26	30	6.5	6.9	7.1	10	20	32	4.9	4.6	3.6	0.4	0.4	0.5
	Max	30	30	33	28	28	31	7.4	7.2	8.1	15	30	38	5.6	4.9	3.9	0.5	0.5	0.6
	Mean	29	30	32	27	27	31	7	7.1	7.6	13	25	35	5.3	4.8	3.8	0.5	0.5	0.6
KC	Min	27	29	30	25	25	27	6.6	6.6	6.9	11	24	30	3.4	3.1	3.4	0.5	0.5	0.7
	Max	30	30	32	28	28	31	7.2	6.9	7.4	20	27	37	4.2	3.6	3.8	0.8	0.8	1
	Mean	29	30	31	27	27	29	6.9	6.8	7.2	16	26	34	3.8	3.4	3.6	0.7	0.7	0.9
SB	Min	25	26	29	24	25	27	6.6	6.7	6.9	10	12	18	5.2	5.7	4.1	0.4	0.4	0.5
	Max	28	28	29	26	27	28	7.2	7.2	7.4	15	17	21	5.8	5.9	4.5	0.6	0.5	0.6
	Mean	27	27	29	25	26	28	6.9	7	7.2	13	15	20	5.5	5.8	4.3	0.5	0.5	0.6

AT- Air temperature, WT –Water temperature, DO –Dissolved oxygen, BOD – Biological oxygen demand
S I, S II and S III= Season 1, Season 2, and Season 3: CC-Carbyn's Cove, BD-Beodanabad, MR-Manjery, SG-Sippighat, OB-Ograbranch, CR-Chouldary, KC-Kadakachand and SB-Shoal Bay

Highest salinity was observed in all the three Seasons in Manjery with average being 31.7 PSU and lowest in Shoal Bay, Beodanabad and Ograbranch (12.5 PSU) during Season- I while lowest average salinity was in Shoal Bay (15.5 PSU). The lowest average pH was recorded in Sipighat (6.3) and highest average in Manjery (7.4). Whereas the dissolved oxygen ranged between 2.5 mg/l to 6.65 mg/l, highest in Chouldary during Season- I (6.65 mg/l) followed by Shoal Bay (5.8 mg/l) in Season- II and least (2.5 mg/l) in Beodanabad in Season- III. BOD ranged between 0.35-1.15 mg/l overall and the highest was recorded in Carbyn's Cove (1.15 mg/l) during Season- III and lowest in Beodanabad during Season- I and II (0.35 mg/l).

Catch composition

A total of fifty five species of commercial importance was recorded from the study area (Table 2). *Scylla serata* (15.1%) dominated the catches followed by *Penaeus (Fenneropenaeus) indicus* (6.3%), *Penaeus (Fenneropenaeus) merguiensis* (5.3%), *Plotosus canius* (5.2%), *Oreochromis mossambicus* (4.1%) and *Scylla tranquebarica* (3.7%). Out of the thirteen major groups, Shrimp (22%) was the most dominating resource (Table 3) followed by Mud Crabs (17%), Mullets (12%) and Silver-biddies (7%). Spatially, the highest catch was recorded from Shoal bay (40%) followed by Sipighat (17%) and least in Beodanabad (4%).

Seasonal catch composition

A total of 20049 Kg of annual catch was estimated from the study area during the study period. The highest landings were observed in Season - I (45%) followed by Season- II (34.9%) and least was observed in Season- III (20%).

The highest catch was recorded in Season- I followed by Season- II in all the study sites except in case of Carbyn's Cove where Season- I was followed by Season- III (Table 4). In Carbyn's Cove, Sardines (216 kg) and Trevally (167 kg) were the dominant catch in Season- III while Shrimps (150 kg), Sardines (110 Kg) and Mullets (107 kg) dominated in Season- I. Catch consisted mainly of Shrimps, Mud Crabs, Mullets and Trevally in all the Seasons while Sardine and Anchovies constituted the least in Beodanabad. Mud Crabs (675 Kg) were the major fishery resources in Manjery while all the other groups were very less in the landings. In Sipighat, Mud Crabs (550 Kg) was dominant in all the seasons followed by Mullets, Silver-biddies and Shrimps. In addition to Shrimps and Mullets, Tilapia formed the major landings in Chouldary in Season- I, II and moderate in Season- III. Grunts (206 kg) formed average landings in Ograbranch along with Shrimps, Mud Crabs, Silver-biddies, Snappers, Mullets and Trevally. Grunts, Mullets and Shrimps formed the major landings in Kadakachand. In Shoal Bay all the twelve groups contributed to the landings except Tilapia which contributed the least (23 Kg) while Shrimps (2290 Kg) dominated the landings followed by Mullets (930 Kg).

Cluster and MDS analysis

The cluster analysis have segregated the sampling months into three groups 1) May, June, July, August and September (96%) 2) October, November, December and January (97%) 3) February, March and April (96%). 95% similarity was depicted between season –I and –II and least (89.7%) between Season – I, -II and –III (Figure 2). Similarly MDS analysis of environmental parameters and catch also stated the clustering of months into three groups.

Table 2 List of species (Relative percentage composition) exploited from mangrove habitats of South Andaman

Species	CC	BB	MR	SG	CR	OB	KC	SB	Total
Carangoides caeruleopinnatus	1.29	3.69	1.08	0.53	0.60	0.94	1.06	0.83	0.96
Carangoides malabaricus	3.99	4.38	1.21	0.68	0.31	1.21	1.63	1.53	1.57
Carangoides ferdau	2.87	2.05	0.53	0.48	0.70	1.35	1.22	1.29	1.21
Carangoides chrysophrys	2.22	1.09	0.55	0.26	0.14	0.66	0.65	0.98	0.83
Caranx ignobilis	1.97	1.37	0.71	0.53	0.43	0.91	1.06	0.81	0.87
Caranx sexfasciatus	2.50	1.64	0.86	0.48	0.24	0.88	0.73	0.87	0.92
Oreochromis mosambica	5.57	2.19	6.62	0.66	30.79	0.99	7.17	0.29	4.12
Sardinella melanura	8.78	0.16	0.34	0	0.63	0.23	0.53	0.40	1.07
Sardinella fimbriata	8.05	0.12	0.67	0	0.99	0.20	0.16	0.37	1.03
Sardinella gibbosa	6.53	0.12	0.34	0	0.47	0.09	0.12	0.31	0.79
Stolephorus commersonii	1.41	0.88	1.09	0.57	0.54	1.07	2.55	1.70	1.32
Stolephorus indicus	1.04	0.22	0.20	0.03	0.01	0.15	0.63	0.06	0.20
Gerres abbreviatus	3.04	5.13	1.16	3.69	1.44	2.50	1.63	2.26	2.50
Gerres filamentosus	1.48	1.94	1.55	3.71	1.90	4.54	1.96	2.40	2.56
Gerres oyena	0.55	0.86	0.28	1.14	1.97	0.26	0.24	0.10	0.51
Gerres oblongus	1.91	2.05	1.50	1.51	1.36	2.89	0.90	1.37	1.58
Hemiramphus far	0.73	1.78	0.50	0.81	0.73	1.05	1.25	1.29	1.05
Hyporhamphus dussumieri	0.87	0.82	0.62	0.51	1.32	0.99	1.36	1.61	1.16
Zenarchopterus buffonis	0.39	0.82	0.50	0.42	0.73	0.99	0.41	1.69	1.02
Zenarchopterus dispar	0.48	0.55	0.45	0.33	0.90	0.64	0.16	1.91	1.05
Leiognathus brevirostris	0.70	2.12	1.01	0.74	1.42	0.40	0.94	1.66	1.21
Leiognathus daura	0.28	0.68	0.22	0.48	0.66	0.13	0.81	1.11	0.70
Leiognathus splendens	0.28	0.75	0.22	0.36	0.69	0.26	1.18	0.79	0.60
Leiognathus equulus	0.25	0.27	0.17	0.47	0.49	0.23	0.57	0.82	0.54
Leiognathus fasciatus	0.20	0.48	0.56	0.39	0.21	0.17	0.57	0.67	0.48
Secutor insidiator	0.08	0.55	0.17	0.21	0.21	0.17	0.49	1.08	0.57
Secutor ruconius	0.09	0.34	0.11	0.27	0.42	0.03	0.73	0.91	0.52
Gazza minuta	0.20	0.34	0.17	0.17	0.35	0.06	0.81	0.87	0.50
Gazza achlamys	0.39	0.34	0.34	0.32	0.56	0.29	0.98	0.91	0.62
Lutjanus argentimaculatus	3.01	1.09	1.35	4.46	2.22	5.30	5.38	1.37	2.66
Lutjanus russelli	1.10	0.21	0.45	1.17	0.76	2.33	1.71	1.51	1.31
Lutjanus fulviflammus	0.45	0.21	0.17	0.39	0.49	1.40	0.81	1.09	0.77
Mugil cephalus	0.47	0.94	0.42	0.61	0.33	0.64	0.90	0.25	0.45
Liza macrolepis	2.60	3.61	1.47	2.49	1.25	0.87	2.12	1.72	1.89
Liza melinoptera	2.04	2.95	2.60	2.57	1.83	1.60	3.53	2.81	2.56
Liza subvirdis	1.19	1.07	0.84	0.78	0.33	0.37	0.81	0.75	0.75
Liza carinata	0.23	1.05	0.64	0.21	0.08	0.13	0.24	0.40	0.34
Liza viagiensis	0.28	2.41	1.65	0.63	0.73	0.97	0.94	1.37	1.11
Valamugil seheli	3.84	0.34	1.51	1.78	0.74	1.21	1.61	1.40	1.60
Valamugil buchanni	2.23	0.62	1.51	3.30	0.89	0.58	1.62	1.80	1.84
Valamugil cunnesius	1.46	0.27	1.91	1.99	1.18	0.86	1.10	1.19	1.34
Plotosus canius	2.00	0	6.31	6.29	3.96	0	0	7.97	5.27
Plotosus lineatus	0.14	0	0.81	0.15	1.39	0	0	1.64	0.87
Siganus javus	1.35	1.50	1.29	0.30	0.83	3.93	9.21	1.48	1.89
Siganus vermiculatus	0.62	0.82	2.30	1.32	0.97	4.57	14.91	1.48	2.48
Siganus guttatus	0.73	1.23	1.40	0.27	0.42	3.49	9.29	1.17	1.65
Metapenaeus affinis	0.96	2.74	1.46	0.87	1.39	2.71	1.47	2.22	1.77
Metapenaeus dobsoni	0.84	2.74	1.23	0.66	1.53	2.13	1.22	2.17	1.63
Parapenaeopsis stylifera	0.53	4.73	0.79	0.81	1.46	1.66	1.30	2.92	1.92
Penaeus (Fenneropenaeus) indicus	5.29	11.52	1.96	7.65	5.98	6.90	3.91	6.82	6.33
Penaeus (Fenneropenaeus) merguiensis	3.43	8.48	2.75	4.76	5.28	7.48	2.28	6.35	5.35
Penaeus(Penaeus) monodon	0.25	0	0.50	0.30	0.28	0.29	0.41	1.37	0.74
Penaeus (Penaeus) semisulcatus	2.19	0.30	2.41	3.07	2.36	3.00	1.14	2.88	2.58
Scylla serrata	4.16	10.53	34.15	30.01	9.52	18.11	1.43	10.10	15.14
Scylla tranquebarica	0.45	2.87	4.37	3.40	2.57	5.18	0.12	4.92	3.71

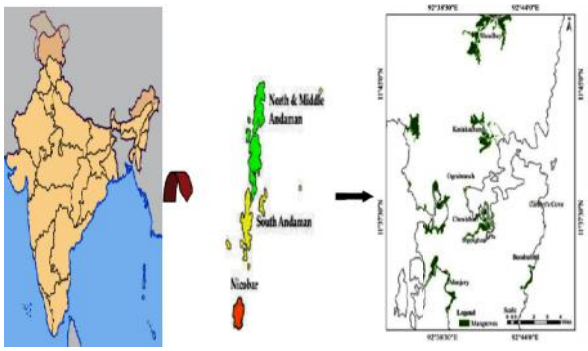

Figure 1 Study area: South Andaman

Influence of environmental parameters on catch composition

CCA analysis revealed that Season -I was influenced by rainfall and season –III by salinity and water temperature in the study sites (Figure 3). Trevally, sardines and mud crabs were found to be positively influenced with salinity and temperature whereas shrimps showed positive relation with rainfall, dissolved oxygen and negative relation with BOD. Mullets, catfish and tilapia have also shown more or less positive relation with dissolved oxygen and rainfall. However the other fishery groups did not show any marked relation with the environmental parameters.

Table 3 Relative percentage composition of the major groups exploited in mangrove regions of South Andaman

Major Groups	Carbyn's Cove	Beodanabad	Manjery	Sipighat	Chouldary	Ograbranch	Kadakachand	Shoal Bay	Combine
Trevally	20.625	8.125	7.11	7.66	2.73	7.97	6.09	39.69	6.38
Tilapia	11.99	1.94	14.29	2.66	53.63	2.06	10.65	2.78	4.12
Sardines	71.80	0.52	4.15	0	5.19	1.56	1.73	15.05	2.88
Anchovies	14.10	2.62	7.54	6.89	2.62	6.89	12.79	46.56	1.52
Silver-biddies	8.67	5.10	5.38	23.36	6.71	12.24	4.06	34.48	7.13
Half beaks	3.08	2.03	2.59	4.83	3.71	4.41	2.73	36.64	4.28
Silverbellies	3.82	3.73	4.60	9.81	6.25	2.60	7.55	61.63	5.75
Snappers	8.45	1.15	3.65	20.86	5.21	16.16	10.11	34.41	4.78
Mullets	10.76	4.09	9.45	20.08	4.47	5.23	6.67	39.24	11.82
Catfish	3.09	0	10.33	17.40	6.26	0	0	62.93	6.13
Grunts	3.98	2.16	7.38	5.22	2.65	17.08	34.00	27.53	6.02
Shrimps	5.46	5.21	4.78	13.69	5.98	9.44	3.37	52.08	21.93
Mud Crabs	2.37	2.66	19.52	32.10	5.03	11.57	0.43	26.32	17.25
Combine	8.86	3.65	8.89	16.57	7.18	8.56	6.12	40.17	100

Table 4 Station wise seasonal catch (Kg) of the major fishery groups

Station/Season	Trevally	Tilapia	Sardines	Anchovies	Silver-biddies	Half beaks	Silverbellies	Snappers	Mullets	Catfish	Grunts	Shrimps	Mud Crabs	Total
CC-I	30	44	110	14	46	22	22	49	107	20	20	150	15	649
CC-II	67	45	89	18	52	18	18	27	87	14	16	60	32	543
CC-III	167	10	216	11	26	4	4	5	61	4	12	30	35	585
BD-I	15	8	1	3	30	18	24	6	40	0	9	110	15	279
BD-II	28	5	1	5	26	4	12	3.5	38	0	11	75	37	245.5
BDIII	61	3	1	0	17	7	7	1.5	19	0	6	44	40	206.5
MR-I	10	55	9	10	30	13	25	16	80	49	33	125	270	725
MR-II	24	54	5	7	25	14	16	10	77	43	31	60	255	621
MR-III	57	9	10	6	22	10	12	9	67	35	25	25	150	437
SG-I	18	12	0	10	177	33	63	112	270	130	40	333	550	1748
SG-II	25	7	0	8	141	23	41	68	190	74	13	210	350	1150
SG-III	55	3	0	3	16	13	9	20	16	10	10	59	210	424
CR-I	7	250	4	2	40	25	35	29	50	39	18	150	77	726
CR-II	9	150	11	4	35	17	25	19	40	29	9	80	57	485
CR-III	19	43	15	2	21	11	12	2	16	9	5	33	40	228
OB-I	20	6	3	4	84	28	17	77	70	0	89	220	210	828
OB-II	35	7	4	12	67	21	11	37	40	0	44	175	130	583
OB-III	47	4	2	5	24	14	2	41	14	0	73	20	60	306
KC-I	10	51	3	22	33	20	54	40	76	0	188	98	5	600
KC-II	41	22	2	13	16	9	20	22	35	0	123	35	3	341
KC-III	27	15	5	4	9	10	13	35	47	0	99	15	7	286
SB-I	137	10	20	72	233	286	332	174	450	355	165	890	350	3474
SB-II	173	9	11	48	220	138	248	104	390	251	145	1090	210	3037
SB-III	198	4	56	22	40	100	130	52	90	168	22	310	350	1542
Total	1280	826	578	305	1430	858	1152	959	2370	1230	1206	4397	3458	20049

CCA plot Axis 1 showed Eigen value of 0.16294 and 48% similarity and Axis 2 showed 0.084024 Eigen value and 25.08% similarity. Similarly BEST analysis also revealed water temperature, salinity and BOD as the environmental variable best related with the fishery catch in the study area, spearmen correlation method showed q=0.86 value which was less than <1 hence significant.

DISCUSSION

The present study aimed to investigate the influence of the environmental variables in relation to seasonal fish catch of the islands mangrove ecosystem. Lowest air and water temperature in Season -I compared to other two Seasons which can be attributed to the heavy rainfall recorded during this Season. A similar trend was also observed in Swarnamukhi river estuary east coast of India (Reddi *et al*., 1993) and in Devi-estuary Odisha coast of the Bay of Bengal, India (Sahu *et al*., 2013). The highest average air, water temperature and salinity was observed in Manjery could be due to the fact that the mangrove patch is situated mostly parallel to the open sea.

While the lowest average air, water temperature and salinity in Shoal Bay compared to the other stations can be due to the vast and dense mangrove coverage while the low salinity might be due to high influx of freshwater (5 streams running into the creek). In Sipighat, the devastating tsunami of 2004 caused mass destruction of the vast mangrove coverage by submergence in the standing saline water (Roy and Krishnan, 2005), which might be a reason of high salinity and low pH in this station. The average highest DO recorded from Shoal Bay was in agreement with the finding of Boyd and Gross (1999) who has observed that DO in natural water decreases with increase in temperature and salinity of water. But in contrast, although the highest temperature and salinity was recorded in Manjery lowest DO was estimated in Beodanabad where the temperature and salinity was average. This can be explained by the fact that Beodanabad is a shallow creek with least mangrove coverage compared to the other sites. Rahman *et al* (2013) reported that DO levels in natural water bodies depend on the physical, chemical, and bio-chemical activities occurring at surface and subsurface levels.

As various research states that abiotic factor such as salinity, temperature and dissolved oxygen greatly influence the fish

assemblages in estuaries (Wagner, 1999; Kupschius and Tremain, 2001; Martino and Able, 2003; Maeset *et al*., 2004; Eby and Crowder, 2004).

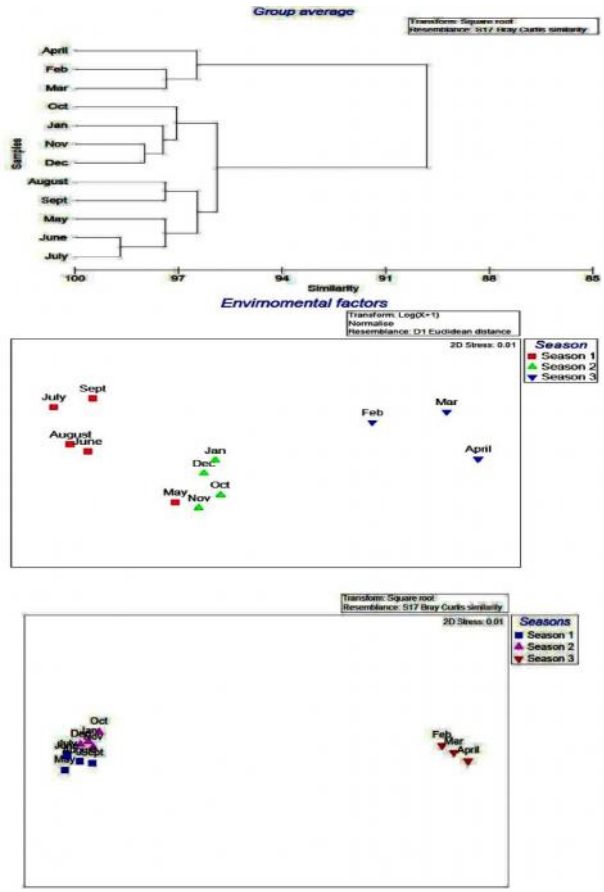

Figure 2 Cluster analysis (90% similarity) and MDS showing the clustering of months into three groups (Ordination MDS stress=0.01)

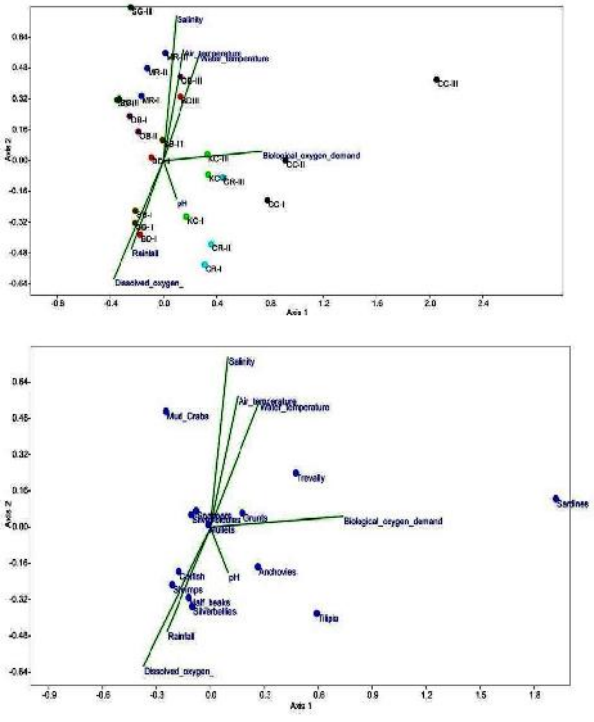

Figure 3 Canonical correspondence analyses (CCA) of major fishery and environmental parameters

Correspondingly in the present study, a significant seasonal variation was observed in the fishery of South Andaman mangrove ecosystems. Rainfall the only source of freshwater in Andaman Islands played a major role in seasonal variation as there are no perennial rivers in this group of islands other than the rivers in Nicobar group of islands. Rainfall affected salinity and temperature in the study area furthermore multivariate analysis have shown water temperature and salinity as the major variables influencing the fishery assemblage structure of South Andaman mangrove regions. Similarly Pombo *et al*. (2005) and Nandan *et al*. (2012) also found temperature and salinity significantly predicting the fish assemblages. Mansoor *et al*. (2012) stated that rainfall is the most important environmental factor governing fish community structure in estuarine systems because it is associated with changes in turbidity, conductivity, salinity, temperature, water depth, and pH. Similarly Hoguane *et al*. (2012) also mentioned that rainfall, in the coastal basin, can increase the productivity of the coastal waters, and hence the coastal fisheries. So in accordance to the studies season- I, with maximum rainfall have shown high fish catch and Season- III, with minimum rainfall have shown reduced catch.

The Seasonal variations in the catch composition and the maximum catch during rainy Season is supported by similar findings in Terminos Lagoon, in Gulf of Mexico (Yanez-Arancibia *et al*., 1980), Italian lagoons (Ardizzone *et al*., 1988), Alligator creek in Australia (Roberston and Duke, 1990) and Puri sea shore in Odisha (Mohapatra and Patra, 2012). However in contrast to the present observation, landings in Kodungallur-Azhikode estuary in Kerala (Nandan *et al*., 2012) and Gulf of Kachchh mangrove ecosystem, Gujarat (Saravankumar *et al*., 2009) situated in mainland India found reduced landings in monsoon. This might be due to the presence of rivers in mainland India in addition to rain which may cause overflow of coastal basin compared to Andaman group of islands were rivers are absent.

Shrimps contributed the highest catch in the present study and formed a significant catch in the study area which confirms that mangrove habitats and shrimp resources are tightly linked. Moreover commercial shrimp catches show strong correlation between abundance and biomass of shrimps and extent of the mangrove areas around the world (Martosubroto and Naamin, 1977; Turner, 1977; Subramanian and Krishnamurthy, 1990; Sasekumar *et al*., 1992; Vance *et al*., 1996). Mullet were found more abundant in Season I as they feed primarily on detritus which is more abundant when the rainfall is more. A similar observation that is domination of mullets in monsoon compared to other seasons was made by Bhatta and Panda (2007). Mud crabs, were the major catch from Sipighat, where habitat contains destructed mangroves region resulting in more exposed burrows in the soft mud therefore its fishing comparatively easier than other station. Sardine, were the major fishery in Carbyn's Cove it may be due to the fact that in this region the opening to the sea is situated very near to mangrove creek which immediately forms a long channel. Due to which its more convenient for fishing when compared to other stations where the creek opening was far or creek was short or the mangrove stretch is situated all along the wide

coastline without a creek. It was found out that the sardine fishing was done during high tide when water is more and mostly near to the entry points where the sea water comes in contact with the mangrove water. Perceptive on influence of environmental variable on mangrove fishery is very much essential to implement any plan or management in future. As these ecosystems are the natural heritage providing great benefit and protection to the local community, shelter to numerous commercial species as well as add splendour to the island. The present study provided an insight of how the islands mangrove fishery behaves in relation to environmental variables.

CONCLUSION

The Mangrove regions of South Andaman hold a good potential for fishery resources and the exploitation level was found to be low. Rainfall was found to influence the seasonal catch and Water temperature and salinity were found to be the major parameters affecting the fish assemblages. Present level of exploitation will not give much pressure to the ecosystem however a proper conservation and management plan must be adopted by the government in order to protect these ecosystems for the sustainable and responsible use in future as well.

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