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Analysis of trawl-net operation and major fish landings at Andaman and Nicobar Islands, India

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ABSTRACT

Trawl-net is an important fishing gear in Andaman and Nicobar Islands (ANIs) India since three decades with minimum number(n=10) of boats meeting the daily fish consumption of Islanders with minimum costs. A study was carried out between 2014 to 2018 to investigate the major fish landings of Trawl-net in the ANIs coast. The trawl-net landing is occurring only from Junglighat fish landing centre(FLC) which is having loading and unloading facilities in ANIs. The total number of FLC visits, fishing-trips, operations and fish-landing of trawl-net recorded during this period were 692(n), 533(n), 7561(n) and 691(tonnes) respectively. The maximum fishing-trips(149) and fishing-operations(2086) occurred during the year 2018 and minimum of same (87 and 1218) occurred during 2015. Similarly, the maximum(170.51tonnes) and minimum (109.33tonnes) of fish landings were observed during the year 2014 and 2015 respectively with an average of 138.21±10.54tonnes/year. The contribution of trawl-net landing amongst other gears was 17.8% including fin-fishes(598.7tonnes) and shell-fishes(115.34tonnes) during the study period. The trawl-net operation was occurring at very few fishing grounds(n=14) in ANIs and the maximum fish catch occurred in the Coast of Havelock Island (26.7%). Totally 52 genera of fishes were recorded in trawl-net landings under 37 families in which Leiognathidae was found more dominant(21.38%). Altogether 21 Trawl-net validations were conducted at each PFZ and Non-PFZ during the period. The fishes captured at PFZ 3288kg with an average of 156.6±13.5kg/operation and at Non-PFZ 1237kg with an average of 58.9±5.3kg/operation. The minimum range of fish cost in the market was maintaining in this Island due to the trawl-net landings, in-spite of there was controversy of non-selective fish catch and by-catch in trawl-net fishing.

Figures : 03 References : 58 Tables : 04
KEY WORDS : Andaman, Have-lock, Junglighat, Landings, Operations, Trawl-net

Introduction

Trawling is an efficient commercial fishing method for the capturing of non-selective fishes in Indian coast which targeted mainly Penaeid shrimps, Anchovies, silver bellies, silver buddies, Carangids, emperors, nemipterides, Sardines, mackerels, Croakers, Upenids, cat fishes, lizard fishes *etc.,* It is very essential to improve the fishing activities to meet the scarcity of foods in growing countries. It[26] was reported that the trawling was first attempted in India before second world war in Bombay coast but the outcome of the initial trials were not encouraged as that might not prove economically successful in the areas worked. According to a Worker[35] this fishing method has been introduced after 1960s in India which was occurring in different parts of our country according to their types and sizes. It is a bag shaped gear towed through water, the mouth of which is kept open by frame, beam, otter boards, kites or floats and sinkers. A Worker[13] revealed, in a known fishing ground the quantity of fish caught by the gear trawl-net had direct bearing on the volume of water filtered during a certain period of operation and depends on both the horizontal

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TABLE-1: Year wise fish Landings of trawl net details during 2014-2018 at Andaman and Nicobar Islands

Details \Year	2014	2015	2016	2017	2018	Total	Ave with SE
FLC visits	177	129	137	136	113	692	138.4± 10.5
Trawler Fishing trips	93	87	99	105	149	533	106.6± 11.0
Operations	1587	1320	1371	1412	2086	7776	1555.2± 140.0
Fin fishes (in tonnes)	151.9	92.4	102.1	124.2	128.3	598.7	119.8±10.4
Shell fishes (in tonnes)	18.7	16.9	20.0	20.2	16.5	92.3	18.5±0.8
Total catch(in tonnes)	170.6	109.3	122.1	144.4	144.8	691.0	138.2±10.5

and vertical opening of the net while in operation. When it began in the 1960s, shrimp was the main revenue provider but not in fin fishes catch. Shrimp fishery by mechanised trawls in a depth range of 30 to 40 m is one of the major fisheries in the Palk Bay. This fishery is supported by 59 species under the family Penaeidae, of which *Penaeus semisulcatus, P. monodon* and *P. indicus* are the top three landed species[41,42]. A Scientist[48] reported that the demersal fishes obtained by this gear were leiognathids (33%), upenids (19%), sciaenids (12%), skates (5%), rays (3.5%), shark (3%), nemipterides (3.5%), carangids (2.5%), catfish (2%), perches (1%), lizard fishes (0.8%) and other miscellaneous fishes.

The operation of Trawl-net Industrial multi-day trawling began in India[8] but did not provide a significant contribution to total catches until the mid-1980s, when the contribution increased to about 5% of total catch. Since 1980, the contribution from multi-day trawling increased dramatically to contribute almost 20% of catches by mid-1990. After 2005, the contribution continued to increase about 37.5% of total marine landings in India[32]. The scale of overfishing and lack of effectively enforced regulation in combination with indiscriminate trawling results in considerable economic losses from suboptimal exploitation[36]. The improvement in catch for an offshore fishery along the coastal waters of Gujarat for a similar validation exercise indicates that the results can be better for deep sea trawling where long liners can also supplement well[37]. A third type of fishing present in these islands is the offshore, mechanized fishery that targets pelagic and demersal fish through long line and bottom trawl gear. According to Fishers of trawl-net are getting better benefit due to the type of wide variety of fishes coming along with the hauls[19].

Technological improvements allowed trawlers to increase multi-day operations, expanding into deeper fishing grounds after 1999 and which is an important fishing method occurs in Indian coast that one or more boat engaged to pull a fishing-net in the water[45]. It has emerged as the most important means through which demersal resources are exploited and accounts for half of the total Indian catch. The marine fishing fleet of India is currently made up of around 72,500 mechanized vessels, of which approximately 35,000 are trawlers, 71,300 motorized and 50,690 unpowered vessels. Indian trawlers have been reported to regularly fish in the Sri Lankan EEZ of the Palk Bay area[46]. In subsequent years several designs of demersal trawls have been introduced in Indian fisheries. Bottom or demersal trawling continues to be one of the most important fishing methods of the world. In India more than 35,230 trawlers of various sizes ranging from 9 to 24 m LOA with engine power ranging from 45 to 450 hp @ 2000 rpm are in operation[43]. According to FAO[16] estimates, India currently has the sixth largest fisheries by catch in the world, increasing from approximately 530,000 tonnes in 1950 to almost 3.6 million tonnes in 2018.

Study area

Andaman and Nicobar group of Islands (ANIs) stretch out between 92°12'E and 93°57'E Longitude and 6°45'N and 13°41' N Latitude with 10°N channel isolate Andaman group and Nicobar group of islands in the southern reaches of Bay of Bengal. It is the largest indian archipelago comprising of 572 islands, islets and rocky outcrops with a total coastline of 1962 km, which is almost 26.10% of the Indian Coast. The continental shelf is nearly 34965 km^2, which nearly forms 6.60% of the

TABLE-2: Month wise analysis of fish catches (in tonnes) of trawl-net during the study period (2014-2018)

M\Y	2014	2015	2016	2017	2018	Total (2014-2018)				Average Fish catch (in tonnes)
						FLC visit	Fishing Trip	Fishing operations	Fish Catch	
Jan.	**2.84**	10.37	11.08	14.17	13.72	49	42	598	52.2	10.4 ±2.0
Feb.	11.60	9.79	12.45	22.30	16.34	55	55	779	72.5	14.5 ±2.2
Mar.	3.09	11.54	**15.42**	12.23	13.55	65	48	683	55.8	11.2 ±2.1
Apr.	8.61	9.23	**7.41**	7.55	9.45	61	**31**	**439**	42.2	**8.5 ±0.4**
May	April 16 to May 31					58	Fishing ban			
Jun.	4.00	10.19	10.45	11.23	10.32	55	43	612	46.2	9.2 ±1.3
Jul.	27.10	**17.19**	10.47	13.21	15.20	**69**	**59**	**835**	**83.2**	**16.6 ±2.8**
Aug.	19.24	7.63	13.28	14.43	12.43	56	47	668	67.0	13.4 ±1.9
Sept.	17.80	**7.52**	12.38	15.35	13.52	65	52	738	66.6	13.3 ±1.7
Oct.	**29.04**	8.54	10.03	12.25	15.33	57	56	793	75.2	15.0 ±3.7
Nov.	25.31	8.76	8.40	10.23	11.36	**51**	48	679	64.0	12.8 ±3.2
Dec.	21.88	8.58	10.69	11.45	13.54	**51**	52	737	66.1	13.2 ±2.3

whole Indian continental shelf. The Andaman Sea surrounding these islands is relatively deep with narrow beaches. In many places the continental shelf is fouled by Coral outcrops[5]. India's Exclusive Economic Zone (EEZ) covers a total area of 2.02 million sq.km in the Indian Ocean with 0.86 million sq. km in the west coast and 1.16 million sq. km in the east coast including the ANIs about 0.6 million Sq.km. which comprises 30% of total Indian EEZ[34,5,11]. There are 51 beach landing centers, 8 fish markets, 169 fishermen's villages, and 5944 fishermen's families with a population of 26521 in 3 districts. A number of 13,481 full-time fishermen and 1,358 part-time fishermen are engaged in marine fishing activities in the Islands[23]. They operate 1,311 traditional country crafts, 1,532 motorized crafts, and 105 mechanized boats, and also engage 123 co-operative societies in fisheries activities in these islands[4]. Fish stocks, both demersal and pelagic, have been targeted in the Andaman Islands since the 1900s. Mechanized fishing began in 1908 with the introduction of the trawler Golden Crown to these waters[1]. In the late 1940s, a private firm, Andamarine Development Corporation Ltd., was established to exploit fishery resources using only four crafts[15]. The annual landings of fish (including elasmobranchs, prawns, and crustaceans) have been increasing steadily since the 1950s.

Richness of fringing coral reefs and enormous of flora & fauna diversity of these Islands are one of the bestowed gift of our Indian subcontinent. Workers[54] reported about 6540 species fauna and 2500 species flora of which 4% of marine species to be endemic. Scientists[27] reported approximately 139000 tonnes of pelagic, 22500 tonnes of benthic and 82500 tonnes of oceanic fishery resources are estimated to be available for exploitation. The marine fishery is dominated by pelagic catches, which comprise about 60% of the total

TABLE-3: Family wise Fish landings (in tonnes) of trawl-net during visited period (2014-2018)

Family and Genus	2014	2015	2016	2017	2018	Total	Aveg	%
Fin fishes								
Ariidae :*Arius* sp.	3.89	0.86	1.07	1.06	1.00	7.89	1.58	1.14
Bothidae: *Pseudorhombus* sp.	5.58	2.88	2.95	2.98	3.28	17.66	3.53	2.56
Carangidae:*Alectis sp., Carangoids* sp.*, Caranx* sp.*, Atule* sp.*, Megolopsis* sp. & *Selar* sp.	14.52	10.39	12.27	14.63	**18.40**	70.21	14.04	10.16
Carcharhinidae: *Carcharhinus* sp.	1.51	0.82	0.94	1.36	2.15	6.78	1.36	0.98
Chanidae:*Chanos chanos*	0.35	0.16	0.10	0.12	0.14	0.87	0.17	0.13
Coryphaenidae:*Coryphaena* sp.	0.22	0.13	0.12	0.16	0.15	0.78	0.16	0.11
Dasyatidae:*Dasyatis* sp.	6.16	6.22	8.69	12.24	10.39	43.70	8.74	6.32
Drepaneidae:*Drepane sp.*	1.47	0.79	0.64	0.77	0.83	4.51	0.90	0.65
Engraulidae:*Stolephorus* sp.	8.81	6.30	6.16	7.60	7.51	36.38	7.28	5.26
Gerreidae: *Gerres* sp.*, Diapterus sp.* & *Eucinostomus* sp.	4.91	4.94	5.12	4.66	5.35	24.97	4.99	3.61
Haemulidae:*Pomadaysis* sp.	4.76	2.92	2.82	5.65	4.03	20.18	4.04	2.92
Hemiramphidae: *Hemiramphus* sp.	1.32	0.68	0.37	0.56	0.72	3.64	0.73	0.53
Latidae: *Lates* sp.	0.36	0.18	0.08	0.12	0.11	0.86	0.17	0.12
Leiognathidae: *Leiognathus* sp.*, Equulites* sp. & *Eubleekeria* sp.	37.91	22.42	26.37	30.50	30.51	**147.71**	**29.54**	**21.38**
Lethrinidae: *Lethrinus*sp.	1.14	1.46	1.46	1.71	1.30	7.08	1.42	1.02
Lutjanidae: *Apharus*sp.*,Lutjanus sp., Pinjalo spp.* & *Pristipomoides sp.*	7.54	1.94	2.00	1.93	2.55	15.97	3.19	2.31
Mobulidae: *Manta sp.*	0.22	0.11	0.18	0.16	0.12	0.78	0.16	0.11
Mugilidae: *Mugil sp.*	3.76	1.44	1.34	1.44	1.32	9.29	1.86	1.34
Mullidae: *Parupeneus sp.*& *Upeneus sp.*	8.56	4.01	4.10	6.50	6.39	29.56	5.91	4.28

Family and Genus	2014	2015	2016	2017	2018	Total	Aveg	%
Muraenidae:*Gymnothorax sp.*	1.67	0.48	1.93	0.82	1.08	5.98	1.20	0.87
Nemipteridae:*Nemipterus sp.*	15.06	11.84	11.54	13.42	12.78	64.64	12.93	9.35
Rachycentridae:*Rachycentron sp.*	0.15	0.06	0.10	0.10	0.05	0.45	0.09	0.07
Sciaenidae:*Johnius sp.*	1.75	1.69	3.22	3.43	4.09	14.18	2.84	2.05
Scombridae:*Scamberomorus sp., Euthynnussp.*&*Rastrelliger sp.*	1.05	1.14	0.60	1.43	1.59	5.81	1.16	0.84
Serranidae:*Epinephelus sp.*	1.68	0.33	0.38	0.38	0.36	3.12	0.62	0.45
Sphyraenidae:*Sphyraena sp.*	5.55	2.82	2.72	3.05	4.91	19.04	3.81	2.76
Stromateidae:*Pampus sp.*	0.22	0.20	0.02	0.04	0.04	0.52	0.10	0.08
Synodontidae:*Saurida sp.*	9.30	4.18	3.47	5.83	5.57	28.34	5.67	4.10
Trachipteridae:*Trichiurussp.*	1.39	0.48	0.82	1.11	0.92	4.73	0.95	0.68
Miscellaneous fin fishes	0.97	0.57	0.52	0.43	0.61	3.10	0.62	0.45
Shell fishes								
Penaeidae: *Penaeus sp.*	9.34	6.55	5.59	10.32	8.83	40.62	8.12	5.88
Pandalidae: *Heterocarpus sp.*	0.77	1.19	1.43	0.80	0.45	4.64	0.93	0.67
Palinuridae:*Panulirus sp., Puerulus*	2.28	4.28	7.90	2.87	1.30	18.62	3.72	2.69
Scyllaridae: *Thenus*	0.46	0.74	1.16	1.81	1.22	5.38	1.08	0.78
Portinidae: *Portunus*	0.10	0.04	0.04	0.06	0.12	0.36	0.07	0.05
Loliginidae: *Loligo*	0.91	0.97	0.82	1.23	1.22	5.15	1.03	0.75
Sepiidae: *Sepia*	4.87	3.14	3.04	3.13	3.36	17.53	3.51	2.54

catch in ANIs. Gillnet (27%), hand-line (54%), long-line (5%), and ring net/seine (1%) are the major types of fishing gears used in the Andaman fishery[18]. According to Workers[6] FSI estimates that these islands are home to 9.2% demersal, 57.1% coastal, and 33.7% oceanic fish stocks. The exploitation of fishery resources at present is restricted to coastal waters[39]. According to Organization[17], the total capture fisheries production of India was estimated about 93 million tonnes[53] and the contribution from marine capture fisheries was about 90%. ANIs are unique in possessing high quantity of harvestable fishery resources, current marine capture fisheries remain greatly underutilized. Though more than 1.48 lakh tonnes of fishery resources are estimated to be available for exploitation of which 56,000 tonnes are pelagic, 32,000 tonnes are demersal and 60,000 tonnes

Table-4 : Analysis of ground wise visits and fish catch (in tonnes) of trawl-net at Andaman Coast during the study period (2014 – 2018)

Fishing Ground		2014	2015	2016	2017	2018	Total	Average
Baratang Island	Fishing Trips	12	20	10	18	26	86	
	Catch (in tonnes)	21.39	21.22	10.68	20.58	15.69	89.55	17.91
Diglipur	Fishing Trips	1	-	-	-	-	1	
	Catch (in tonnes)	1.22	-	-	-	-	1.22	0.24
Havelock Island	Fishing Trips	47	30	31	25	54	**187**	
	Catch (in tonnes)	62.03	31.67	31.32	24.79	34.86	**184.65**	**36.93**
Hut Bay West	Fishing Trips	-	1	-	-	-	1	
	Catch (in tonnes)	-	0.39	-	-	-	0.39	0.08
Interview Island	Fishing Trips	2	2	40	53	28	**125**	
	Catch (in tonnes)	3.25	3.11	52.32	67.08	34.30	**160.06**	**32.01**
Long Island	Fishing Trips	40	27	12	13	36	**128**	
	Catch (in tonnes)	58.30	28.35	15.53	12.27	20.53	**134.98**	**27.00**
Mayabunder	Fishing Trips	1	9	1	3	-	14	
	Catch (in tonnes)	1.60	11.26	2.03	2.20	-	17.10	3.42
Neil Island	Fishing Trips	7	3	-	12	21	43	
	Catch (in tonnes)	5.85	1.51	-	6.24	11.57	25.17	5.03
North Sentinel	Fishing Trips	3	6	5	-	9	23	
	Catch (in tonnes)	2.16	5.53	5.56	-	7.85	21.09	4.22
OutrumIsland	Fishing Trips	1	-	-	5	23	29	
	Catch (in tonnes)	0.68	-	-	3.75	9.49	13.92	2.78

Fishing Ground		2014	2015	2016	2017	2018	Total	Average
Rangat Bay	Fishing Trips	-	1	-	-	-	1	
	Catch (in tonnes)	-	1.09	-	-	-	1.09	0.22
Shoal Bay	Fishing Trips	1	-	1	-	-	2	
	Catch (in tonnes)	2.00	-	1.10	-	-	3.10	0.62
Straight Island	Fishing Trips	11	9	3	9	23	55	
	Catch (in tonnes)	12.04	4.42	3.52	7.49	10.46	37.92	7.58
Wandoor	Fishing Trips	-	1	-	-	-	1	
	Catch (in tonnes)	-	0.78	-	-	-	0.78	0.16

are oceanic. According to earlier study the marine fish production in the Islands was amounted 0.31 lakh tonnes during 2003-04, it has been decreased to 0.18 lakh tonnes during 2004-05 due to Tsunami on 26th December 2004. After Tsunami the amount of fish of ANIs is increasing every year till now[5]. Similarly the amount of fish catch during 2020-21 was 0.43 lakhs tonnes constituting a meagre 28.9% of the estimated potential[4]. There are 20 main fish landing centres (FLC) recorded recently in ANI of which the FLC Junglighat is the biggest and active FLC amongst others[22,28-30]. According to Workers[14] Trawl fisheries sector account more than 50% of the marine fisheries production of India. Annual average fish landing from trawlers was 17, 21, 000 t (2008-2011), which formed around 51 % of the marine fish landing of the coast.

Potential Fishing Zone (PFZ)

Understanding of oceanic processes and interaction of water-biological parameters are leading to identify the PFZ[12]. The Indian Remote Sensing Satellite P4 Ocean Colour Monitor (IRS P4 OCM) derived concentration of chlorophyll and National Oceanographic Aerospace Administration Advanced Very High Resolution Radiometer (NOAA AVHRR) derived Sea Surface Temperature (SST) images used to characterize the relationship between biological and physical variables in coastal waters and it was observed that the concentration of chlorophyll and SST were reversely correlated[49]. SST is the mostly and easily observed environmental parameter and is quite repeatedly correlated with the specifically availability of pelagic fish. Many of this species are known to concentrate at present boundaries particularly in areas with sharp horizontal temperature gradients. Usually, chlorophyll and SST images are expected to reveal common gradients due to inverse correlation between these two parameters[50]. Indirect methods of monitoring selected parameters such as SST and Chlorophyll-a (phytoplankton pigments) at surface of the sea from satellites are found to be very ideal, as it supplies high repetivity and large special coverage (INCOIS). SST elevation beyond the optimum level also affects the coral reef ecosystem including fishes [31].

Mesoscale eddies increase biological productivity by vertical and horizontal mixing of the water column in the pelagic zone[58]. Eddies reduce thermocline depth and bring nutrients to the photic zone, improving the productivity in stratified tropical and subtropical regions of the oceans[33]. Eddies increase the local productivity in the oligotrophic regions of tropical oceans[25]. Mesoscaleeddies influence productivity at every trophic level, such as the primary production[2,47] and concentration of zooplankton, micro-nekton[44] and plankton feeders[38] which in turn form a forage base and attract tertiary-level producers (tunas, marlin, turtles, sea birds, and cetaceans).

Materials and Methods

Fishing sector is a growing industry in ANIs including trawl-net fishing; it should be improved by creating awareness to the fishermen as well as to look forward for utilizing these valuable resources responsibly. The mechanized fishing vessels are operated primarily

Fig. 1.Trawlnet fishing operations at Andaman coast (a) Net operation (b) Caught fishes in trawl-net, (c) Harvested multiple fishes

from Port Blair, South Andaman and trawlers are operated only from Junglighat fish landing centre (FLC), which is the biggest and active FLC in these Islands. It was visited at regular intervals according to the landings of fishes to get the proper landings data[19,22]. Study has been carried out during 5 (five) consecutive years (2014 to 2018) to investigate the major fish catches through the gear trawl-net in ANI because there is no separate information available on the trawl-net fishery status from these Islands (Fig.1). The making of every fishing gears in small or large scale production is to enhance the fish catch for human consumption. There is no organized offshore fishing from Andaman base. However, the Fishery Survey of India (FSI) is conducting systematic exploratory fishing, since October, 1971. Bottom trawling, long lining, trolling, Kalava lining and purse seining have been conducted. Catch rates of as much as 100 kg per hour obtained in Andaman sea are comparable to those obtained in the east coast of India.

Two types of trawl-net operations observed in ANI: multi fishing trawler at shallow waters from 50 to 100m depth and deep sea trawler especially for deep sea lobster and deep sea prawn upto 250 m depth beyond 5 nm from the shoreline. Fishing trawl-net is dragged as a single net over the back end of a craft but the prawn trawl-net is dragged as two/three/four nets with long arms /booms extend out from both side of the craft to allow the nets to open fully. The trawl net operation is continued 3 to 5 days in each fishing trip; with actual operation is observed at the duration of 12–18 hrs per day. There are different haul (12 to 18) of fishing operations occurring in each fishing trip. It is carried out from 3 to 6 km in straight line every 2 or 3 hours continuously. The time and distances is maintained according to the loading of fishes (caught) in the net, while the operation goes on. Crew including skipper consisting of 8 to 12 persons is engaged in trawl operation subsequently for sorting of fishes according to size in each trawler.

Potential Fishing Zone forecasts, based on IRS P4 OCM derived concentration of chlorophyll and NOAA AVHRR derived SST are received from Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. After the receipt of the satellite picture (PFZ forecast) with Lat& Long, the same is printed and disseminated in person to the targeted fishermen to enhance their fish catch and also reducing the scouting time. A Digital Display Board (DDB) also has been installed at Junglighat FLC for regular Oceanic weather report with PFZ forecast. Advantages of PFZ lies in locating large fish shoals without wasting time and human energy and more importantly, brings down the expenses of fishing operation by saving diesel consumption, without damaging see floor that happens to be the spawning ground of several fish species.

Month-wise periodic FLC visits were carried out during the study period at Junglighat FLC where the trawl-net landings were occurring. The data have been collected like fishing trip, number of operations and fish catches of trawl-net. Validation experiments were carried out at PFZ and Non-PFZ of South Andaman to recognize the significance of PFZ forecast[28-30]. Family wise fish landings, ground wise operations and fish catches of trawl-net were also analyzed in this study.

Results

Periodic FLC visits were carried out at Junglighat FLC during the study period from 2014 to 2018 and investigated the major fish landings. The total of 692 days visited with maximum 177 days and minimum 113 days during the years 2014 and 2018 respectively. The total number of fishing trips, fishing operations and fish catches of trawl-net were documented during the FLC visited days *i.e.* 533, 7561 and 691(in tonnes) respectively. The maximum fishing trips and fishing operations occurred during 2018 (149 and 2086) and minimum occurred during 2015 (87 and 1218). Similarly

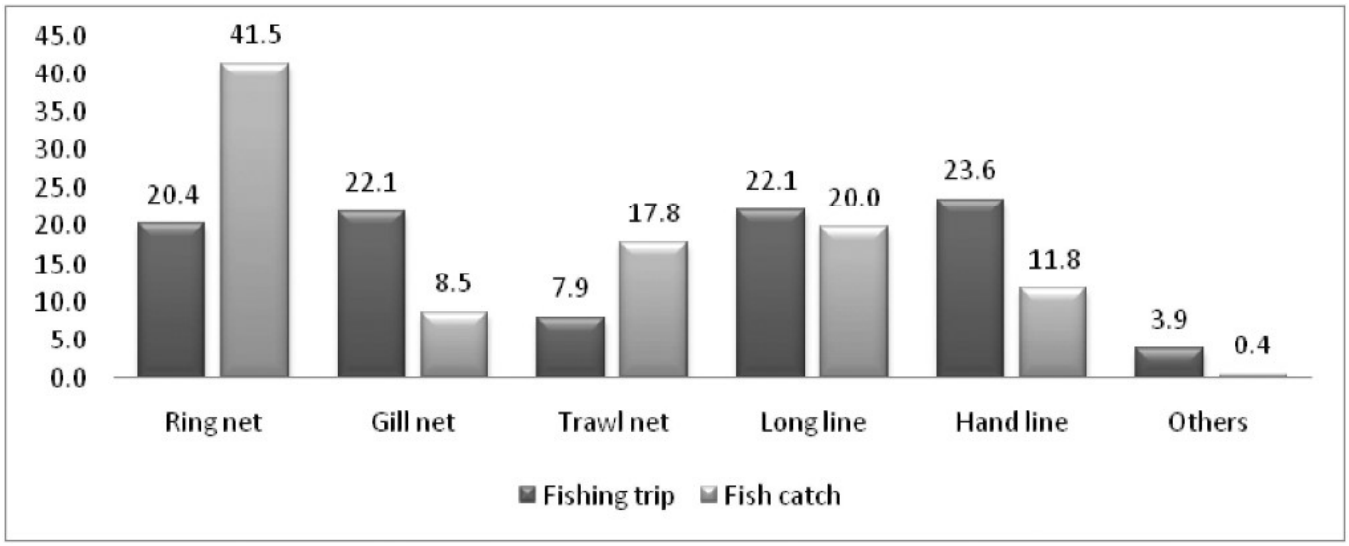

Fig. 2: The percentage of fishing trip and fish catch through different gears during 2014-18

the maximum (170.51 tonnes) and minimum (109.33 tonnes) of fish landings were observed during 2014 and 2015 respectively with an average of 138.21±10.54 tonnes. The total landings of fin-fishes were 598.7 tonnes (86.6%) with an average of 119.8±10.4 tonnes/year. Similarly the total shell fish landing was 92.3 tonnes (13.4%) with an average of 18.5±0.8 tonnes /year (Table-1). The contribution of the trawl-net in fishing trip was 7.9 % and fish catch was 17.8 % during the visited period amongst the other gears operated from ANIs.The percentage of fishing trip of trawl-net and ring net found lower than the fish catch and other gears found contradictory of the same during study period (Fig. 2).

Month wise analysis was documented for the study period to find out the fluctuation of month wise fish landings and significant variations were also acknowledged in this study. The month wise fish catch for each year has been analyzed between the years 2014 and 2018. The maximum (29.04 tonnes) and minimum (2.84 tonnes) fish catch of the year 2014 was observed during the month of October and January respectively. The same has been observed for 2015 during the month of July (17.19 tonnes) and September (7.52 tonnes), for the 2016during the month of March (15.42 tonnes) and April (7.41 tonnes), for the 2017 during the month February (22.3 tonnes) and April (7.55 tonnes) and for 2018 during the month of February (16.34 tonnes) and April (9.45 tonnes) respectively (Table-2).

According to the total analysis, the maximum FLC visit (69 days) occurred during the month of the July and the minimum visit (51) during the month of November and December. The maximum (59 nos.) and minimum (31) of fishing trips were observed during the month of July and April respectively. The fishing operations found maximum (835) and minimum (432) during the month July and April respectively. The maximum fish landing was observed *i.e.* 83.2 tonnes during the month of July with an average of 16.6 ±2.8 tonnes/year and minimum was noted *i.e.* 42.2 tonnes during the month of April with an average of 8.5 ±0.4 tonnes/year. It has been observed that no fishing trip and fish landings occurred through trawl netters from 16th April to 31st May due to 45 days ban on fishing operations for mechanized vessels in the Indian East coast (Table-2).

The contribution of fin fishes and shell fishes in the total trawl-net fish landings were 86.6% and 13.4% respectively. The family wise fish catch analyzes has been carried out during the study period. Altogether 52 genera of fishes recorded under 37 families in which fin fishes 45 genera under 30 families and shell fishes 7 genera under 7 families were recorded from the fishes landed through trawl-net. The fishes of Leiognathidae family were found dominant amongst all the families *i.e.* 147.71 tonnes during the visited period with an average of 29.54 tonnes / year. The fishes of 19 families were contributed significantly in the landings *i.e.* Leiognathidaewas 21.38% followed by Carangidae (10.16%), Nemipteridae (9.35%), Dasyatidae (6.32%), Penaeidae(5.88%), Engraulidae (5.26%), Mullidae (4.28%), Synodontidae (4.10%), Gerreidae (3.61%), Sphyraenidae(2.75%), Palinuridae(2.69 %), Bothidae(2.56%), Sepiidae (2.54%), Haemulidae (2.92%), Lutjanidae (2.31%), Sciaenidae (2.05%), Mugilidae (1.34), Ariidae (1.14%), Lethrinidae (1.02%), and other family fishes were contributed each below 1% including miscellaneous fin fishes (Table-3).

The fishermen ventured repeatedly at Potential Fishing ground of Andaman Sea to enhance their fish catch in short time with minimum expenditure. A total of

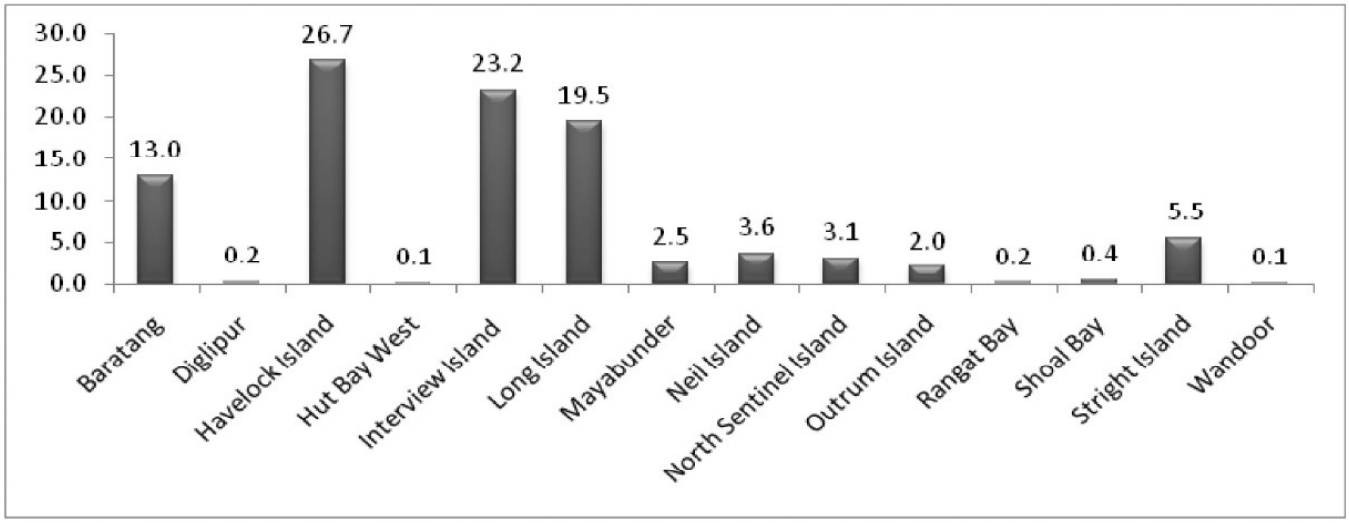

Fig. 3: Ground wise contribution of fish catch in percentage through Trawl-net

696 fishing trips were carried out to 14 fishing grounds explored by the trawl-netters with 7561 operations and the fish catch of 691.03 tonnes during the study period. The fishing grounds around the coast of Havelock Island was the most explored area with 187 visits followed by Long Island coast (128), Interview Island coast (125), Baratang coast (86), Straight Island (55), Neil Island (43)etc for the fishing operation by trawl-net. The major fish catch was occurred at the coast of Havelock Island *i.e.* 184.65 tonnes with an average of 36.93 tonnes/year followed by Interview Island coast (160.06 tonnes), Long Island coast (134.98 tonnes), Baratang coast (89.55 tonnes) *etc.,* (Table-4).

The contribution of fish catch around the coast of Havelock Island was 26.7%followed by Interview Island coast (23.2%), Long Island coast (19.5%), Baratang coast (13 %), Straight Island coast (5.5%), Neil Island coast (3.6 %), North Sentinel Island (3.1 %), Mayabunder (2.5 %) and other fishing grounds contributed each below 1% (Fig. 3).

PFZ forecast which was received from INCOIS, Hyderabad disseminated to the Trawl-netters and Validated for the study period *i.e.* 2014 to 2018. It has been witnessed the increasing of fish catch significantly at the PFZ area than the Non-PFZ area in ANIs. Altogether 21 operations of Trawl-net were observed at PFZ and the fishes captured 3288 kg with an average of 156.6 ± 13.5 kg /operation. Similarly 21 operations were observed at Non-PFZ and fishes captured 1237 kg with an average of 58.9 ± 5.3 kg/ operation. PFZ forecasts proved to be exceptional sources for deriving pecuniary benefits and a potent tool in harvesting the under-exploited fishery resources of ANI[3,19-21,28,29,30]. The water samples were collected at PFZ and Non-PFZ from various trawl-net towing sites during the study period. The same were analyzed and variations identified. The average visibility and dissolved oxygen at PFZ were 15.8±0.4 m and 6.2±0.1 mg/lit respectively. The same were at Non-PFZ 17.5 ± 0.3m and 5.9±0.1 mg/lit respectively. The dissolved oxygen has been increased at PFZ than Non-PFZ due to the density of phytoplankton and Eddies. The alkalinity recorded at PFZ and Non PFZ was 113.9±1.1 ml/lit and 115.8±1.5 ml/lit respectively.

Discussion

Trawl-net is slowly emerging as a main gear in India since four decades which is a beneficial fishing gear because of wide variety of fishes coming along with the hauls with high flexibility[19]. Trawl netting however an effective method of fishing is known to be one of the most non-selective methods of fish capture. It is a significant marine fishing gear; nearly 20 % of marine fish landed in the world is caught by trawl-net[51]. A trawl net is a large tapered fishing net that is towed along the sea bottom or at a given depth below the surface on a fishing boat for catching fish, shrimps, crabs, shellfish or mollusks. The trawling operation has high flexibility, adaptability, and production efficiency, but can unselectively damage fishery resources, especially for endangered species or a spawning population[57]. Trawling remains a controversial method of fishing due to the perceived lack of selectivity of the trawl net and the resultant capture of a huge quantity and diversity of non-target species, including endangered species such as sea turtles, coupled with its effect on the marine ecosystem[7]. Bottom trawling, one among the most damaging fishing methods still remains unmanaged in many countries including India even though many studies have proved its impact on fisheries, benthic biodiversity and sea floor structure[54]. Except these scattered reports,

detailed published reports on the quantity of trawl by-catch is lacking from the Indian waters. The size of vessel and the gear operation are not adequate in deep waters and the offshore fishing is not organized from Andaman base fishery[10].

Fisheries management and stock assessment require the accounting of total removals from the ecosystem and recent assessments have highlighted the role of the world's fisheries in providing food and the need for better catch information[9,52,56]. Each maritime states gas designated fish landing sites for small-scale fisheries and fishing harbors for large mechanized trawlers operating beyond 5-12 nautical miles. Each of the maritime states in India (including the remote ANIs) reveal that 45000 to 60000 tonnes is taken annually by illegal foreign fishing vessels, while 1.2 million tonnes of discarded and 293,000 tonnes remain unreported in the small scale and commercial trawl fisheries[40].

Trawling and the use of push nets and dragnets can also cause severe impacts on sea grasses. The trawling net is not suitable for a large-scale commercial operation due to its poor selectivity on fish species, high energy consumption, damage to fishery resources, and impact on ecological diversity. The catches of fish species from the trawl-net are messy and difficult to classify. The amount of fish species with high economic value is low, and most of the catches are trash fish. An initial assessment was made on the trawl-net operations along the Coast of ANIs and studied the landing of major fishes through trawl-net. Since there is an increase in the requirement of food fishes which increased in these Islands due to the rising of population as well as the Tourism development. Although sustainability is a core policy of the Comprehensive Marine Fishing Policy implemented in 2004, real action and movement towards sustainability has been lacking until recently, when a committee for trawl capacity reductions was formed[24].

Conclusion

The fishes captured through the trawl-net are being disposed in local market itself and no export has been observed from the trawl-net fishery except Ray fishes. It also maintains the high rate fluctuation of the fishes and support to the fish consumers due to the availability of various food fishes. Because of the multiple fish capturing, the fishermen are also getting more benefit by meeting the consumers' requirements but there are many controversial reports against trawl-net operation in ANIs like non-selective fishing, exceeding by-catch and creating plowing effect on the sea bed leads to spoil of benthic ecosystem. ANIs has remained as potential fishing ground to utilize the marine fisheries resources in India. The unavailability of mechanized/ deep sea fishing crafts are the challenges faced with regard to exploitation of fishery resources. According to the validation experiments that the satellite based PFZ forecasts are brilliant sources for deriving economic benefits and a potent tool in harvesting the under-exploited fishery resources of ANIs. A worthy increase in total catch identified by follower of PFZ forecasts has been recorded from ANIs ($p<0.01$). The better benefit with trawlers is due to the type of wide variety of fishes coming along with the hauls. Fishing trips and fish landings trawl-net were documented in this study only for the visited period and it may be more than the reported landings. Single or similar stock of fish is attracted to PFZ in comparison to Non–PFZ has been observed in the catches of small pelagic fishes caught were very appreciatively higher at Potential Zones. From the quantitative results of the fishing operations done by the same vessels simultaneously PFZ and Non- PFZ area, it was concluded that the average income earned by vessels operating in the PFZ areas were significantly higher than vessels operating in non PFZ areas. Fishing operational expenses were also relatively less for vessels which operated within PFZ.

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