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Analysis of ring operation from south Andaman Fish Landing Centres (FLC)

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ABSTRACT

A study was carried out during 2014-2018 to find out the major fish catches through the Gear Ring net at the coast of Andaman Islands. The data were collected from four major Fish Landing Centres (FLC) *viz* Junglighat, Dugnabad, Guptapara and Wandoor which are located at South Andaman. Altogether 1097 FLC visits have been carried out during the study period at all four FLC with an average of 219 visits / year. Altogether 1379 operations of Ring net were observed from two FLC *i.e.* Junglighat (1322) and Dugnabad (57) amongst four FLC. The total fishes captured were 1609 tons from the two FLCs, *i.e.* 1594 tons from Junglighat FLC and 15 tons from Dugnabad FLC respectively. The contribution of gear the Ring net was 41.5 % amongst the other gears operated from all four FLCs. The major fish catch by ring net were Scombrids (52.3%), followed by Sardines (22.4%), Carangids (21.3%), Anchovies (2.7%) and others (1.2%). 39 ring net fishing ground identified during the period around the coast of Andaman Islands. The maximum fish catch occurred at around the coast of Havelock Island (15.5%) followed by Rutland (10.5%), Chidiatappu (8 %), Shoal Bay (7.6%), Baratang (7 %), Carbyns cove (6 %), Burmanallah (5.2%), Madhuban (5.2%), Out-drum Island (4.7%), Mayabunder (4 %), Colinpur (3.3%), Long Island (3.3%), Wandoor (2.1%) *etc* and minimum fish catch was observed at the coast of Pachim Sagar (0.02%) .

PFZ forecast disseminated to the Ring netters and validated during the study period. Forty nine operations of gear the ring net were observed at PFZ with an average of 9.8 operations /year. The fishes captured from the PFZ were 91.1 tons with an average of 18.2± 5.6 tons / year. Similarly 49 operations of ring net were also observed at Non-PFZ with an average of 9.8 operations /year. The fishes captured from the Non PFZ were 23.77 tons with an average of 4.5±1.5 tons / year.

The Length-weight measurements of the pelagic fishes *viz Atule mate, Decapterus russelli, Sardinella albella, Sardinella sirm, Herklotsichthys quadrimaculatus and Rastrelliger kanagurta* caught from both the zones have been done. 12 Class Intervals with respect to length were observed from the catch of *all the fishes i.e. 81-100 mm, 101-120, 141-160 mm,.....301-320 mm.* In the Class Intervals, the length category 121-140 mm was the most representating class for *Atule mate* with 128 specimens (19.1%) at PFZ and 159 specimens (23.7%) at Non-PFZ respectively. It has been observed for other fishes *i.e.* for *Decapterus russelli, Sardinella albella, Sardinella sirm, Herklotsichthys quadrimaculatus and Rastrelliger kanagurta* which collected from the PFZ were class 161-180 mm with 172 specimens (48.6%), 141-160 mm with 195 specimens (53.1%), 221-240 mm with 177 specimens (48.2%), 121-140 mm with 189 specimens (47.7%) and 261-280 with 199 specimens (30.9%) respectively. The same species were collected at the Non-PFZ were 141-160 with 173 specimen (49.0%), 121-140 with 194 specimens (53.3%), 221-240 with 159 (45.4%), 101-120 with 173 (49.4%) and 201-220 with 144 specimens (23%) respectively.

The water samples have been collected during day time from various sites of PFZ and Non-PFZ during the study period and analysed. The average visibility at PFZ and Non-PFZ were 15.49±0.28 m and 16.74 ± 0.25 respectively. The average dissolved oxygen (DO) at PFZ and Non-PFZ were 6.30±0.05 mg/lit and 5.94 ±0.06 mg/lit respectively. Due to density of phytoplankton and Eddies the dissolved oxygen increased at PFZ than Non-PFZ. Alkalinity was at PFZ 111.16±1.09 ml/lit and Non PFZ 113.68 ± 1.28 ml/lit respectively.

Figures : 09 References : 40 Tables : 07
KEY WORDS : Andaman, Dugnabad, Guptapara, Fish landing centre, Junglighat, Ring net, Wandoor.

Introduction

Fisheries play an important role in Indian economy and it is one of the most important economic activities along the coastal areas[11]. According to FAO[12] total capture fisheries production of India was estimated about 93 million tons[38] and the contribution from marine capture fisheries was about 90%. Annual marine fishery potential of Indian EEZ is estimated as 3.93 million tons and the sector – wise contribution of marine fish landings are 71% in mechanized sector, 24% in motorized sector and 5% in artisanal sector[7].

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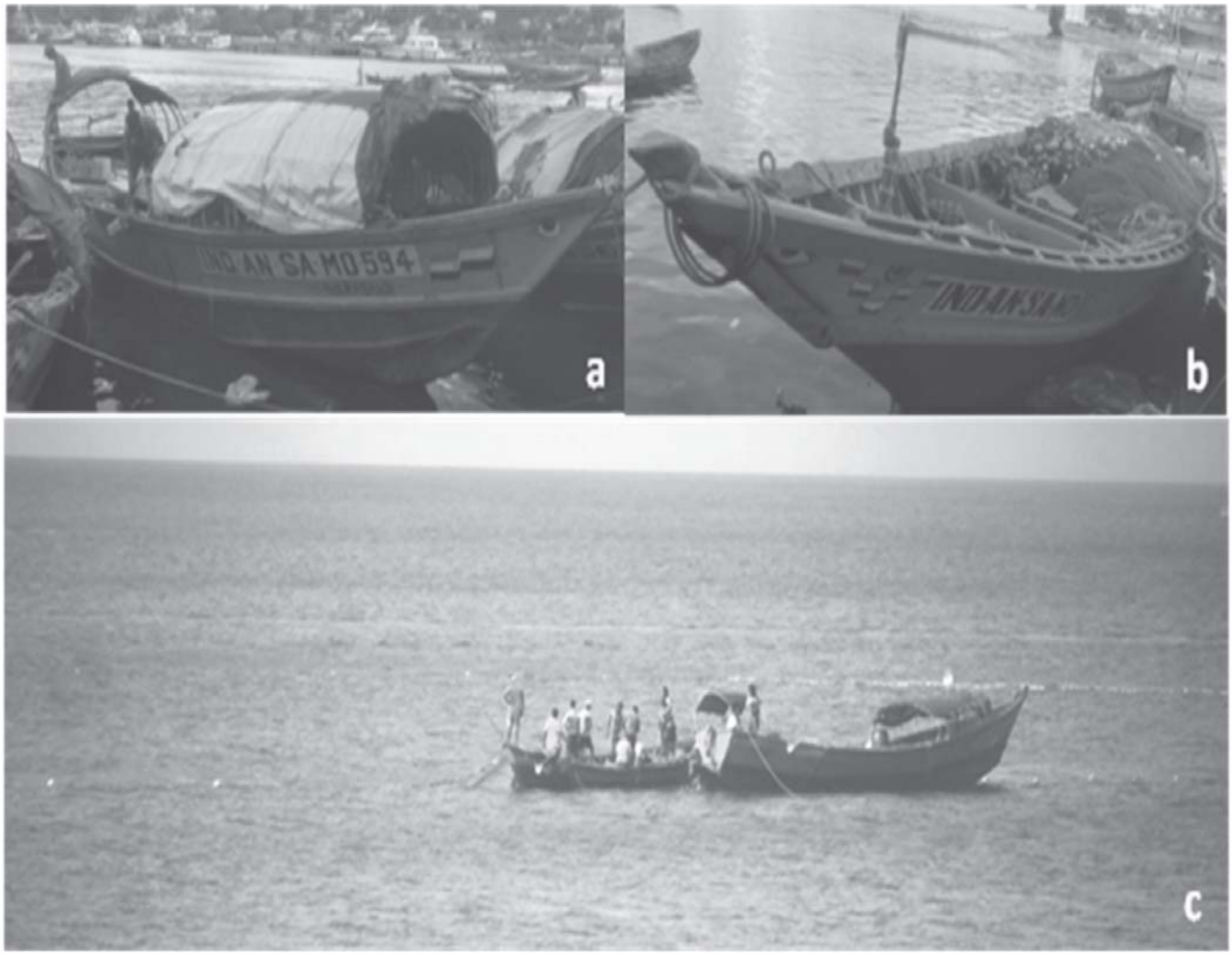


Fig.1: Dinghies for Ring net operation at Andaman Islands (a) Main dinghy, (b) Net dragging dinghy and (c) Occurring of Ring net operation at North Bay, South Andaman.

The Andaman Sea is situated in the southern part of the Bay of Bengal between 92º 12' E and 93º 57' E longitude and between 6º 45'N and 13º 41'N latitude with 10ºN channel separating Andaman group and Nicobar group of islands. The total length of these islands is about 700 km covering an area of about 8249 sq.km with a total coastline of 1,192 km. These islands are generally oceanic in nature and comprise an Exclusive Economic Zone (EEZ) of 0.6 million km^2 , *i.e.* about 28% of total EEZ of the country. The continental shelf is limited with an estimated area of 16,000 km^2 and the sea is very deep within few km from the shore[2]. The Fishery Survey of India estimates that these islands are home to 9.2% demersal, 57.1% coastal, and 33.7% oceanic fish stocks[3].

Recognition of Potential Fishing Zones (PFZ) occupies an understanding of oceanic processes and interaction of hydro-biological parameters[9]. Many of pelagic fish species are known to concentrate at present boundaries especially in areas with sharp horizontal temperature gradients. 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).

The purse seine belongs to the surrounding net class in which fish are surrounded not only from the side but also from below, letting them to be caught in deep waters[13]. Purse seine is named from the feature that along the bottom of the net are a number of rings, a rope passes through the rings, and when pulled the bottom of the seine is closed, like a purse, preventing the fish from escaping. The purse seine is a preferred technique for capturing schooling fish species, close to the surface such as sardines, mackerel and anchovies[30].

Review of the Literature

The total fishery resources of Andaman sea is about 1.48 lakh tonnes of which 56,000 tonnes are pelagic, 32,000 tonnes are demersal and 60,000 tonnes are

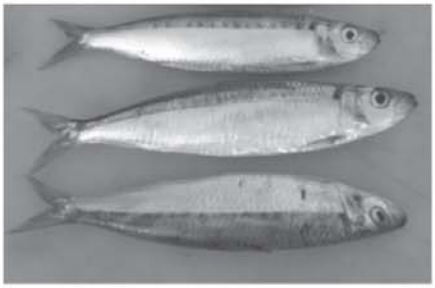
CARANGIDS

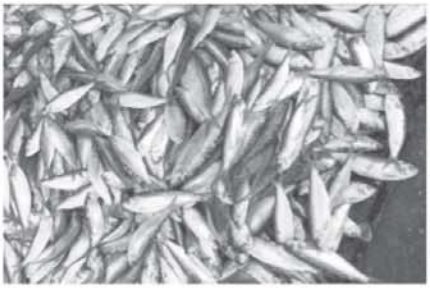
Atule mate

Decapterus sp.

Selar sp.

SARDINES

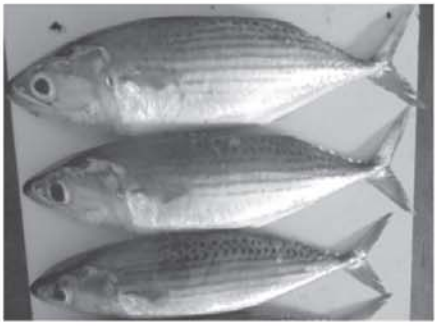




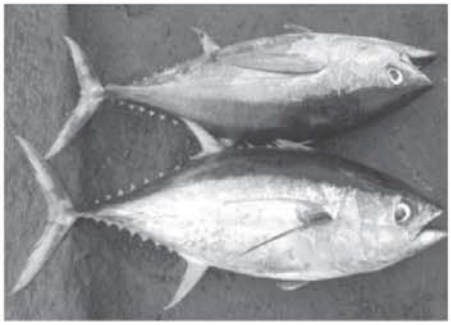
Sardinella species

SCOMBRIDS

Little tuna (*Auxis sp.*)



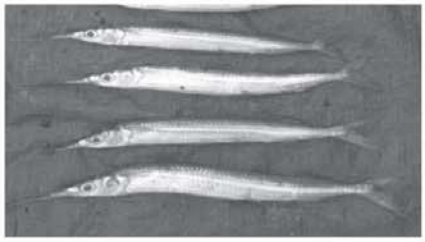
Mackerel (*Rastrelliger sp.*)



Yellow fin tuna (*Thunnus sp.*)

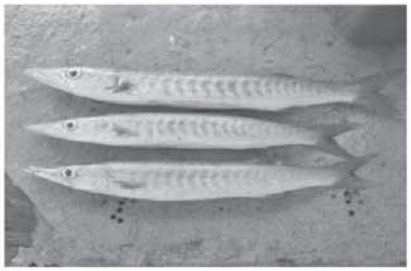
OTHER FISHES

Anchovy (*stolephorus sp.*)



Half beak (*Hemiramphus sp.*)

Silver belly (*Lieognothus sp.*)



Barracuda (*Sphyreana sp.*)

Devil Ray (*Manta birostris*),

Fig. 2. Some Pelagic Fishes

TABLE-1: FLC visits and total fish catch at Junglighat, Dugnabad, Guptapara and Wandoor

FLC	Year	2014	2015	2016	2017	2018	Total
Junglighat	Total visits (N)	177	129	137	136	113	692
	Total catch (ton)	914.1	665.7	747.2	802.3	696.5	3825.9
Dugnabad	Total visits (N)	24	21	54	42	28	169
	Total catch (ton)	5.0	5.3	7.0	7.7	5.4	30.4
Guptapara	Total visits (N)	27	18	35	28	21	129
	Total catch (ton)	2.5	1.9	2.8	2.7	2. 5	12.4
Wandoor	Total visits (N)	10	15	35	28	19	107
	Total catch (ton)	2.0	2.1	2.1	2.4	3.4	12.0

oceanic. The marine fishery in the ANI is dominated by pelagic catches, which comprise about 60% of the total catch. 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[14]. The exploitation of fishery resources at present is restricted to coastal waters[29]. There is no organized offshore fishing from Andaman base fishery[8].

Although ANI is unique in possessing high quantity of harvestable fishery resources, current marine capture fisheries remain greatly underutilized. The marine fish production in the Islands amounted to 30,000 tonnes constituting a meagre 19% of the estimated potential[8]. The ring seine is targeted at shoaling pelagic fishes like scombrids, carangids, clupeids and anchovies[20]. Indian Remote Sensing Satellite P4 Ocean Colour Monitor (IRS P4 OCM) derived chlorophyll concentration and National Oceanographic Aerospace Administration Advanced Very High Resolution Radiometer (NOAA AVHRR) derived Sea Surface Temperature (SST) images have been used to characterise the relationship between biological and physical variables in coastal waters and it was observed that both chlorophyll concentration and SST were inversely correlated[37].

Mesoscale eddies increase biological productivity by vertical and horizontal mixing of the water column in the pelagic zone[40]. The eddies reduce thermocline depth and bring nutrients to the photic zone, improving the productivity in stratified tropical and subtropical regions of the oceans[21]. Eddies increase the local productivity in the oligotrophic regions of tropical oceans[18]. Mesoscale eddies influence productivity at every trophic level, such as the primary production[4,22,32] and concentration of zooplankton, micro-nekton[31] and plankton feeders[27], which in turn form a forage base and attract tertiary-level producers (tunas, marlin, turtles, sea birds, and cetaceans). IRS P4 OCM were disseminated through different modes *viz*., Digital display boards, e-mail, telephoning/text messaging, radio, community networking and distribution of print-outs in person to the targeted fishermen and the efficacy was tested[16].

Although Andaman and Nicobar Islands (ANI) are unique in possessing high magnitude of harvestable fishery resources[8] a significant increase (30%) in total catch by following PFZ forecasts has been documented from Andaman and Nicobar Islands[15]. Some workers[17] have documented the species composition and food and feeding behaviours of fishes harvested within and outside PFZs. However, these Islands (ANI) are having cloud covers for about eight months of the year, which obscures optical and thermal imagery and hinders the generation of PFZ advisories[16].

Materials and Methods

A study was carried out to investigate the major fish catches through the Gear Ring net consecutive years from 2017-2018 at four fish landing centres *viz* Junglighat, Dugnabad, Guptapara and Wandoor in South Andaman. Every fish landing center was visited periodically according to the landings of fishes to get the proper landings data.

TABLE.2: Fish Landings through different gear operation at South Andaman

Year	2014	2015	2016	2017	2018	Total	Ave with SE
Number of all gear operations	**1551**	**1252**	1296	1279	1367	6745.0	1349.0 ±54.0
Total catch (in ton)	**923.7**	**675.1**	759.1	815.1	707.7	3880.6	776.1 ±43.8
Number of ring net operations	**298**	**277**	**297**	**253**	**254**	**1379**	275.8 ±9.6
Total catch through Ring net (in ton)	**398.1**	**314.9**	**324.6**	**308.4**	**263.3**	**1609.2**	321.8±21.8
Scombrids (in ton)	209.4	124.2	178.2	175.1	155.4	842.3	168.5 ±14.0
Carangids (in ton)	106.6	77.0	52.7	57.3	48.9	342.6	68.5±10.7
Sardines (in ton)	79.84	97.52	80.30	55.6	47.4	360.7	72.1±9.1
Anchovies (in ton)	0.35	11.48	10.30	13.4	8.5	44.0	8.8±2.3
Other fishes (in ton)	1.9	4.7	3.1	7.0	3.1	19.6	3. 9±0.9

The Ring net is the main gear used to capture the pelagic fishes like Scombrids included Indian Mackerels - *Rastrelliger sp.*, rarely Little tuna - *Auxis thazard*, Yellow fin tuna -*Thunnus albacares*, Skipjack tuna - *Katsuwonus pelamis etc.,* Sardines included all the *Sardinella* species, small Carangids and Anchovies in large quantity (*i.e.* 0.5 to 5 ton/ boat) from Andaman Islands. The other fishes like Milk fish (*Chanos chanos*), Silver bellies *(Lieognothus sp.,),* Silver buddies *(Gerres sp.,),* Barracuda *(Sphyreana sp.),* Devil Ray (*Manta birostris*), Reef sharks *etc.*, were also observed in catch occasionally. Schools of sardines, mackerel, skipjack and other varieties of fishes have been very frequently sighted around the islands, which provide much scope for purse seine operations and also comprised as highly economic varieties.

Ring net was twine 1.5/2, mesh size 18 mm, with mesh length 1000 m and depth 50 m. Two types of wooden dinghies which were used in each fishing operation for ring net *i.e.* main dinghy with the length 13 to 17m, width 2 to 3m and height 1.5 to 2 m having inboard diesel engine with 10 to 20 hp for transporting and storing the capturing fishes and net handling dinghy with net rotating engine engaging in the fishing operation (Fig. 1). The word for small boats in these islands is *dungi* used as a tender for larger vessels[5]. All traditional craft are locally made with the wood of *'taung-pienne'* (*Artocarpus chaplasha*) as the preferred choice. These craft are paddled, punte, or sailed in waters upto 20 m deep across the length of the Andaman Islands[24]. The commercial fishery of the Andaman Islands has grown steadily from its modest start of a few plank built canoes to a fleet of 2,813 craft. More than a half of these (1,465) are still non-motorised[1].

The maximum Ring net operations, occurring from Junglighat FLC is maintained by the Department of Fisheries, Andaman and Nicobar Administration; which is extending loading and unloading facilities with proper arrangement of security. The fishing harbours, fish landing centres (FLCs) are significantly important meeting places for artisanal fishers, buyers, traders, government officials and those providing services to a fishing community[33].

The Potential Fishing Zone (PFZ) forecasts by the Indian National Centre for Ocean Information Services (INCOIS) have been proved beneficial to the fish catcher of the Islands[15,17]. PFZ forecasts have been disseminated to the targeted fishermen of four landing centres during the visits. Gear wise fish landings were recorded in different gears like ring net, various type of gill net, Anchor net, Trawl net, Hand liners and Long liners. Identical fishing vessels of different types have been used for carrying out simultaneous validation experiments in PFZ

TABLE-3 : Traditional fishing grounds of Ring netters at Andaman Islands during the study period 2014-2018.

Fishing grounds	2014			2015			2016			2017			2018			Grand Total			% of Fish Catch
	Trip	Operation of net	Total catch	Trip	Operation of net	Total catch	Trip	Operation of net	Total catch	Trip	Operation of net	Total catch	Trip	Operation of net	Total catch	Trip	Operation of net	Total catch	
Bada balu	6	12	6300	4	7	3400	1	2	530	6	12	3700	5	13	6550	22	46	20480	1.27
Baratang	20	45	20929	27	55	28950	20	43	16575	31	73	29510	30	71	17350	128	287	113314	7.04
Baaludera	1	3	2250	0	0	0	1	3	1000	2	2	2100	2	2	1320	6	10	6670	0.41
Bambooflat	0	0	0	0	0	0	1	1	300	2	2	300	2	3	500	5	6	1100	0.07
Betapur	11	23	14350	1	2	1400	1	0	900	7	12	6200	9	15	6500	29	52	29350	1.82
Burmanallah	14	32	27400	13	20	16000	9	21	10350	16	27	15850	17	33	13650	69	133	83250	5.17
Carbyns cove	16	35	25700	13	28	21650	13	21	15800	18	38	21100	16	30	11700	76	152	95950	5.96
Chidiatappu	39	75	41650	40	81	36130	23	31	22350	14	26	13300	21	41	15810	137	254	129240	8.03
Chouldari	0	0	0	0	0	0	1	1	300	3	4	1400	2	2	500	6	7	2200	0.14
Chunnapatta	0	0	0	0	0	0	1	3	700	0	0	0	0	0	0	1	3	700	0.04
Colinpur	2	3	1250	10	20	15900	4	5	7400	17	32	18200	17	32	11150	50	92	53900	3.35
Cynque	0	0	0	1	3	2900	1	2	700	3	4	2200	4	7	2200	9	16	8000	0.50
Diglipur	8	10	8800	6	9	5900	8	21	6210	4	7	4300	9	16	6400	35	63	31610	1.96
Gomiyo	4	8	5500	0	0	0	1	1	500	3	5	2800	5	9	3000	13	23	11800	0.73
Guptapara	0	0	0	0	0	0	1	1	600	2	2	1600	3	6	2100	6	9	4300	0.27
Havelock	**63**	**130**	**89930**	**50**	**97**	**49520**	**52**	**113**	**52020**	**30**	**68**	**32812**	**30**	**73**	**25660**	225	481	249942	**15.53**

Contd. Table- 3

Kid Island	0	0	0	0	0	0	1	2	1000	3	4	1800	3	5	1700	7	11	4500	0.28
Hut Bay	0	0	0	6	12	4260	1	7	1590	1	2	1590	4	7	2090	12	28	9530	0.59
Interview Island	2	4	2800	0	0	0	1	1	500	7	13	5800	9	21	6830	19	39	15930	0.99
Kalipur	1	1	800	0	0	0	0	0	0	1	3	1000	1	3	1000	3	7	2800	0.17
Long Island	19	42	27600	5	9	3700	6	10	5900	8	14	6420	14	27	9002	52	102	52622	3.27
Madhuban	12	20	13900	20	34	22500	24	37	16880	15	26	16066	20	40	13700	91	157	83046	5.16
Mayabunder	19	32	18100	8	13	10080	11	38	11200	13	29	13050	13	33	11550	64	145	63980	3.98
Middle Straight	1	2	1200	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1200	0.08
Minnie Bay	1	1	10	0	0	0	1	1	600	1	1	152	0	0	0	3	3	762	0.05
Mundapahad	0	0	0	0	0	0	0	0	0	1	1	200	1	1	200	2	2	400	0.32
Neil Island	5	10	3625	4	7	4900	0	0	1000	8	11	5020	12	23	7984	29	51	22529	1.09
Nimbubageecha	1	2	1500	0	0	0	0	0	0	0	0	0	0	0	0	1	2	1500	0.09
Nimbutala	1	3	4100	1	1	1000	0	0	0	0	0	0	1	1	300	3	5	5400	0.34
North Bay	6	10	3630	3	3	4200	8	13	8110	8	11	7310	8	14	6200	33	51	29450	1.83
Outrum Island	4	8	3200	8	18	12350	15	22	18600	17	31	21886	20	47	20240	64	126	76276	4.74
Pachim Sagar	**0**	**0**	**0**	**1**	**1**	**250**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	1	1	250	0.02
Ross Island	5	12	4100	4	8	7000	7	9	6300	6	11	5000	12	22	7253	34	62	29653	1.84
Rutland	20	43	25500	25	45	30500	36	69	70740	19	33	25030	20	38	16830	120	228	168600	10.48
Shoal Bay	26	55	27500	16	31	15150	33	72	32880	19	39	25030	26	55	22100	120	252	122660	7.62
Sraight Island	6	12	2835	2	2	900	2	7	4160	5	12	4300	4	11	1700	19	44	13895	0.86
Tarmugli Island	0	0	0	5	5	2770	2	3	3200	6	7	6190	10	15	5181	23	30	17341	1.08
Tirur	2	4	3500	1	1	1000	3	6	2730	4	5	1790	6	8	2000	16	24	11020	0.68
Wandoor	8	17	10100	12	20	12600	4	2	2950	9	12	5388	8	12	3000	41	63	34038	2.12
Total	**323**	**654**	**398059**	**286**	**532**	**314910**	**293**	**568**	**324575**	**309**	**579**	**308394**	**364**	**736**	**263250**	**1575**	**3069**	**1609188**	**100**

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TABLE – 4: Month wise data regarding trip, operation and fish catch from four FLC for the period 2014-2018

Name of the Month	Total Trip	Trip Av/month	Gear Operation	Gear Operation Av/month	Fish Catch (in ton)	Av/month (in ton)
January	90	18.0	**90**	**18.0±3.5**	109.4	21.9±4.0
February	97	19.4	114	22.8±2.4	134.3	26.9±3.5
March	100	20.0	94	18.8±3.3	**107.5**	**21.5±3.3**
April	82	16.4	105	21.0±2.1	151.4	30.3±4.1
May	88	17.6	115	23.0±1.8	125.0	25.0±4.0
June	98	19.6	128	25.6±6.3	149.7	29.9±7.9
July	**105**	**21.0**	**165**	**33.0±3.0**	**179.8**	**36.0±9.3**
August	96	19.2	137	27.4±3.2	150.0	30.0±3.5
September	93	18.6	123	24.6±2.5	137.0	27.4±3.9
October	86	17.2	98	19.6±2.4	122.7	24.5±1.9
November	82	16.4	112	22.4±3.7	120.0	24.0±4.7
December	**80**	**16.0**	98	19.6±2.1	122.5	24.5±2.4

and Non-PFZ areas.

The length-weight relationships (LWR) of fishes are very important in fishery biology with the various developmental events in life such as metamorphosis, growth and on-set of maturity[39]. After the receipt of the satellite picture, the same is printed and disseminated amongst the fishermen to enhance their fish catch by indicating with Lat & Long and reducing the scouting time.

Identification of Potential Fishing Zones involves an understanding of oceanic processes and interaction of hydro-biological parameters[8]. Each fishing operation executes a unique harvesting technique and thus varies in terms of number of crew, duration of fishing, depth of operation, type of gear deployed and species/quantity of fish harvested[25].

Result and Discussion

It was concluded that the average income generated by vessels operating in the PFZ areas were significantly more than vessels operating in non PFZ areas. The expenses of fishing operation were also comparatively lower than vessels which operated within PFZ.

The data have been collected for 5 (five) consecutive years (2014 to 2018) from four fish landing centres (FLC) *viz* Junglighat, Dugnabad, Guptapara and Wandoor in South Andaman. The visits have been carried out at above mentioned four FLCs during the study period. The maximum visits have been occurred during the year 2016 (261) and the minimum visits were done during the year 2018 (181). Altogether 1097 numbers of visits have been occurred with an average of 219 visits per year (Table 1). According to the FLC wise visit (Table 1), the maximum visits have been done at Junglighat (692) followed by Dugnabad (169), Guptapara (129) and Wandoor (107). Similarly the landings of fishes were observed more at Junglighat FLC (3825.9 ton) followed by Dugnabad (30.4 ton), Guptapara (12.4 ton) and Wandoor (12 ton) during the visiting period.

The total operations of Ring net 1379 were observed

TABLE – 5: Validation conducted on Ring net operation In and Out of PFZ during the year 2014 to 2018.

Year	2014	2015	2016	2017	2018	Total	Average
Validations conducted at PFZ	13	3	13	9	11	49	9.8± 1.9
Fish catch in PFZ (in tons)	24.1	2.5	24.5	7.8	32.2	91.1	18.2± 5.6
Validation conducted at Non-PFZ	13	3	13	9	11	49	9.8± 1.9
Fish catch in Non-PFZ (in tons)	6. 8	0.7	6.9	1.7	7.8	23.8	4.8 ±1.5

Length weight relationship of the pelagic fishes captured at PFZ and Non-PFZ:

from two FLC *i.e.* Junglighat (1322) and Dugnabad (57) amongst four FLC. The total pelagic fishes were captured 1609.2 tons with an average of 321.8 tons / year. It was observed that the fish catch from the above two FLC were 1594.2 tons and 15 tons respectively. The contribution of the gear Ring net was 41.5 % amongst the other gears operated from all four FLCs. The more fish catches of the gear ring net were Scombrids (52.3%) followed by Sardines (22.4%), Carangids (21.3%), Anchovies (2.7%) and others (1.2%) (Table-2). Among the scombrids *R. kanagurta* was observed to be dominant and the catch of other scombrids like Little tuna *i.e. Auxis thazard*, Yellow fin tuna i.e. *Thunnus albacares*, Skipjack tuna i.e. *Katsuwonus pelamis etc.*, also observed occasionally at low quantity. Among the clupidae *Sardinella albella, Sardinella sirm, Sardinella brachisoma, Herklotsichthys quadrimaculatus etc* were observed to be dominant in the landings. The other fishes are Milk fish (*Chanos chanos*), Silver belly *(Lieognothus sp.),* Silver buddy *(Gerres sp.),* Barracuda *(Sphyreana sp.),* Devil Ray (*Manta birostris*) (Fig. 2).

According to the yearly study the maximum ring net operations and maximum fish catch occurred during the year 2014 i.e. 298 nos. and 398.06 tons respectively. The minimum gear operation (253) occurred during the year 2017 and minimum fish catch (263.25) observed during the year 2018 (Fig. 3)

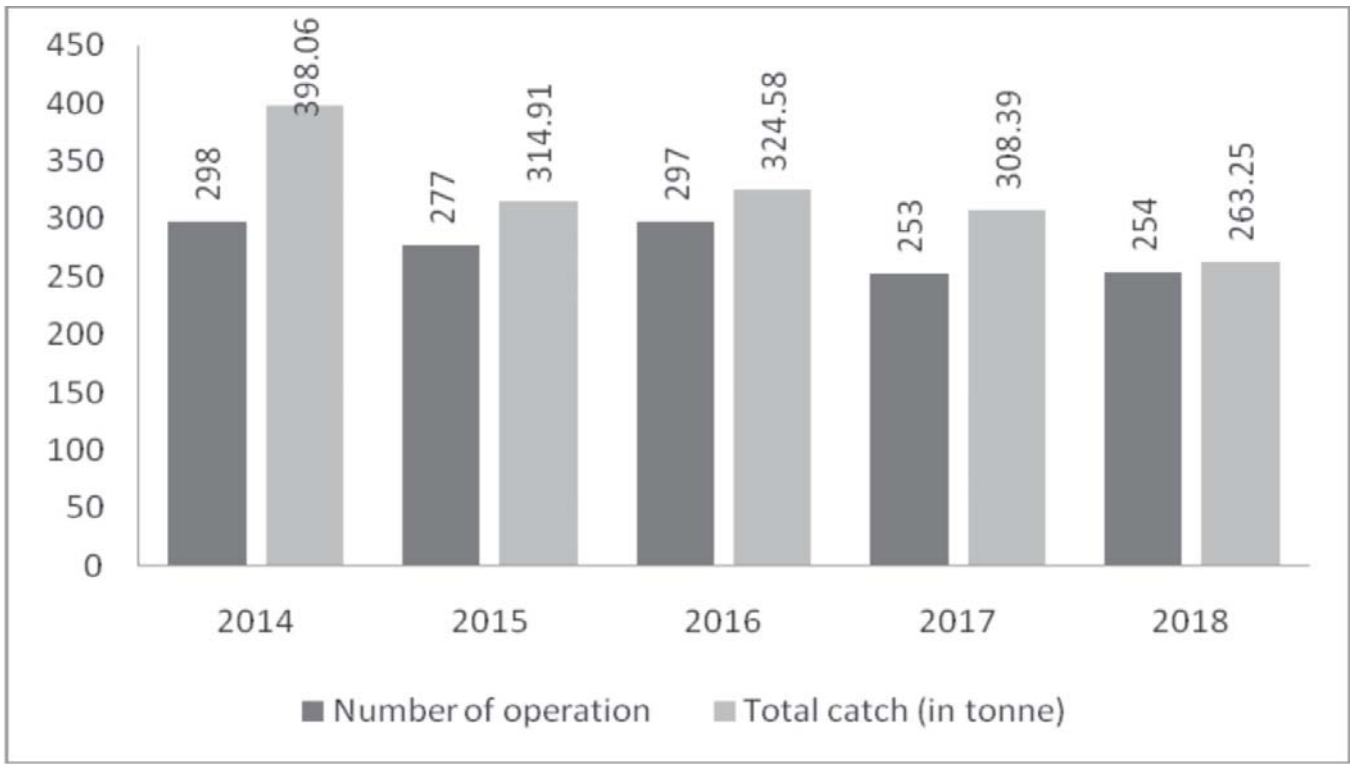

Fig. 3 Diagram showing the year wise (2014-18) boat operation and fish catch in tons

TABLE – 6 : Length weight of the pelagic fishes captured at PFZ and Non-PFZ:

Species	*n*	Range		Mean (mean ± SE)	
		Length (mm)		Weight (g)	
Family: CARANGIDAE					
Atule mate (PFZ)		100-260	180.17 ± 1.63	9-175	74.78 ± 1.90
Atule mate (Non - PFZ)		102-243	168.73 ± 1.34	10-163	61.93 ± 1.51
Decapterus russelli (PFZ)		108-202	160.65± 0.99	12-78	38.62 ± 0.68
Decapterus russelli (Non-PFZ)		130-197	161.43 ± 0.68	12-72	38.03± 0.51
Family: **CLUEPIDAE**					
Sardinella albella (PFZ)		120-166	141.61 ± 0.46	14-41	25.40 ± 0.27
Sardinella albella (Non-PFZ)		120-162	139.35 ± 0.42	14-36	23.78 ± 0.25
Sardinella sirm (PFZ)		185-260	219.92± 0.70	59-181	108.92 ± 1.12
Sardinella sirm (Non-PFZ)		136-256	219.07 ± 0.75	22-177	108.43 ± 1.22
Herklotsichthys quadrimaculatus (PFZ)		83-145	119.54 ± 0.56	4-32	16.51 ± 0.26
Herklotsichthys quadrimaculatus (Non-PFZ)		105-150	121.6 ± 0.38	10-28	16.54 ± 0.18
Family: **SCOMBRIDE**					
Rastrelliger kanagurta (PFZ)		145-320	250.6 ± 1.09	32-410	188.37 ± 2.45
Rastrelliger kanagurta (Non-PFZ)		142-308	233.25 ± 1.37	29-361	152.14± 2.78

Fishing ground:

Altogether 39 fishing grounds have been identified and 1575 fishing ground trips have been carried out with 3069 fishing operation during the study period by the ring netters (Table-3). The fishermen ventured repeatedly at Potential Fishing ground by using PFZ forecast which is received from INCOIS, Hyderabad. The maximum fishing ground trips (225) and maximum number of operation (481) occurred around the Coast of Havelock Island. The maximum fish catch (249.9 tons) occurred around the Coast of Havelock Island (15.5%) followed by Rutland (10.5%), Chidiatappu (8.0%), Shoal Bay (7.6%), Baratang (7.0%), Carbyns cove (6.0%), Burmanallah (5.2%), Madhuban (5.2%), Out-drum Island (4.7%), Mayabunder (4.0%), Colinpur (3.3%), Long Island (3.3%), Wandoor (2.1%) etc and minimum fish catch was observed at the coast of Pachim Sagar (0.02%).

The month wise FLC visits, gear operation and fish catch during the study period (January 2014 to December 2018) have been analyzed. The maximum number of FLC visit was observed in the month of July (105) with an average of 21 and minimum was observed during December (80) with an average of 16. The gear ring net operation was observed maximum in July (165) with an average of 33 and minimum during January (90) with average of 18. The fish catch found maximum (179.8 tons) during the month of July with an average of 36 tons and minimum catch observed on March (107.5 tons) with an

TABLE – 7: The composition of fishes under different class of interval in PFZ and Non-PFZ.

Length Classes	*Atule mate*		*Decapterus russelli*		*Sardinella albella*		*Sardinella sirm*		*Herklotsichthys quadrimaculatus*		*Rastrelliger kanagurta*	
(mm)	(%)		(%)		(%)		(%)		(%)		(%)	
	PFZ	Non-PFZ	PFZ	Non-PFZ	PFZ	Non-PFZ	PFZ	Non-PFZ	PFZ	Non-PFZ	PFZ	Non-PFZ
81-100									4.8	0.0		
101-120	5.5	5.7	2.8	0.0	0.8	0.6			45.7	49.4		
121-140	19.1	23.4	15.0	4.5	44.4	54.3	0.0	0.6	47.7	48.6		
141-160	16.7	20.3	23.2	49.0	53.1	44.8	0	0	1.8	2.0	0.8	5.0
161-180	10.9	7.4	48.6	39.1	1.6	0.3	0.0	0.3			0.6	4.6
181-200	6.7	17.8	8.8	7.4			11.2	7.4			2.3	2.7
201-220	17.8	19.9	1.7	0.0			37.9	42.6			13.0	23.0
221-240	14.3	5.4					48.2	45.4			15.7	20.0
241-260	9.0	0.4					2.7	3.7			27.1	21.1
261-280											30.9	18.4
281-300											8.7	4.3
301-320											0.9	0.8

average of 21.5 tons (Table 4).

Validation for PFZ advisories:

PFZ forecast disseminated to the Ring netters and Validated during the study period. A total of 49 validations for PFZ advisories carried out at each PFZ and Non- PFZ with an average of 9.8 operations /year. The fishes captured from the PFZ were 91.1 tons with an average of 18.2± 5.6 tons / year. Similarly the fishes captured from the Non PFZ were 23.8 tons with an average of 4.5±1.5 tons /year. (Table.5). The validation of PFZ advisories have inferred significant increase in fish catch along northwest coast of Gujarat[10,25,34,35] and all over the country[6]. The annual exploitable fisheries of Andaman and Nicobar Islands are estimated to be 1.48 lakh t of which a meagre 22% is harvested currently. Potential Fishing Zone (PFZ) forecasts based on remotely sensed chlorophyll concentration and sea surface temperature were applied for harvesting the unexploited marine fishery resources[17].

The number of fish samples *Atule mate* collected from the FLC which captured at PFZ and Non PFZ were 670 and 680 respectively. The number of fish samples of *Decapterus russelli, Sardinella albella, Sardinella sirm, Herklotsichthys quadrimaculatus and Rastrelliger kanagurta* collected from the FLC which captured at PFZ were 354, 367, 367, 396 and 645 respectively. The number of same species samples collected from Non- PFZ were 353, 357, 350, 350 and 625 respectively.

Fish samples of six pelagic species *viz*., *Atule mate, Decapterus russelli* under the family Carangidae, *Herklotsichthys quadrimaculatus, Sardinella albella* and *Sardinella sirm* under the family Cluepidae and *Rastrelliger kanagurta* under the family Scombridae have

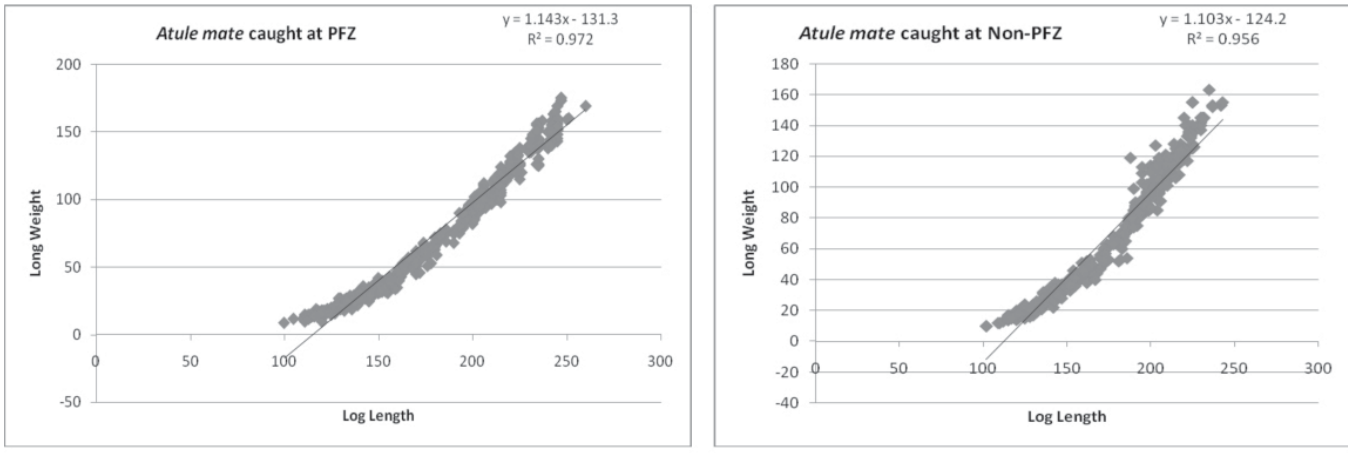

Fig. 4. LWR of *Atule mate at in & outside of PFZ*

been collected from the landing centres, which were captured from PFZ and Non-PFZ of Andaman Islands and Length frequency of the fish has been carried out. Details with respect to the sample size (n), the mean (± SE) length and weight are summarized in the Table 6.

The length of *Atule mate* at PFZ and Non-PFZ were ranging from 100-260 mm with a mean length of 180.17 ± 1.63 mm and 102-243 mm with mean length 168.73 ± 1.34 mm respectively. The weight of *Atule mate* at PFZ and Non-PFZ were ranging from 9 – 205 g with a mean weight 75.13 ± 1.91 g and ranging from 10-182 with mean weight 62.18 ± 1.53g respectively. The length of *D. russelli* at PFZ and Non-PFZ were ranging from 130-201 mm with a mean length of 165.57 ± 1.04 mm and 143-193 mm with mean length 159.49 ± 0.56 mm respectively. The weight of *Decapterus russelli* at PFZ and Non-PFZ were ranging from 15-81 g with a mean weight 42.15± 0.86 g and ranging from 25-80 with mean weight 37.42 ± 0.56 g respectively.

The anchovy is an important food source for almost each and every predatory fishes and is also extremely significant to oceanic birds and mammals. Like various fish species of *Sardinella, Decapterus* and anchovies commonly form schools of similar fish species and uniform size, swimming in a dense formation maintaining an approximately uniform course and speed of swimming. The fish *Decapterus russelli* is generally coastal schooling fish, are found in the coastal waters between 30-170 m depth. *Sardinella* species are generally coastal, schooling fishes and abundant richly in warmer waters. There is also accumulation of other fishes, which are attracted to light. Such accumulation can be composed of many fish species and of different sizes whose behaviour is not often uniform.

The length of *Sardinella albella , Sardinella sirm* and *Herklotsichthys quadrimaculatus under the family* Cluepidae captured at PFZ were ranging from 121-166, 185-260 and 83-145 mm with mean length of 141.0 mm, 219.9 mm and 119.5 mm and the weight ranging from 13-41 g, 59-181 g and 4-32 g with mean weight of 25.2 g, 108.9 g and 16.5 g respectively. The length of the same species captured at Non-PFZ were ranging from 120-162

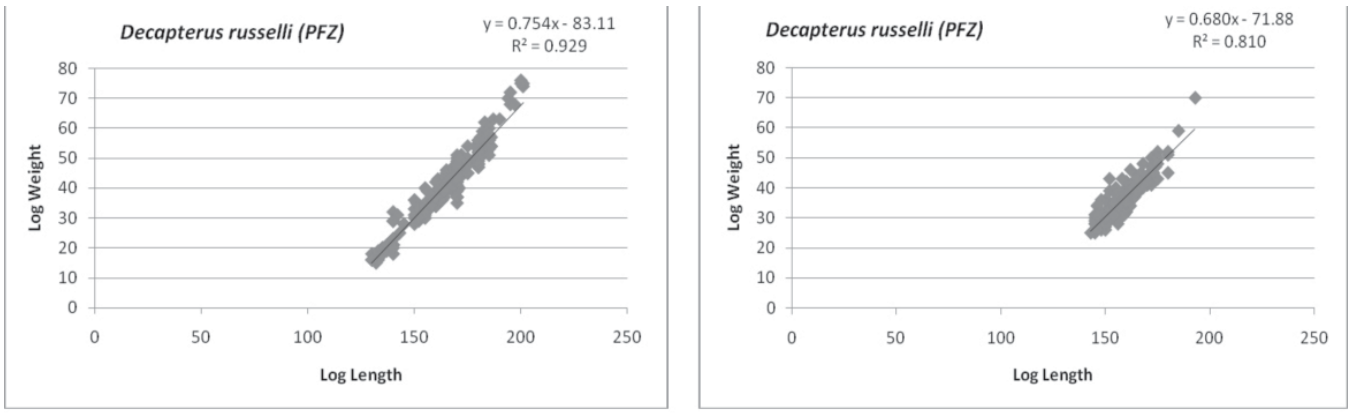

Fig. 5. LWR of *Decapterus russelli at in & outside of PFZ*

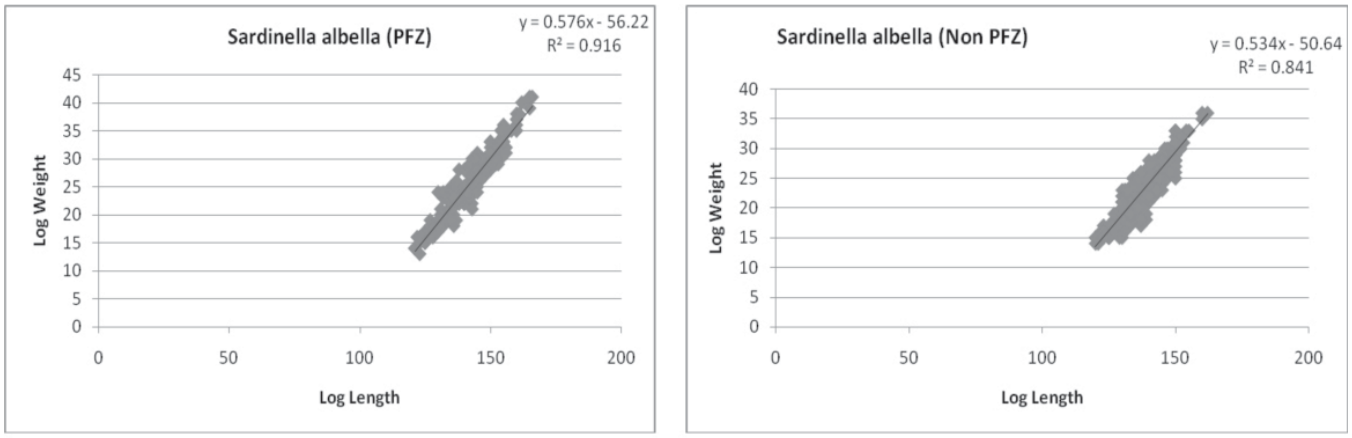

Fig. 6. LWR of *Sardinella albella at in & outside of PFZ*

mm, 136-256 and 105-150 mm with a mean length of 138.2 mm, 219.1 mm and 121.6 mm and the weight ranging from 14-36 g, 22-177g and 10-28 g with mean weight of 23.2 g, 108.4 g and 16.5 g respectively.

The length of *Rastrelliger kanagurta* at PFZ and Non-PFZ were ranging from 145-320 mm with a mean length of 250.6±1.09 mm and 142-308 mm with mean length 233.25±1.37 mm respectively. The weight of *R. kanagurta* at PFZ and Non-PFZ were ranging from 32-410 g with a mean weight 188.37±2.45 g and ranging from 29-361 with mean weight 152.14±2.78 g respectively (Table-6).

The total of length cattegories were observed from the species *Atule mate, Decapterus russelli, Sardinella albella, Sardinella sirm, Herklotsichthys quadrimaculatus and Rastrelliger kanagurta were 9 (81-100 to 241-260), 5 (121-140 to 201-220),4(101-120 to 161-180),6 (121-140 to 241-260),4 (81-100 to 141-160), and 9 (141-160 to 301-320) respectively.* The length category 121-140 was the most representating class with 128 specimens (19.1%) at PFZ and 159 specimens (23.7%) at Non-PFZ respectively from the *Atule mate*. It has been observed from other species *Decapterus russelli, Sardinella albella, Sardinella sirm, Herklotsichthys quadrimaculatus and Rastrelliger kanagurta* which collected from the PFZ were class 161-180 mm with 172 specimens (48.6%), 141-160 mm with 195 specimens (53.1%), 221-240 mm with 177 specimens (48.2%), 121-140 mm with 189 specimens (47.7%) and 261-280 with 199 specimens (30.9%) respectively. The same species were collected at the Non-PFZ were 141-160 with 173 specimen (49.0%), 121-140 with 194 specimens (53.3%), 221-240 with 159 (45.4%), 101-120 with 173 (49.4%) and 201-220 with 144 specimens (23%) respectively (Table 7).

Length frequency of the pelagic fishes from PFZ and Non- PFZ :

The log converted values of length (X) and weight (Y) are depicted in scatter diagrams and length frequency for all the species above mentioned. Length weight relationships (LWR) were illustrated for all the species above mentioned. The R^2 value of *Atule mate, Decapterus russelli, Sardinella albella, Sardinella sirm, Herklotsichthys quadrimaculatus and Rastrelliger kanagurta were* corresponded at PFZ were 0.972,

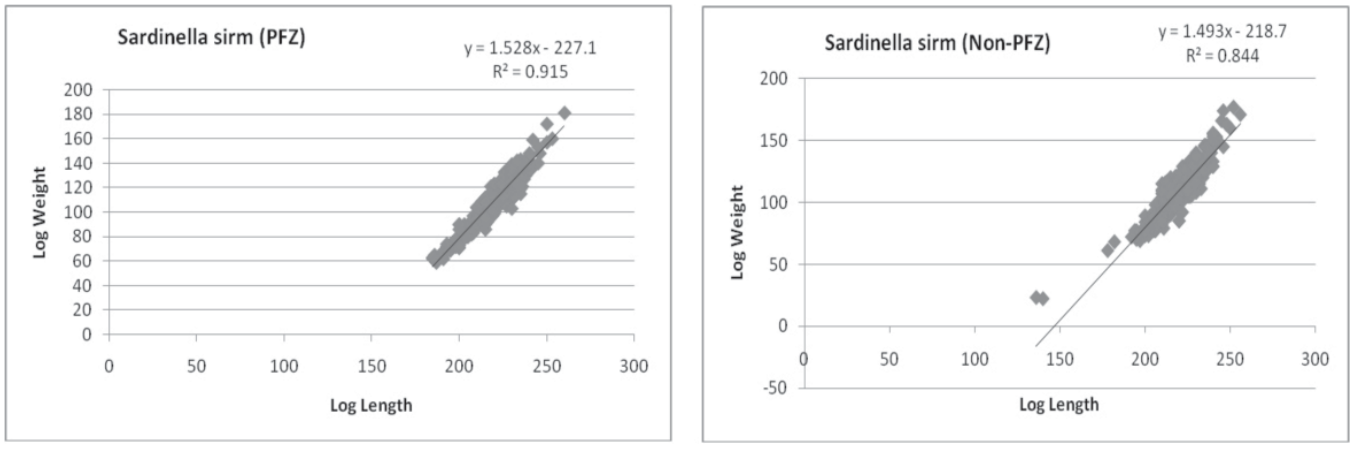

Fig. 7. LWR of *Sardinella sirm at in & outside of PFZa*

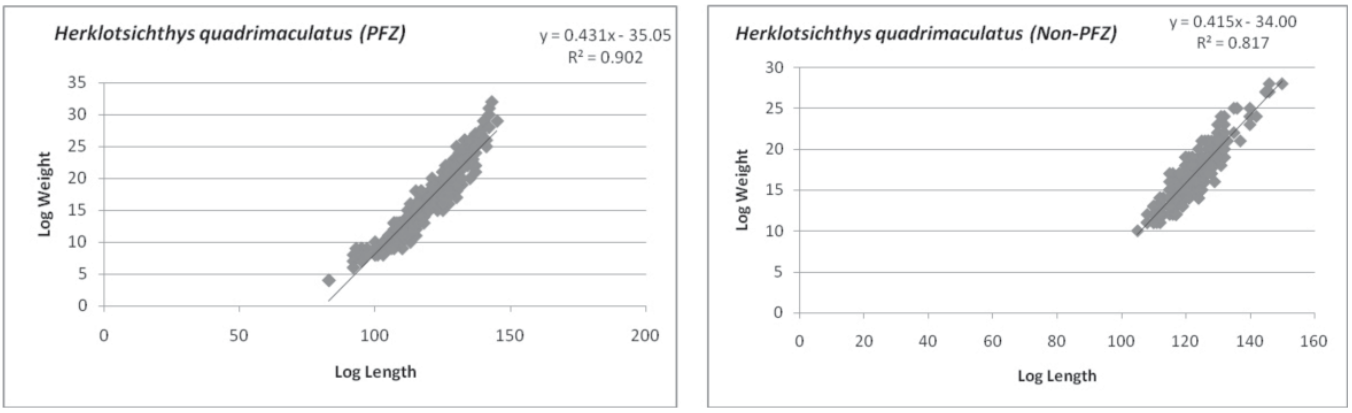

Fig. 8. LWR of *Herklotsichthys quadrimaculatus at in & outside of PFZ*

0.929,0.916, 0.915, 0.902 and 0.926 subsequently the same value corresponded at Non-PFZ were 0.956, 0.810, 0.841, 0.844, 0.817 and 0.893 respectively. The R^2 value of all the fishes at PFZ were perfectly correlated which could be attributed to the abundance food from the Potential Fishing Zone. The same value at Non-PFZ is showing less due to less food abundance (kindly find in the figures given below (Fig. 4 – Fig. 9).

Hydrographical study:

A total of **103 sites** were covered during the study period at PFZ and 94 sites were covered at Non-PFZ for the collection of water samples and the traditional fishing grounds along the coast of Andaman Islands during the study period. The average depth which the water samples collected at PFZ and Non- PFZ was 44.72± 1.78 and 45.08 ± 2.17 respectively. The collected water samples from various sites have been analysed. There is no much variation in Sea surface temperature both PFZ and Non-PFZ. But according the Secch Disk, there are differences in Visibility between PFZ and Non-PFZ due to more density of both the phyto and zoo planktons. The average visibility at PFZ and Non-PFZ were 15.49±0.28 m and 16.74 ± 0.25 during respectively. There is no much variation in pH within and outside of the PFZ *i.e.* 8.0±0.02 and 8.05±0.02 respectively. The average dissolved oxygen (DO) at PFZ and Non-PFZ were 6.30±0.05 mg/lit and 5.94 ±0.06 mg/lit respectively. The average of Alkalinity at PFZ and Non PFZ were 111.16 ± 1.09 ml/lit and 113.68± 1.28 ml/lit respectively. There were variation in alkalinity between PFZ and Non-PFZ due to water current and Eddies (upwelling and down welling) more at PFZ.

It is well known that the mesoscale, eddies increase the productivity in a stratified coastal atmosphere by upwelling. The seas around the Andaman and Nicobar Islands have been found to have repeated mesoscale eddy activity. Commercial fishing grounds are coinciding with upwelling areas related with cyclonic and anti-cyclonic eddies and also with areas between two adjoining eddies. There are various eddy zones supporting different types of fishing mechanisms and fishes. The current study aimed at identifying the different zones of mesoscale eddies in the Andaman Sea and compares the productivity and fishing activity in each of them[2].

The fishing ground Havelock Island is covering 15.5% fish catch amongst all the 39 fishing ground, Since

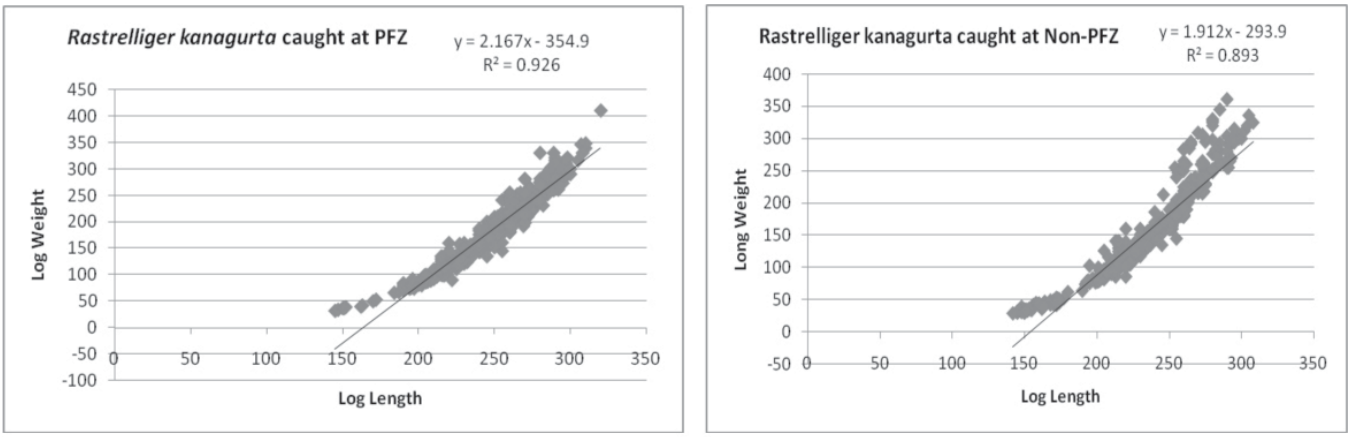

Fig.9. LWR of *Rastrelliger kanagurta at in & outside of PFZ*

the water current running from Hut Bay (Little Andaman) to Havelock Island for a long distance (approximately 150 km) transports both the phyto plankton and zoo planktons. The same way, the shoal of pelagic fishes are travelling in straight line from Hut Bay to Havelock for feeding on the abundance of available plankton. The fishing ground landmarks Rutland (10.48%), Chidiatappu (8.03%), Shoal Bay (7.62%), Carbyns cove (5.96%), Burmanallah (5.17%), Madhuban (5.16%) and Colinpur (3.34%) falls on the same straight line.

A significant increase in total catch by following PFZ forecasts has been documented from ANI[15]. Validation experiments concludes that satellite based fishing is advantageous in ANI with proven increase in total fish catch in PFZs[17]. The variation of Length and Weight relationship has been observed in both areas. The R^2value of the species *Atule mate, Decapterus russelli, Sardinella albella, Sardinella sirm, Herklotsichthys quadrimaculatus and Rastrelliger kanagurta* at PFZ was higher which could be attributed to higher abundance food from the Potential Fishing Zone.

According to the validation the fish catch inside the PFZ gave more CPUE and net profit compared to the outcome of operations in the outside PFZ. Fishing operations carried out on or nearer to dates on which linked SST/Chlorophyll imageries have been received positive outcome. When the gap increases the fish catch within PFZ is likely to decrease unless the features remain more or less in the same fishing location as revealed by the succeeding satellite imagery. There is not much variation in Sea Surface Temperature between PFZ and Non-PFZ. But there are differences between PFZ and Non-PFZ in Visibility due to accumulation of both the phytoplankton and zoo planktons. There were variation in alkalinity between PFZ and Non-PFZ due to water current and Eddies (upwelling and down welling) more at PFZ.

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