https://doi.org/10.33451/florafauna.v31i2pp307-319
FLORA AND FAUNA ISSN 2456 - 9364 (Online)
2025 Vol. 31 No.2 PP 307-319 ISSN 0971 - 6920 (Print)

Major fish landings of the gears Hand-line and Long-line at four main landing centres (FLCs) in South Andaman, India

***M. Kaliyamoorthy[1], S. Dam Roy[2] and V.K. Sahu[3]**

[1]PRIST University,
VALLAM,THANJAVUR-613403 (TN) INDIA
[2]Central Island Agricultural Research Institute,
GARA CHAVAMA, SRI VIJAY PURAM-744105
SOUTH ANDAMAN (ANDAMAN & NICOBAR ISLANDS), INDIA
[3]Department of Zoology,
JNRM, SRI VIJAY PURAM-744104 (ANDAMAN & NICOBAR ISLANDS), INDIA
*Corresponding Author
E-mail : kamuthy@gmail.com

Received **:** 02.10.2025; ***Accepted*** : 08.11.2025

How to cite : Kaliyamoorthy M, Roy SD, Sahu VK. Major fish landings of the gears Hand-line and Long-line at four main landing centres (FLCs) in South Andaman, India. *Flora and Fauna* 2025. 31(2) : 307-319.

ABSTRACT

Hand and Long-line are most important commercial fishing gears in selective capture fisheries of Andaman and Nicobar Islands. Visit was carried out at four fish landing centres (FLCs) of South Andaman *viz.,* Junglighat (n=692), Dignabad (n=169), Wandoor (n=107) and Guptapara (n=129) to investigate the major fish landings. Total fishing-trips of Hand and Long-line were 1495 and 1493 and total landings of same were 775.9tons and 458.7tons respectively. The maximum landing of Hand-line(97.7%) and Long-line(98.3%) occurred at Junglighat. The hand-liners explored in 35 potential fishing grounds(PFG) and the long-liners explored in 32 PFG around the coast of ANIs. The maximum catch of both the gears occurred in North Andaman sector *i.e.* 54.2% and 38% and the minimum catch of the same occurred at Little Andaman *i.e.* 5.7% and 8.6% respectively. The fishes of family *Serranidae* landed majorly(171.8tons) through Hand-liners and long-liners (183.4tons) with an average of 34.**0**±6.4tons/year and 36.7±2.5tons/year respectively. The validation experiments of Hand-line (n=31) and Long-line (n=22) were carried out at each PFZ and Non-PFZ. The total fish catch of Hand-line at PFZ and Non-PFZ were 5470kgs and 1810kgs & Long-line of the same were 4570kgs and 1643kgs respectively. It was observed that there was a statistically significant difference in the fish caught between PFZ and non-PFZ of hand-line (x^2=14.53, P=0.00014) and long-line (x^2=152.69, P<0.00001). PFZ forecasts proved to be an excellent source for deriving economic benefits and a potent tool in harvesting the under-exploited fishery resources of ANI.

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KEY WORDS : Andaman, Fishing-trips, Hand-line, Long-line, Junglighat, Wandoor

Introduction

Fisheries sector of marine provides livelihood, food security and employment to the dynamic fishers by using various types of advanced crafts and gears for their better income. Industrial fishing activities with modern techniques are continuing to increase in every year which has a great contribution to economic development in India supporting for growing population. The estimated production of capture fisheries in India was about 93 million tons[25] in which, the marine fisheries

ACKNOWLEDGEMENTS : This research is funded by Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, India. Cooperation from Department of Fisheries-ANI and the fishermen for conducting validation experiments are acknowledged

contributed about 90% included 71% mechanized sector, 24% motorized sector and 5%artisanal sector[5]. Andaman and Nicobar Islands (ANIs) Fisheries Policy revealed that the present scenario in India with respect to fish catch and efforts is that among active fishermen, 62% are employed in motorized sector, 33% in Mechanised sector, and 5% in Artisanal Sector. Of the total marine fish production 75% comes from Mechanized sector, 23% from motorized sector and 2% from Artisanal Sector[1].

The main gear of ANIs was gill-net in early days, which declined due to increasing of other fishing gears such as Hand-line, Long-line, ring-net, trawl-net *etc.*[15] The good catches of sharks and marlins were obtained from long lining in Andaman Sea including the Invisible banks[24]. The estimated fishery potential of the Exclusive Economic Zone (EEZ) of ANIs is estimated at 2.435 lakh tons[12] as compared to 39.21 lakh tons for India forming only 6.21% of the fishery potential of our country Estimates by the Fishery Survey of India (FSI) recommend that ANIs is home to 9.2% demersal, 57.1% coastal, and 33.7% oceanic fish stocks[2] which are unique in possessing a high magnitude of harvestable marine fishery resources. The landing of marine fishes in ANIs has increased significantly, evidentially it was 0.01104 lakh tons during 1975 and it increased to 0.31 lakh tons during 2004 which was only 13% of the estimated yield of its EEZ[21]. Similarly it has increased to 0.39284 lakh tons (16%) during 2018, 0.43 lakh tons (17.7%) during 2020-21[10] and 0.44 lakh tons (18.1%) during 2021- 22[11].

TABLE-1 : FLC wise fish landings (in tons) every year during 2014 – 2018

	FLC	Junglighat		Dignabad		Wandoor		Guptapara		Total	
	Year	Trip	Landing	Trip	Landing	Trip	Landing	Trip	Landing	Trip	Landing
Gear-Hand-line	**2014**	355	75.3	12	1.1	15	1.0	8	1.2	390	78.6
	2015	160	25.0	8	1.0	9	0.9	6	0.9	183	27.7
	2016	261	97.8	22	1.8	5	0.4	10	1.3	298	101.3
	2017	336	140.0	25	2.3	8	0.8	11	1.4	380	144.5
	2018	308	103.2	11	0.9	12	1.3	9	1.3	340	106.7
	Total	1420	441.3	78	7.0	49	4.3	44	6.1	1591	458.7
	Avrg		**88.3±18.9**		**1.4±0.3**		**1.2±0.1**		**1.2±0.1**		**91.7±19.2**
Gear-Long-line	**2014**	251	169.2	-	-	7	1.3	8	1.0	266	171.4
	2015	274	128.9	-	-	10	1.0	9	1.3	293	131.1
	2016	260	148.1	-	-	12	1.5	11	1.3	283	150.9
	2017	301	177.2	-	-	8	1.3	7	1.0	316	179.5
	2018	316	140.5	-	-	9	1.2	10	1.3	335	143.0
	Total	1402	763.8	-	-	46	6.3	45	5.9	1493	775.9
	Avrg		**152.8±9.0**	**-**	**-**		**1.3±0.1**	**0**	**1.2±0.1**		**155.2±8.9**

TABLE-2: Family wise major fishes captured by Hand liner (in tons)

Gears Hand line /fishes/years	**2014**	**2015**	**2016**	**2017**	**2018**	**Total**	**Average**
Serranidae (Genera 6, species 24)	**33.66**	**10.70**	**40.79**	**49.12**	**37.50**	**171.77**	**34.0**±6.4
Epinephelus tauvina E.bleekeri E. coioides, E. coeruleopunctatus , E. areolatus, E. fuscoguttatus, E. flavocaeruleus, E. lanceolatus, E. merra, E. malabaricus, E. melanostigma, E. sexfasciatus	23.6	5.62	18.68	21.54	17.15	86.59	17.3±3.1
Plectropomus spp.,	7.84	4.07	18.52	22.64	16.59	69.66	13.9±3.5
Cephalopholis miniata, C. argus C. sonnerati, C. Formosa	1.72	0.43	2.44	3.35	2.53	10.47	2.1±0.5
Pomadasys argenteus, P. furcatus, P. maculates, P. kaakan	0.13	0.45	0.54	0.78	0.48	2.38	0.5±0.1
Variola albimarginata, V. louti	0.29	0.12	0.44	0.66	0.47	1.98	0.4±0.1
Aethaloperca rogaa	0.08	0.01	0.17	0.15	0.28	0.69	0.14±0.05
Lutjanidae (Genera 5, species 18)	**15.63**	**7.92**	**22.98**	**34.48**	**24.52**	**105.53**	**21.0**±4.5
Lutjanus argentimaculatus, L.bohar, L.fluviflamma, L. gibbus, L. johnii, L.lunulatus, L. malabaricus, L.rivulatus,L.sebae	9.58	3.99	11.55	14.24	11.07	50.43	10.1±1.7
Pristipomoides filamentosus, P. multidens, P.sieboldii, P.typus,P.zonatus	2.66	2.15	3.59	5.21	5.72	19.33	3.9±0.7
Aprion virescens	1.28	0.96	2.38	6.56	4.61	15.79	3.2±1.1
Pinjalo pinjalo	0.76	0.6	4.94	5.45	0.77	12.52	2.5±1.1
Aphaerus rutilanes, A. furca	1.35	0.22	0.52	3.02	2.35	7.46	1.5±0.5
Carangidae (Genera 3, species 10)	**5.82**	**3.53**	**15.17**	**20.17**	**13.06**	**57.75**	**11.6±3.1**
Caranx ignobilis, C. sexfasciatus, C. melampygus, C. papuensis	1.42	2.74	14.57	19.58	11.95	50.26	10.1±3.5
Carangoides malabaricus, C. fulvoguttatus, C. armatus, C. bajad, C. coeruleopinnatus	4.26	0.76	0.45	0.47	0.85	6.79	1.4±0.7
Alectis indicus	0.14	0.03	0.15	0.12	0.26	0.7	0.1±0.0
Lethrinidae: (Genus 1, species 7) *Lethrinus amboinensis, L. lentjan, L. microdon, L.obsoletus, L.ornatus, L. variegates, L. xanthochilus*	**3.43**	**3**	**12.59**	**16.97**	**12.48**	**48.47**	**9.7±2.8**

Dasyatidae: (Genera 6) *Dasyatis sp-, Himantura sp., Neotrygon sp, Pateobatis sp, Taeniura sp., Rhinoptera sp*	**2.86**	**0.33**	**1.77**	**4.07**	**4.26**	**13.29**	**2.7±0.7**
Alopiidae: *Alopias pelagicus, A superciliosus, A. vulpinus*	**3.55**	**0.11**	**0.88**	**4.49**	**2.35**	**11.38**	**2.3±0.8**
Sphyraenidae: **(Genus 1, species 6)** *Sphyraena obtusata, S. acutipinnis, S. barracuda, S. chrysotaenia, S. jello, S. qenie*	**1.79**	**0.77**	**1.55**	**2.86**	**2.73**	**9.7**	**1.9±0.4**
Haemulidae: (Genus 1, species 7) *Plectorhinchus albovittatus, P. diagrammus, P. flavomaculatus, P. gibbosus, P. orientalis,P. schotaf, P.sordidus*	**5.53**	**0.07**	**0.54**	**1.47**	**2.45**	**10.06**	**1.8±1.0**
Siganidae : **(Genus 1)** *Siganus sp.,*	**0.12**	**0.04**	**0.14**	**0.05**	**0.04**	**0.39**	**0.1±0.02**
Scombridae (Genera 4) *Scomberomorus sp. Thunnus sp. Gymnosarda sp., Katsuwonus sp.,*	**0.42**	**0.33**	**0.85**	**0.88**	**1.42**	**3.9**	**0.8±0.2**
Carcharhinidae: (Genus 1) *Carcharhinus melanopterus,C. brevipinna, C.amblyrhynchos*	**0.33**	**0.22**	**0.25**	**0.34**	**0.18**	**1.32**	**0.3±0.03**
Laminidae: (Genus 1) *Isurus oxyrinchus*	**1.25**	**0.21**	**0.55**	**3.34**	**0.94**	**6.29**	**1.3±0.5**
Sphyrnidae: (Genus 1) *Sphyrna sp.,*	**0.83**	**0.07**	**0.47**	**2.56**	**1.42**	**5.35**	**1.1±0.4**
Muraenidae :**(Genus 1)** *Anarchias sp.,*	**2.27**	**0.28**	**0.95**	**2.46**	**1.62**	**7.58**	**1.5±0.4**
Mobulidae: (Genus 1) *Manta birostris*	**1.11**	**0.12**	**1.82**	**1.24**	**1.73**	**6.02**	**1.2±0.3**

The estimated harvestable marine fishery potential of ANIs is 1.48 lakh tons/year including oceanic (40.5%), pelagic (37.8%) and demersal (21.6%). It was noticed that the increasing of yearly fish production gradually due to implementation of various schemes by department of fisheries, A&N Administration to enhance the fish production of these Islands. The yearly fish production from 2014 – 2018 were 24.8%, 25%, 25.1%, 26.1% and 26.5% respectively. Further it increased to 28.9% of the estimated yield during 2021[1,4]. ANIs are normally oceanic and encompass an Exclusive Economic Zone (EEZ) of 0.6 million km^2, which is about 30% of the total EEZ of the country while the coastline constitutes 26.10% of the country's coastline. Potential of fisheries resources in ANIs is 43794 tons, excluding oceanic with 0.83 % of the contribution. The Continental shelf is about 34965 Sq.kms, which nearly forms 6.60% of the total Indian Continental Shelf [9,10].

Hook and line fishing is considered more species- and size-selective than other types of fishing such as trawling[19] and so may capture fewer numbers of non-target species and unwanted smaller fish. In addition, survival of unwanted fish catch may also be higher after

TABLE-3. Family wise major fishes captured by long liner (in tons)

Gears Long-line/fishes/years	2014	2015	2016	2017	2018	Total	Average
Serranidae : Genera 6, species 24	**45.89**	**31.33**	**35.63**	**37.15**	**33.43**	**183.43**	**36.7±2.5**
Epinephelus tauvina,E.coeruleopunctatus,E. bleekeri, E.coioides, E. areolatus, , E merra, E.fuscoguttatus, E.flavocaeruleus, E.lanceolatus, E.malabaricus E.melanostigma, E. sexfasciatus	28.3	21.87	26.85	25.1	21.62	123.74	24.8±1.3
Plectropomus areolatus,P.leopardus, P.pessuliferus, P.maculates, P. laevis	10.30	6.10	5.86	9.42	7.47	39.15	7.8±0.9
Cepalopholis miniata, C. argus, C. sonnerati,C. Formosa	6.96	2.78	2.34	2.32	3.71	18.11	3.6±0.9
Variola albimarginata, V. louti	0.31	0.51	0.34	0.25	0.42	1.83	0.4±0.05
Aethaloperca rogaa	0.02	0.07	0.24	0.06	0.21	0.60	0.1±0.04
Lutjanidae (Genera 5, species 17)	30.67	30.88	36.89	45.06	39.56	183.06	36.6±2.7
Lutjanus gibbus, L. bohar, L. johnii, L. fluviflamma, L.lunulatus, L. malabaricus, L. rivulatus, L. sebae, L. argentimaculatus,	13.79	13.69	20	24.36	18.41	90.25	18.1±2.0
Pristipomoides filamentosus, P. multidens, P. sieboldii, P. typus, P. zonatus	6.80	11.15	9.33	11.91	11.75	50.94	10.2±1.0
Aprion virescens	1.65	4.01	2.41	4.37	5.01	17.45	3.5±0.6
Pinjalo pinjalo	6.25	1.33	4.95	2.71	0.95	16.19	3.2±1.0
Aphareus rutilans	2.18	0.7	0.2	1.71	3.44	8.23	1.6±0.6
Alopiidae: (Genus 1, species 3) *Alopias pelagicus, A. superciliosus, A. vulpinus*	**25.51**	**15.51**	**14.2**	**13.2**	**8.51**	**76.93**	**15.4±2.8**
Lethrinidae: (Genus 1, species 5) *Lethrinus amboinensis, L. atkinsoni, L.crocineus, L harak, L.variegatus*	**7.78**	**11.23**	**17.4**	**22**	**15.74**	**74.15**	**14.8±2.5**
Carangidae(Genera 3, species 10)	**12.09**	**14.07**	**18.86**	**13.95**	**14.02**	**72.99**	**14.6±1.1**
Caranx ignobilis, C. sexfasciatus, C. melampygus, C. papuensis	3.06	9.63	15.86	11.73	10.97	51.25	10.3±2.1
Carangoides malabaricus, C. fulvoguttatus, C. armatus, C. bajad, C. coeruleopinnatus	8.65	4.29	2.77	2.08	2.94	20.73	4.1±1.2

Alectis indica	0.38	0.15	0.23	0.14	0.11	1.01	0.20±.05
Centrophoridae: (Genus 1) *Centrophorus sp.,*	**15.42**	**7.09**	**5.63**	**6.81**	**3.32**	**38.27**	**7.7±2.1**
Dasyatidae: (Genus 8) *Dasyatis sp, Pastinachus sp, Bathytoshia sp, Himantura sp. Neotrygon sp., Pateobatis sp., Taeniura sp.,Rhinoptera sp.,*	**7.60**	**3.80**	**5.14**	**10.08**	**5.20**	**31.82**	**6.4±1.1**
Laminidae: (Genus 1) *Isurus oxyrinchus*	**8.29**	**7.85**	**5.5**	**6.41**	**3.19**	**31.24**	**6.2±0.9**
Sphyraenidae: (Genus 1) *Sphyraena obtusata, S.acutipinnis,S.barracuda, S.chrysotaenia, S. jello, S. qenie*	**4.62**	**2.30**	**2.14**	**6.14**	**4.98**	**20.18**	**4.0±0.8**
Haemulidae: (Genus 1, species 3) *Plectorhinchus diagrammus, P. vittatus,P. gibbosus*	**2.46**	**0.32**	**0.39**	**3.72**	**3.98**	**10.87**	**2.2±0.8**
Mobulidae : (Genus 1) *Manta birostris*	**3.22**	**0.62**	**1.01**	**3.95**	**1.85**	**10.65**	**2.1±0.6**
Sphyrnidae: (Genera 2 species 3)	**1.47**	**1.67**	**1.75**	**2.07**	**2.18**	**9.14**	**1.8±0.1**
Sphyrna lewini, S. mokarran	1.24	1.32	1.42	1.51	1.71	7.20	1.4±0.1
Eusphyra blochii	0.23	0.35	0.33	0.56	0.47	1.94	0.4±0.1
Scombridae: (Genera 3) *Scomberomorus sp., Thunnus sp., Katsuwonus sp.,*	2.46	1.12	0.34	2.12	1.06	7.1	**1.4±0.4**
***Hemigaleidae:* (Genus 1)** *Chaenogaleus macrostoma*	0.42	0.77	1.23	0.82	0.58	3.82	**0.8±0.1**
Istiophoridae: (Genus 1) *Makaira (Marlin)*	0.94	0.53	0.28	0.91	0.44	3.1	**0.6±0.1**
Carcharhinidae: (Genus 1 species 3) *Carcharhinus melanopterus, C. brevipinna, C. amblyrhynchos*	0.53	0.50	1.71	0.78	0.70	4.22	0.8±0.2
Muraenidae : (Genus 1) *Anarchias sp.,*	1.48	0.98	2.43	3.45	3.75	12.09	2.4±0.5
Rachycentridae: (Genus 1) *Rachycentron sp.,*	0.33	0.42	0.23	0.62	0.31	1.91	**0.4±0.1**
Coryphaenidae: (Genus 1) *Coryphaena sp.*	0.22	0.11	0.14	0.26	0.20	0.93	**0.2±0.03**

TABLE-4 : Ground and sector wise fish catch of Hand & long-lines at PFZ and Non-PFZ in ANIs

Hand-line	Ground	2014	2015	2016	2017	2018	Total	Average	%
Sectors	**35**								
S. Andaman	12	13.35	6.83	13.01	54.02	41.14	128.34	25.67±9.25	27.98
N. Andaman	13	49.47	5.28	70.84	69.70	53.54	248.82	49.8±11.9	54.24
M. Andaman	6	11.56	12.80	13.13	10.60	7.19	55.28	11.06±1.07	12.05
L. Andaman	4	4.25	2.80	4.31	10.17	4.75	26.27	5.25±1.27	5.73
Long-line	**32**								
S. Andaman	10	42.27	28.89	47.19	50.38	41.95	210.68	42.14±3.7	27.15
N. Andaman	8	83.20	47.27	69.91	46.04	48.32	294.73	58.9±7.5	37.98
M. Andaman	5	13.30	31.18	7.19	16.17	17.31	85.15	17.03±3.9	10.97
L. Andaman	3	13.89	8.97	12.86	20.58	10.09	66.39	13.28±2.03	8.56
Nicobar	6	18.79	14.82	13.72	46.34	25.30	118.97	23.8±6.0	15.33

capture by hook and line[26] and this method of fishing may have little direct impact on the seabed and fish habitats.

Materials and Methods

This study was carried out during the years 2014 and 2018 to investigate the marine fish landings through the fishing gears Hand and Long-line in South Andaman. ANIs is an Union Territory of India, located between 6º45'N and 13º 41'N Latitude and 92º12'E and 93º 57'E Longitude with 10°N channel separating Andaman group and Nicobar group of islands in the southern reaches of Bay of Bengal. It is the largest archipelago comprising of 572 islands, islets and rocky outcrops spread over a length of about 700 km and breadth of about 250 km with an aggregate coastline of 1,962 km about a fourth of Indian coastline[20].

The UT of ANIs consists of three districts *viz.* South Andaman, North and Middle Andaman and Nicobar with the population of 4,17,036[11] having 169 fisher villages, 5944 fishermen families with the Fisher-folk population of 26,521 involving in fishing activities. The total fishing crafts engaged in capture fisheries are 2699 in which 1346 non-motorized traditional country crafts play for daily fishing engaging with 1-2 person, 1353 Motorized crafts (Dinghy) will be engaged for 5-10 days with 3–5 crews upto 250 m depth and 85 Mechanized boats (ANIs FP. 2018) which go for deep sea fishing (300m to 500m) in all around the ANIs, will be engaged for 15 to 30 days fishing with 8–12 crews (Fig. 1).

According to our previous study there were 20 Fish Landing Centers (FLCs) identified in ANIs[6,15], amongst them four main FLCs viz., Junglighat, Dignabad, Wandoor and Guptapara were selected for this study which were located at South Andaman. The mechanized boats of hand-line and long-line were operating only from Janglighat FLC and others crafts from all the FLC. All the vessels were undergoing for capturing fisheries with various gears including Hand & Long lines. Non-mechanized boats (Dinghy) operations occurring from Junglighat and also other FLC of ANIs. The non-mechanized hand-liner would not venture to Nicobar groups islands due to water current and high wave action at 10 degree channel.

Potential Fishing Zone Forecast

The Potential Fishing Zone forecasts (PFZ) based

TABLE-5 : Validation experiment of Hand & long-lines at PFZ and Non-PFZ in Andaman coast

Validation conducted	No. of validation experiments			Fishes caught in kg			Average in kg/day/ boat	Chi square (P value)
	2016	2017	Total	2016	2017	Total		
Hand line						**3.02:1**		
PFZ	10	21	31	1800	3670	5470	176.5±8.7	x^2 =14.53,
Non-PFZ	10	21	31	685	1125	1810	58.4±4.9	P=0.00014
Long line						**2.8:1**		
PFZ	11	11	22	1960	2610	4570	207.7±18.1	x^2=152.69,
Non-PFZ	11	11	22	995	648	1643	74.7±6.1	P<0.00001
Total PFZ	21	32	53	3750	6280	10040	189.43±9.2	x^2=133.55,
Total Non-PFZ	21	32	53	1680	1773	3453	65.1±3.9	P<0.00001
						2.91:1		

on chlorophyll and SST maps retrieved from ocean colour and thermal imagery received from Indian National Centre for Ocean Information Services (INCOIS), Hyderabad. PFZ forecast was described to the fishermen of various landing centers of ANIs. Maximum active fishermen of these islands has been identified and sensitized through awareness campaign to enhance their fish catch. PFZ Forecast printout copies were took and distributed by hand to active fishers, various boat masters and boat owners of every FLCs. The same were also informed through email, text message, cell phone call and Digital Display Board. Sea Surface Temperature (SST) is the mainly and easily observed environmental parameter and is quite often correlated with the especially availability of pelagic fish which affects fish species development during their life cycle on the upper ocean surface (1mm to 20m). Phytoplankton biomass, the primary food source within the sea, is another important factor[17]. The thermodynamic anomalies were investigated in terms of sea surface temperature (SST), isothermal layer depth (ITD), and upper ocean heat content (HCT)[27]. Various regular fishing grounds were identified by fishers with landmark and nick name of the fishing ground during their fishing activities. Identical vessels of different categories were used for conducting simultaneous validation experiments within and outside PFZs.

Hand-line

All the crafts were undergoing for hand-line fishing which is one of the most important fishing gears with many designs and modes of construction to effectively catch the targeted species. An iron rod measuring 50 to 90 cm. with 3 mm. diameter was embedded in a lead sinker of 1.5 mm diameter with a length of 15 mm was used to increase the sinking speed for the tuna hand-line. Commonly a hand-line consists of a primary mainline, secondary mainline, hook and sinker. Multiple hand-lines undergoes from 100 – 300 m depth fishing. Three types of hand-lines with varying hook distances (50, 75, and 100 cm) attached to the mainline baited with red and silver artificial lures were used in the study. Fishing operations were done in the morning and in the afternoon. For hand-line fishing, the fishermen from Junglighat FLC were venturing regular basis for targeted high rated fishes such as dollar *(Plectropomus* sp.,) and

Fig.1 (a) Country crafts, (b)Motorized-Non-Mechanized boats, (c)Motorized-Mechanized Boats

tiger groupers (*Ephinephelus sp*.) under the assignments of various fish exporting companies.

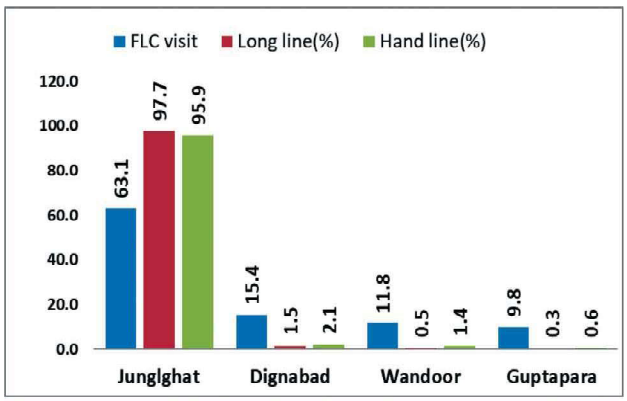
Long-line

The crafts Motorized Non-Mechanized and Mechanized boats were engaged long-lines fishing. Long lines as the name of the gear indicates, the mainline with baited hooks attached at intervals - connected with relatively shorter and thinner leader lines (snoods, gangions). It was mentioned that the Long-line fishing was introduced to the rest of the Pacific Ocean in the 1930s by Japanese fishermen[23]. By 1939 there were about 70 Japanese long-line boats of between 60 and 270 gross registered tons (GRT) operating in the western and central Pacific Ocean. It is set, either by hand or mechanically especially suited to catch scattered and sparsely distributed fish populations. It was usually hauled once daily and allowed to drift freely for 6 – 18 hours which attracted fishes from many hundred meters away. Bait is the key factor in line fishing, which depends on the foraging behavior of fish stimulants, and sensory modalities[22]. The fishes such as frigate, tuna, carangids and squid were used as live baits to increase gear efficiency. Sometimes Andaman fishermen were using big Sardine, Indian mackerels, flying fish, sharks *etc.,* for baits.

Result

The total fishing-trips of Hand-line and Long-line observed at four FLCs included **Junglighat, Dignabad, Wandoor and Guptapara** during the five consecutive years 2014-2018 with 1097 FLC visits were 1591(n) and 1463(n) respectively. Likewise the total landings of Hand-line (458.71 tons) and Long-line (775.91 tons) were recorded with an average of 91.7±19.2 tons/years and 155.2 ±8.9tons/years with landing contributions[13-16] of 11.8% and 20% respectively amongst other gears (Table 1). The average landings of Hand-line in each FLC during the study period were 88.3±18.9, 1.4±0.3, 1.2±0.1and 1.2±0.1 & of long-line 152.8±9.0, 0.0, 1.3±0.1and 1.2±0.1 respectively. Long-line operation was not observed from Dignabad FLC during the visited period (Table 1). According to the year wise analysis, **t**he maximum fishing-trips of both the gears were recorded during the years 2014 (n=390) and 2018 (n=335) respectively. Likewise, the maximum fish landing of both the gears were occurred during the year 2017 (144.5 tons) and 2017 (179.5 tons) respectively.

The maximum % of FLC visits (63.1), fish landings of hand line (95.9) and long-lines (97.7) occurred at Junglighat FLC (Fig. 2-a). A total of 35 Potential Fishing Grounds (PFG) were explored by hand-liner and 32 PFG



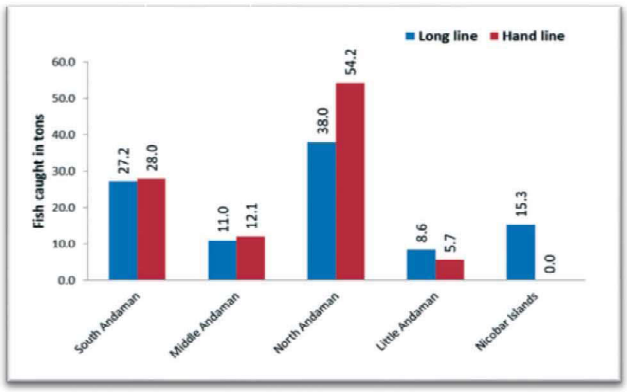


Fig.2: Long and Hand-line (a) % of FLC wise fish landings (b) Sector wise fish catch

Fig. 3 Landings of Hand-line (a)-(b) *Plectropomos* sp., (c) *Plectorhinchites* sp., (d) *Lutjanus* sp.,(e) *Epinephelus* sp., (f) *Lethrinus* sp.,

explored by long-liner in all five sectors included (1) South Andaman, (2) Middle Andaman, (3) North Andaman, (4) Little Andaman and (5) Nicobar. The major fish catches of both gears were recorded from PFG of North Andaman sector (54.2%) and (38%) during the period (Fig. 2-b)

Family wise major fish landings

The family-wise landing of Hand-line and Long-liners were analyzed. Totally 32 genera of fin fishes recorded under 14 families in Hand-line landings and 37 genera recorded under 18 families. The fishes of family Serranidae landed majorly (171.8 tons) through Hand liners with an average of 34**.0**±6.4 tons/year followed by family Lutjanidae (105.5 tons) with an average of **21.0**±4.5 tons/year Carangidae 57.8 tons with an average of 11.6 ± 3.1 tons/year etc, (Table. 2).

Similarly fishes which landed by the long-liners, the family ***Serranidae*** majorly (183.4 tons) with an average of 36.7±2.5 tons/year followed by family ***Lutjanidae*** (183.1 tons) with an average of **36.6**±2.7 tons/year, ***Alopiidae*** 76.9 tons with an average of 15.4 ± 2.8 tons/year, ***Lethrinidae*** 74.2 tons with an average of 14.8±2.5 tons/year, ***Carangidae*** 73.0 tons with an average of 14.6±1.1 tons/ year, etc,(Table-3).

Ground and sector wise fishing

A total of 35 PFG were explored by the gear hand-line in four sectors *viz.* South (12), North(13), Middle(6), and Little (4) Andamans. The maximum fish catch occurred from the sector of North Andaman (248.82tons) which was 54.24% of total hand-line catch followed by South Andaman (27.98 %), Middle Andaman (12.05%) and Little Andaman (5.73%) sectors during the visited period (Table-4). A total of 32 fishing grounds were explored by the gear long-line from four fishing sectors in Andamans of South (10), North (8), Middle (5) and Little (3) & from Nicobar sector (6). The maximum fish catch was recorded from the sector of North Andaman (294.73 tons) which was 38% of total landing through the gear Long-line followed by South Andaman (27.2%), Nicobar (15.3%), Middle Andaman (11%) and Little Andaman (8.6%).

Validation

Altogether 53 validation experiments were carried out during the study period by the fishing gears of Hand-line (31) and Long-line (22). The total fish catch at in and outside of the PFZ were 10040 kgs and 3453 kgs. The fish catch occurred through Hand-line at PFZ was 5470 kgs with an average of 176.5±8.7 kgs/experiment and at Non-PFZ was 1810 kgs with an average of 58.4±4.9 kg/ experiment. Similarly the fish catch occurred through long-line at PFZ was 4570 kgs with an average of 207.7±18.1kgs/experiment and at Non-PFZ was 1643 kgs with an average of 74.7±6.1 kg/ experiment(Table 3). The both gear operation occurred at each PFZ and Non-PFZ was 1:1 and fish catch was occurred 2.91:1 respectively. The operation of Hand-line and Long-line occurred at PFZ and Non-PFZ was 1:1 and fish catch of same were occurred 3.02:1 and 2.8:1 respectively (Table 5). It was found that there was a statistically significant difference in the fish caught between PFZ and non-PFZ of *hand line* (x^2 =14.53,

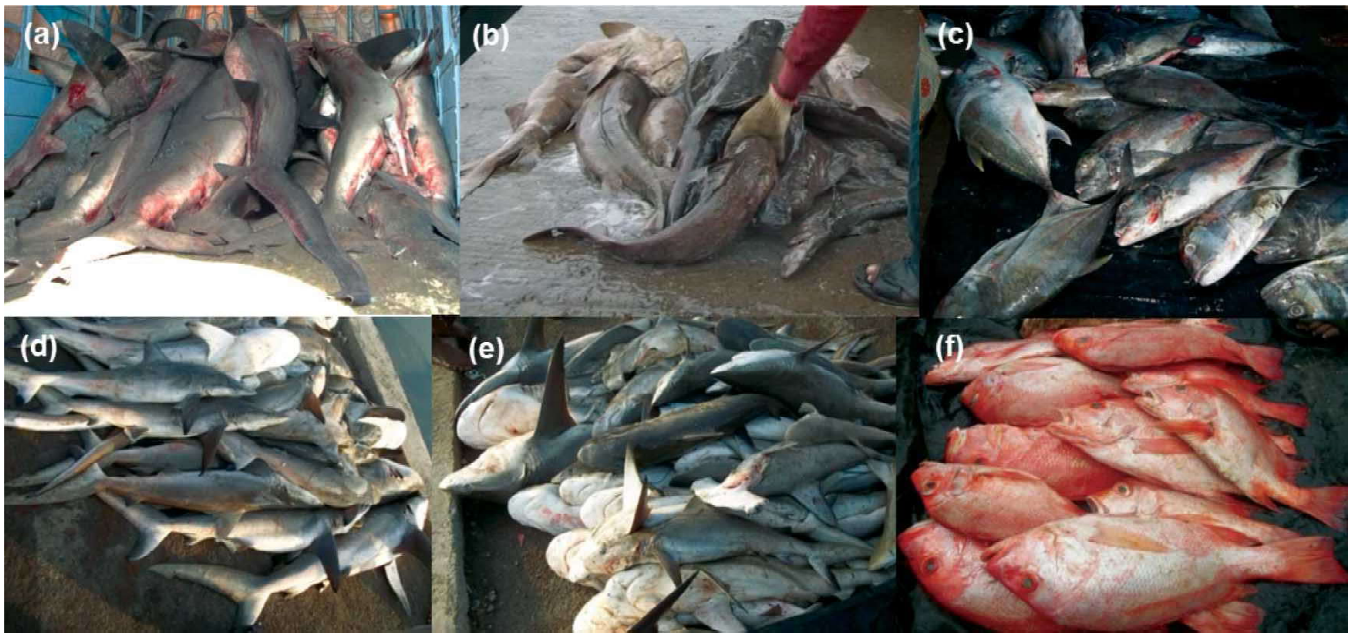


Fig.4 Landings of Long-line (a) *Alopias* sp., (b) *Centrophorus sp* (c) Caranx sp., (d) *Sphyrna* sp., (e) *Isuru* sp., and (f) *Lutjanus* sp.,

P=0.00014). For the *Long line* also similar significance was observed (x^2=152.69, P<0.00001). For both gears included *hand-line and Long-line* was observed that there was also a statistically significant difference in the fish caught between PFZ and non-PFZ (x^2=133.55, P<0.00001). The PFZ forecasts proved to be an excellent source for deriving economic benefits and a potent tool in harvesting the under-exploited fishery resources of ANI[6].

Discussion

The maximum fishermen of Junglighat FLC had the ability for multi gear operation and kept different gears in their dinghy/boat; the gear was changed in time to time according to the fishing area, the tidal, and weather conditions. According to the comparison of the survey, it was showing the increasing of all the gear operation in every year including line operation (n=32858). The number of Hook & lines operation has increased over the years from about 3443(n) in 2012-13, 27676(n) Hook & lines and 5182(n) Long-line in 2021, indicating a substantial increase in fishing effort in the capture fishery[2,3]. The Andaman and Nicobar Islands encompass multiple habitat types support a range of fisheries. The most common gear for catching dollar fish is a baited hook-and-line. Along with dollar fish, many other fish get caught nibbling the bait, including snappers, barracudas, jacks and sharks which are top predators of the sea. Long-line fish catch with mechanized crafts were occurring all around the ANI in deep sea but all landings are occurring at Junglighat FLC. The same mechanized crafts crews were also operating hand-lines for targeted fishes like dollar and tiger groupers. Similarly same dinghy also would be used for other gear operation like gill net, hand-line and long-line. These data were not accountable in the landings and also not recorded by the researchers. The sand beach landings also sometimes not recorded due to unknowing landing. Fisheries of ANI are underdeveloped attributable to operation of vessels with decreased far-sea endurance, underdeveloped infrastructure facilities such as harbour, cold storage and processing and transportation costs[7]. The vessel size and the gears were not adequate for operating in deep waters and there was absence of organized offshore fishing from the Andaman base. The emerging body of evidence suggests the critical need to reliably estimate the fish catches and population dynamics for sustainable fisheries management[18]. The results indicated that the northern and southern parts of the Andaman Sea are habitat for tunas and other large pelagic fishes which are economically important species, and could be considered as fishing grounds for tuna long-line fishing. The long-liners and hand-liners were using other gears for bait fishes by gillnets. Sometimes hand-liners use long-lines to capture groupers, snappers, sharks *etc.* Likewise long-liners also use hand-line to capture dollar and tiger groupers but that landings are not reported under used gears. The indications that a single/similar stock of fish is being attracted to PFZ in comparison to Non–PFZ. Fishing expenses were comparatively less for vessels which operated within PFZ. The fish catch has been reported only for the visited period, it may be more catch than the reported. The maximum number of PFG investigated for the gear hand-

line at North Andaman sector (13) and for long-line South Andaman sector (10). The maximum fish catch occurred from the sector of North Andaman (248.82tons) which was 54.24% of total hand-line catch. A total of 32 fishing grounds were explored by the gear long-line from four fishing sectors in Andamans of South (10), North (8), Middle (5) and Little (3) & from Nicobar sector (6). The maximum fish catch was recorded from the sector of North Andaman (294.73 tons) which was 38% of total landing through the gear Long-line. A significant increase in total catch identified by follower of PFZ forecasts has been documented from ANIs. It was observed that there was a statistically significant difference in the fish caught between PFZ and non-PFZ of *hand-line* (x^2=14.53, P=0.00014) and *long-line* (x^2=152.69, P<0.00001). PFZ forecasts are proved to be an excellent source for deriving economic benefits and a potent tool in harvesting the under-exploited fishery resources of ANI.

Conclusion

Coastal fisheries supply daily food and serve as one of the few sources of income for many coastal populations. Now a days, the skill of multi-gear operation by the young fishermen of these Islands with the advanced fishing technologies (AFT) is increasing the gradual fish catch of the gears *viz* Trawl-net, Ring-net, Gill-nets, Hand line, Long line, Anchor-net, etc. They are changing their gear operation time to time for exportable targeted fishes for their better income. The issues are isolated islands with difficulty in transportation and maintenance like mainland crafts also being faced. ANI has remained as a potential fishing ground to exploit the marine fisheries resources in India due to its vast coastline 1,962 km. It is essential to increase the potential fishing activities to meet out daily needs or demands of fish consumption by the exploding population in these islands. Concerned departments and policymakers to take good steps to promote the Hook&line to increase of the groupers dolor and tiger fishing in these islands will benefit to the islanders. It was concluded that the average income generated by vessels operating in the PFZ areas was considerably higher than vessels operating in non PFZ areas. At present capture fisheries is an income generating sector for our growing young generation, the youngsters can promote their knowledge in this industry to find new technologies for our future generation.

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