AN OVERVIEW OF THE BYCATCH STATUS IN TUNA FISHERY IN INDIA

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ABSTRACT

In the tuna fishery apart from the targeted catch i.e the tunas, the allied catches like the swordfish, sailfish, marlins and pelagic sharks, dolphinfish, turtles etc. contribute to the bycatch. The landing pattern of these resources clearly indicates this. Also the exploratory tuna longline surveys in the exclusive economic zone (EEZ) of India has indicated the abundance of these species. For managing the tuna fishery it is utmost important to know the status of the bycatch occurring in it. In the present study along with the targeted catch i.e the tunas, 39 bycatch species i.e the billfishes, seerfishes, pelagic sharks, rays, barracudas, sickle pomfret, oilfish, sunfish, escolar, dolphinfish, lancetfish etc. were recorded. The fishes recorded during the tuna longline survey in the Indian waters by the four longliners i.e MFV *Matsya Vrushti*, MFV *Matsya Drushti*, MFV *Yellow Fin* and MFV *Blue Marlin* during 2009-19 were studied and the distribution and abundance pattern of the tunas and the bycatch species were recorded. An aggregate hooking rate of 0.28% (number/100 hooks) and a catch rate of 33.3 (kg/1000 hooks) was recorded from the Indian EEZ. This study will definitely help the researchers and entrepreneurs as well as the fishery managers of India for devising the desired policy for the management of bycatch in Indian waters.

(Key words: Bycatch, catch trend, tuna longline, Indian EEZ, hooking rate, catch rate, seasonal distribution)

INTRODUCTION

Bycatch is the non targeted species occurring in any fishing i.e tuna longline, bottom trawling, gill netting, purse seining etc. Longlining is a commercial fishing method which targets the oceanic tunas such as yellowfin tuna, bigeye tuna, skipjack tuna, albacore tuna etc. The bycatch plays an important role in the oceanic fisheries world over. Apart from the targeted catch i.e the tunas, the allied catches like the swordfish, sailfish, marlins and non–targeted pelagic sharks, dolphinfish, turtles, sea birds etc. are recorded. Incidental capture of turtles by longlines, trawls and gillnets is the greatest threat to the population. Among different fishing methods, the longline is considered as eco-friendly fishing technology. Though the targeted species are tunas , the bycatch like sharks contributes a lot to the longline fishery.

The total area of India is 3.29 million sq.km. India has about 7,157 km. of coastal line and 2.02 million sq km of Exclusive Economic Zone (EEZ) covering the west coast, east coast and Andaman Sea and a continental shelf of 0.53 million sq km. The EEZ of India offers an estimated fisheries potential of 5.31 million metric tonnes. Of this, the pelagic resources of the mainland accounted for 2.30 million metric tonnes, demersal resources of the mainland was 2.63 million metric tonnes, potential yield estimated for island groups (excluding oceanic resources) is 58,280 metric tonnes, whereas the potential yield of oceanic resources for the entire Indian EEZ is 2.31 lakh metric tonnes (Anon, 2018). The total Gross Value-Added accounts for about 7.28% share of Agriculture GDP. The total fish production during 2019-20 was 14.16 million metric tonnes which includes 3.72 million metric tonnes from marine sector and 10.43 million metric tonnes from inland and aquaculture.

Multispecies fish stocks are known to occur in the Indian EEZ which are harvested by diversified fishing gears. The bulk of the catch comes from the coastal waters i.e less than 100 m depth. The sardines, mackerels, ribbonfishes, shrimps etc. contribute maximum of the coastal fishery catch. In India, the small-scale and artisanal sectors largely contribute to the tuna fishery, deploying both mechanized and motorized boats, using a variety of gears. The Indian fishers are aiming for the tuna and allied species by operating 12 different types of fishing gears. In Indian waters (FAO area 51-West Coast of India, FAO area-57: East coast of India) three species of oceanic tunas are commonly caught i.e *Thunnus albacares*, *Thunnus obesus* and *Katsuwonus pelamis*. Among the oceanic fauna caught by longlining, apart from the targeted species ie tunas, the common bycatch species are sharks, billfishes, barracudas, seerfishes, dolphinfish etc. Among the different bycatch species encountered in the longline fishery, the oceanic sharks are prominent. These studies on the bycatch play an important role in the management of the oceanic fishery worldwide. The bycatch in the Indian waters is studied earlier by Bhargava *et al*., (2002); Somvanshi *et al*., (2005); John *et al*., (2005); Varghese *et al*., (2007); Kar *et al*., (2011, 2020); Varghese *et al.*, (2013); Aneesh Kumar *et al.*, (2015); Koya *et al*., (2018). The bycatch can be reduced to a greater extent by modifying the longline gear i.e setting it in a much deeper waters. The present study aims at studying the status of the bycatch in the Indian EEZ by taking into consideration the tuna and allied species landings as well as the oceanic fishery resources survey data.

MATERIALS AND METHODS

The tuna and allied species landings data was collected from the National Report of the Government of India to the IOTC (2009- 2020). Also the catch data of tuna and allied resources were retrieved from the web portal http://www.iotc.org. The data was analysed to see the landing pattern over the 11 years period. The tuna long line survey data collected from the four IOTC registered vessels of Govt. of India i.e MFV *Matsya Vrushti* (OAL 37.5 m, GRT 465 t, IOTC reg. No. IOTC 003604) & MFV *Yellow Fin* (OAL 35.7 m, GRT 310 t, IOTC 003602) in the west coast of India (Arabian Sea), MFV *Matsya Drushti* (OAL 37.5 m, GRT 465 t, IOTC 003605) and MFV *Blue Marlin* (OAL 35.7 m, GRT 310 t, IOTC 003603) in the east coast of India (Bay of Bengal and Andaman and Nicobar waters) (Fig.1) during the period of 2009-19 was used in the present study. The vessel MFV *Matsya Drushti* and MFV *Matsya Vrushti* are two monofilament longliners and MFV *Blue Marlin* and MFV *Yellow Fin* are two multifilament longliners. The data was analysed and the species diversity, abundance and distribution of bycatch species were studied. The hooking rate in percentage (number of specimens caught per 100 hooks) and catch rate (weight per 1000 hooks) was estimated and it was used to know the distribution of the resources and abundance pattern, their seasonal variations etc.

RESULTS

In India no commercial tuna fleet is operational however, the small-scale and artisanal sectors largely contribute to the tuna fishery. Both mechanized and motorized boats using a variety of gears are operational which contribute to the tuna fishery. The mechanized boats are the fishing vessels which are fitted with inboard engines that are used for both propulsion and hauling the gear. The overall length (LOA) is less than 24m. The motorized fleet uses outboard motors for propulsion only (LOA < 24m). The fishing fleet of India comprised of 42, 651 nos of mechanized boats, 95,957nos of motorized boats and 25,689nos of non-motorized boats (Table.1). 12 different gears contribute to the tuna fishery of India. 46 species contributed to the tuna and allied species. They are three species of oceanic tunas, four species of coastal or neretic tunas, two species of marlins, one species each of Indo-Pacific sailfish and swordfish, three species of seerfish, twenty one species of pelagic sharks, one species of ray, two species of

barracuda, one species each of dolphinfish, oilfish, escolar, sunfish, cobia, sickle pomfret, ribbonfish and longsnouted lancetfish (Table. 2).

Landing pattern of various groups in the tuna fishery in India

The longline catches from Indian waters during 1986- 1994 by chartered vessels and by Indian commercial and survey and training vessels was studied and found that the average tuna catch during this period was 3,492 tonnes. Similarly the average billfish catch was 651tonnes and that of others (sharks) was 508 tonnes contributing 75%, 14% and 11% respectively to the average total catch (Somvanshi and John (IPTP collective vol.9). During 2005 the tuna landings were 39,948 tonnes from the coastal fisheries. From oceanic fisheries the tuna landings were 1,795 tonnes. The bycatch landing was 148 tonnes (Somvanshi *et al*., 2006).

The tuna and allied fishes landings during the period 2008 to 2019 is shown in Fig. 2. The tuna and allied species are broadly divided into five groups i.e tuna and allied species, billfishes, sharks, seerfishes and others. From 2008 to 2019 the tuna and allied species has shown an increasing trend with an average of around 99,588 tonnes. The tuna landings were more during the year 2013 (1,34,689 tonnes), 2014 (96,290 tonnes), 2018 (1,32,474 tonnes) and 2019 (1,15,606 tonnes). Since 2016 the billfish growth also is increasing with an average of 12,025 tonnes. The pelagic sharks are in the decreasing trend. During the year 2015 the shark landings were 29,268 tonnes and it decreased in subsequent years and it was 15,248 tonnes during 2019. The average shark landings over the years is 11,504 tonnes. The Seerfish catch has not shown major increase or decrease and it averages at 50,013 tonnes.

Distribution and abundance of bycatch in the tuna longline survey of Government of India

During the period 2009-2019 a total of 3049 longline sets consisting of both monofilament and multifilament longlines were made and 17,46,761 hooks were deployed. On an average 573 hooks were operated. In the tuna longline survey, a total of 4956 fishes weighing about 59,747 kg was recorded out of which 1305 tunas, 445 billfishes, 1187 elasmobranchs (sharks and rays) and 2019 other varieties were there (Fig.3). In general the oceanic species landings were more during 2010, 2013 ,2016 and 2019. The tuna landings have shown an increasing trend over the 11 years period from 482 kg during 2011 to 5,250 kg during 2019. The billfish catch was fluctuating over the years and during 2019 it was 1,124 kg. The shark catch

has shown a decreasing trend and from 3,683 kg during 2010 it has come down to 595 kg during 2019.

The percentage contribution of tuna was 26.3%. Billfishes contributed 9.0%, elasmobranchs 24.0% and other varieties contributed 40.7% to the total catch (Fig. 4). The percentage of composition by number is depicted in the Fig. 5. The tuna catch was more in the FAO area 57 than the area 51. However the billfishes and elasmobranchs number was more in the FAO area 51 than 57. The percentage by weight (Fig. 6) shows that the tunas and elasmobranchs are more in the FAO area 57 than 51. In the FAO area 57 the tunas contributed 41.2 % to the total landings and 26.1% to the total landings in the west coast of India i.e FAO area 51. Similarly the elasmobranchs contributed 38.7% by weight of the total catch in FAO area 57 than the area 51(33.3%). The billfish catch was more by weight in the FAO area 51 where it was 29.5 % whereas the billfish catch in the area 57 was 10.1%.

From the table 3 it can be seen that in the Indian waters the average aggregate hooking rate (no of fishes per 100 hooks) was 0.28% and the catch rate (quantity in kg/1000 hooks) was 33.3. The hooking rate of tuna was 0.09% in the area 57 followed by 0.04% in the area 51. The hooking rate of the elasmobranchs i.e sharks and rays was more in the area 51 (0.08%) followed by 0.06 % from the area 57. The aggregate hooking rate from the area 57 was found to be more (0.29%) followed by area 51 (0.25%).

Similarly the catch rate in the area 57 was more i.e 33.5. The catch rate for tunas in the area 57 was 13.8 followed by area 51 where it was 8.6. The catch rate of billfish in the area 51 was more (9.8) whereas it was 3.4 from the area 57. The catch rate of elasmobranchs was found to be more from the area 57(12.9) than the area 51 where it was 11.0.

From the exploratory tuna longline survey it could be seen that over the 11 years period the average aggregate hooking rate (%) was fluctuating in between 0.18 % to 0.39% with maximum during 2016 (0.39%) and minimum during 2012 (0.18%) (Fig. 7). Better hooking rate was obtained during the year 2009, 2016 and 2019. The average tuna catch was more during 2013-14 (0.8%), 2016 (0.17%) and 2019 (0.24%). Billfish catch was steady over the years (hooking rate fluctuating between 0.01% to 0.06%). The elasmobranch catch was in a decreasing trend. In the year 2009 the average hooking rate registered was 0.10%. Subsequently it decreased

over the years. However during 2017 the hooking rate registered was more (0.16%) and subsequently it has decreased.

Seasonal variations

The hooking rate trend indicated better catch of tunas during September to January and it has decreased in the subsequent months (Fig. 8). For tuna fishing the most productive months were January (0.14%) and December (0.09%). Bill fish catch indicated that better catch rate was obtained during March-May, July and October. The elasmobranchs abundance was more during May to October. They were recorded in more numbers with a peak during June (0.18%) followed by September (0.14%). The abundance of the other groups were more during September, November and December.

Abundance and distribution of sharks

During the study period i.e 2009 to 2019, the shark catch was more during the year 2011. In subsequent years it has shown a decreasing trend. The hooking rate for sharks in the area 51 was found to be 0.05% and the catch rate was 10.6. Similarly the hooking rate for sharks in the area 57 was 0.03% and the catch rate was 11.9. During the last 11 years twenty one species of sharks from eight genera were landed all over India. Among them three species of the genus *Alopias*, eleven species of the genus *Carcharhinus* and one genus each of *Galeoceredo, Isurus, Loxodon, Sphyrna, Prionace* and *Triaenodon* were there.

DISCUSSION

Various researchers have worked on the bycatch / non-targeted catches of the tuna fisheries and given the species composition in detail in the Indian waters. Somvanshi *et al*. (2005) recorded 25 bycatch species in the Indian tuna longline survey. Kar *et al*. (2011) recorded 30 bycatch species in the tuna longline survey conducted in the Indian EEZ around Andaman and Nicobar waters. They recorded 17 species from 7 genera and 4 different families of sharks. They showed that shark contributed 38% and 54% by number and weight respectively. Varghese *et al.* (2013) studied the pelagic megafauna bycatch in the tuna longline fishery in India and reported 60 species of large pelagics and sea turtle as bycatch in the tuna longline survey in India with Indo-Pacific sailfish, *I. platypterus,* the main bycatch species and sharks formed the largest group. Out of that 14 species of sharks were recorded and the shark catch contributed 14.5% by number and 39.9% by weight. Kar *et al.* (2020) reported 31 species contributing to the bycatch of Indian tuna longline fishery survey. In the present study 46 species contributed to the tuna

fishery of India and apart from the tunas 39 species contributed to the bycatch. The percentage of billfishes was 9.0%, elasmobranchs 24.0% and other varieties contributed 40.7% to the total catch.

Varghese *et al.* (2007) reported that sharks constituted 24.2% by number and 29.8% by weight to the total catch from the Bay of Bengal during 2005-06. Sinha *et al.* (2010) studied the shark catch from the Andaman waters and it was 41.58% by number and 56.56% by weight and reported 14 species of sharks from 4 families including Alopiidae. Kar *et al.* (2020) reported 14 species of sharks which contributed 14.5% by number and 39.9% by weight. In the present observation 21 species of sharks and one species of ray contributed to the elasmobranch group and contributed 31.9% and 20.6% by number in the FAO area 51 & 57 respectively. They contributed 33.3% and 38.7% by weight from the area 51 & 57 respectively.

Sinha *et al.* (2010) reported an aggregate hooking rate of 0.85 % for all fishes out of which sharks hooking rate was 0.35% followed by tunas with 0.25% for the period April 2000 to March 2005 in Andaman and Nicobar waters. Varghese *et al.* (2007) reported a hooking rate of 0.20% for the sharks from the Bay of Bengal (Area 57). Varghese *et al.* (2013) reported a hooking rate of 0.22% for shark from the Andaman waters and a hooking rate of 0.16% for sailfish from the northwest coast of India.

Aneesh Kumar *et al.* (2015) studied the shark bycatch of Lakshadweep sea in the tuna longline fishery and reported a mean hooking rate of 8.05/1000 hooks and the Bycatch contributed 82.4% of the catch. Silky shark (*Carcharhinus falciformis*) with 89.9% was the dominant shark species followed by *C. amblyrhynchos*, *Galeocerdo cuvier*, *Alopias pelagicus*, *Negaprion acutidens* and *Sphyrna lewini* with 4.7, 2.7, 1.4, 0.7 and 0.7%, respectively. Sharks contributed to 74.1% of the catch, followed by 15.7% sailfishes and 10.2% miscellaneous fishes. Kar *et al.* (2020) obtained a hooking rate of 0.056% from the Arabian sea, 0.009% from the Bay of Bengal and 0.079% from the Andaman & Nicobar waters. They also reported a catch rate of 10.9 for sharks from the Arabian sea, 30.1 from the Andaman & Nicobar waters and 2.4 from the Bay of Bengal (East Coast of India). The higher catch rate of 30.1 from the Andaman waters could be due to the catching of matured/fully matured species in the longline. Similar observations were made in the present study and the hooking rate for elasmobranchs was 0.08% and 0.06% from the area 51 & 57 respectively.

Somvanshi *et al*. (2009) reported hooking of pelagic stingray at a hooking rate of 0.06 per 100 hooks in the tuna longline survey conducted in the seas around India during the period 2005-2007. Varghese *et al*., (2013) recorded a hooking rate for this species from the Andaman and Nicobar waters as 0.077%, followed by Bay of Bengal region (0.064%) and Arabian Sea (0.036%). Kar *et al*. (2020) reported it as 0.025%, 0.009% and 0.069% from Andaman & Nicobar waters, Bay of Bengal and Arabian Sea respectively. In the present survey the hooking rate obtained for the pelagic sting rays for the area 51 was 0.02% and for the area 57 it was 0.03%.

In the present study the aggregate hooking rate for the oceanic species was found to be 0.28%. The abundance of tuna was found to be more in the east coast of India than that of west coast of India. However the elasmobranchs catch i.e (sharks and rays) was more in the west coast of India than the east coast of India. It could be observed that the quantity of tuna in kg caught per 1000 hooks was found to be more from the east coast of India (13.8 kg) than the west coast of India i.e 8.6kg. The catch rate also indicated that the billfish in kg caught per 1000 hooks was found to be more in the east coast i.e 9.8 kg than the west coast i.e 3.4 kg. The quantity of sharks in kg caught per 1000 hooks was more in the east coast i.e 12.9 kg than the west coast i.e 11.0 kg. The present study also indicated that the peak season for the elasmobranchs in the Indian waters is during May to October.

National regulation for the bycatch species in India

NPOA sharks

The National Plan of Action for Conservation and Management of Sharks (NPOA-Sharks) has been prepared by the Bay of Bengal Programme Inter-Governmental Organization.

Sharks finning regulation

Three species of marine sharks are listed under Schedule I of the Indian Wildlife (Protection) Act, 1972. The species are *Rhincodon typus, Carcharhinus hemiodon, Glyphis glyphis.* The Ministry of Environment and Forest vide its policy prohibits the removal of shark fins on board the vessels in the sea. The policy also prohibits possession of shark fins that are not naturally attached to the body of the shark. In addition, the Ministry of Commerce, Government of India has also prohibited the export of shark fins of all species of sharks.

Blue sharks are sporadically reported in the shark bycatch in the Indian tuna fishery. Data on the blue shark catch is recorded and furnished to the regulatory authority i.e IOTC as and when reported.

Sea birds

There were no reported instances of sea bird interactions in any of the Indian tuna fishery.

Marine turtles

All the five species of marine turtles occurring in the Indian waters are listed in the Schedule I of the Indian Wildlife (Protection) Act, 1972. The bycatch of sea turtles in the Indian longline fishery was low.

Marine mammals

Like marine turtles, all the marine mammal species occurring in the Indian waters are protected under the Wildlife (Protection) Act, 1972. Very recently a national project on "Marine Mammal Stock Assessment Programme" is undertaken by the Marine Product Export Development Authority, Fishery Survey of India and Central Marine Fishery Research Institute both in the coastal waters and also in the offshore waters (entire EEZ).

CONCLUSION

The present observation shows the landing pattern of the species occurring in the tuna fishery in India. Also the composition and distribution of the bycatch species are discussed here. The seasonal distribution pattern of various groups occurring in the tuna fishery is also shown here. This study will definitely help the researchers and entrepreneurs as well as the fishery managers for devising the desired policy for the management of bycatch in the Indian waters.

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Table. 1. Fishing fleet structure of India

Craft & Gear	Total
Mechanized	42,813
Motorized	99,421
Non-motorized	27,537
Total	1,69,771

Table. 2. Species composition in the tuna fishery in Indian EEZ during 2008-2019

GROUPS	SCIENTIFIC NAME	GROUPS	SCIENTIFIC NAME
OCEANIC TUNAS	*Thunnus albacares*	PELAGIC SHARKS	*Carcharhinus albimarginatus*
	Thunnus obesus		*Carcharhinus leucas*
	Katsuwonus pelamis		*Carcharhinus melanopterus*
NERETIC TUNAS	*Euthynnus affinis*		*Carcharhinus macloti*
	Auxis thazard		*Carcharhinus sorrah*
	Auxis rochei		*Carcharhinus amblyrhynchos*
	Thunnus tonggol		*Carcharhinus dussumieri*
MARLINS	*Makaira Mazara*		*Carcharhinus longimanus*
	Istiompax indica		*Carcharhinus brevipinna*
INDO PACIFIC SAILFISH	*Istiophorus platypterus*		*Carcharhinus falciformis*
SWORDFISH	*Xiphias gladius*		*Carcharhinus hemiodon*
DOLPHINFISH	*Coryphyaena hippurus*		*Galeocerdo cuvier*
SEERFISHES	*Acanthocybium solandri*		*Isurus oxyrinchus*
	Scomberomorus commerson		*Sphyrna lewini*
	Scomberomorus guttatus		*Sphyrna zygaena*
SICKLE POMFRET	*Taractichthys steindachneri*		*Triaenodon obesus*
TAPER-TAIL RIBBONFISH	*Zu elongatus*		*Loxodon macrorhinus*
BARRACUDAS	*Sphyraena jello*		*Prionace glauca*
	Sphyraena barracuda		*Alopias pelagicus*
ESCOLAR	*Lepidocybium flavobrunneum*		*Alopias supercilliosus*
OILFISH	*Ruvettus pretiosus*		*Alopias vulpinus*
SUNFISH	*Mola mola*	PELAGIC STINGRAY	*Pteroplatytrygon violacea*
COBIA	*Rachycentron canadum*		
LANCETFISH	*Alepisaurus ferox*		

Table. 3. Hooking rate (%) and catch rate (kg/1000hooks) of fishes recorded in the tuna long line survey in the Indian EEZ during 2009-2019

Groups	Area 51		Area 57		Total	
	HR	CR	HR	CR	HR	CR
Tunas	0.04	8.6	0.09	13.8	0.07	12.1
Billfishes	0.04	9.8	0.02	3.4	0.02	5.5
Elasmobranchs	0.08	11.0	0.06	12.9	0.07	12.3
Others	0.09	3.7	0.13	3.4	0.11	3.5
Total	0.25	33.1	0.29	33.5	0.28	33.3

Fig.1. Study area

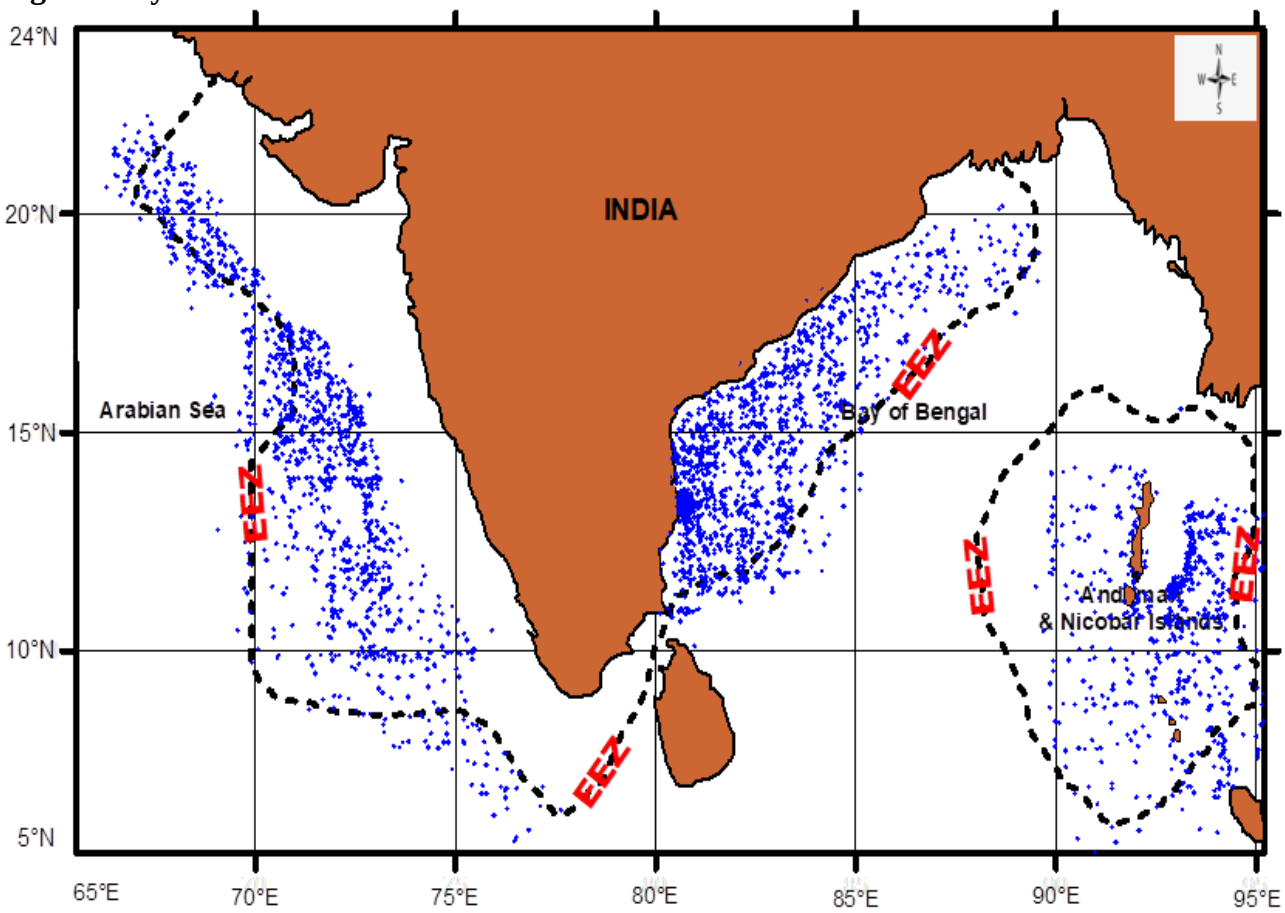

Fig. 2.Trend in catch(tonnes) of tuna and allied resources during 2008-19

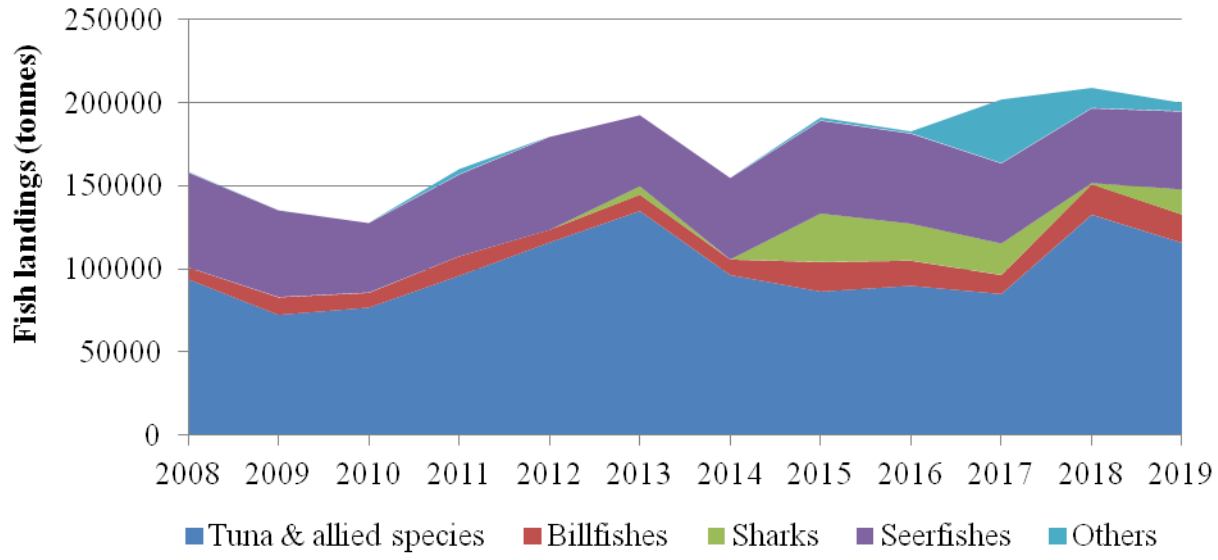

Fig.3.Trend in catch(kg) of tuna and allied resources in the exploratory surveys conducted during 2009-19

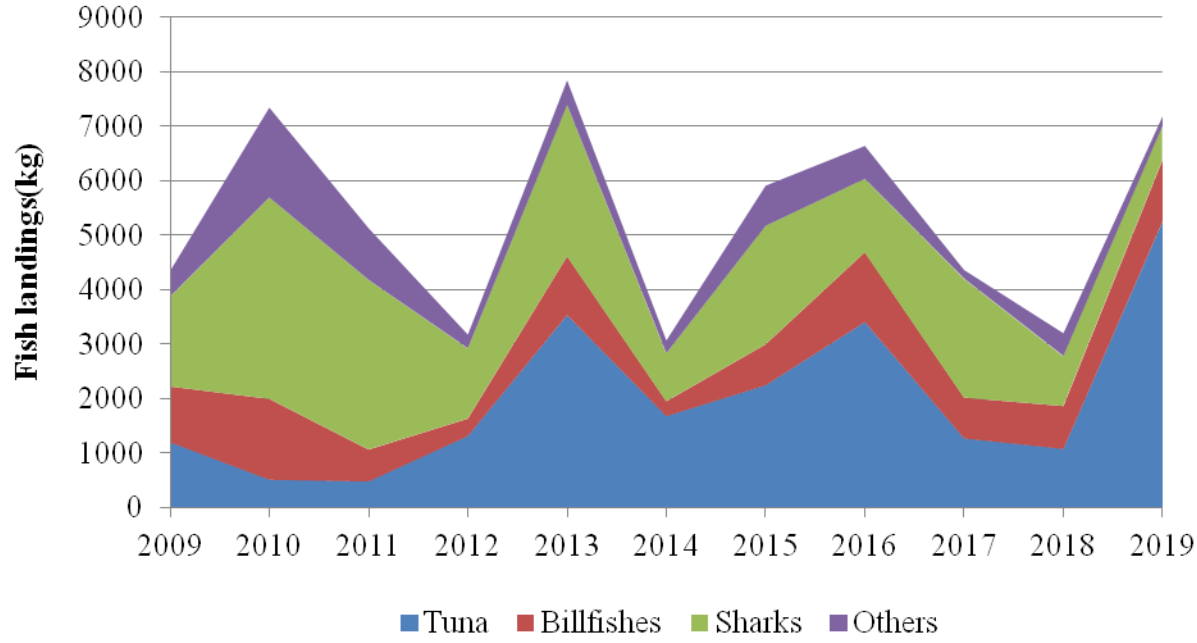

Fig.4.Perecentage of tuna & allied resources in Indian waters

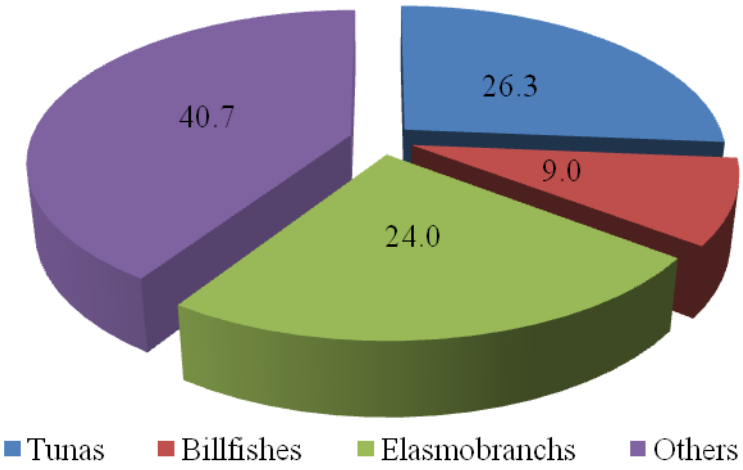

Fig.5. Tuna & allied resources in FAO area 51 & 57(% by number)

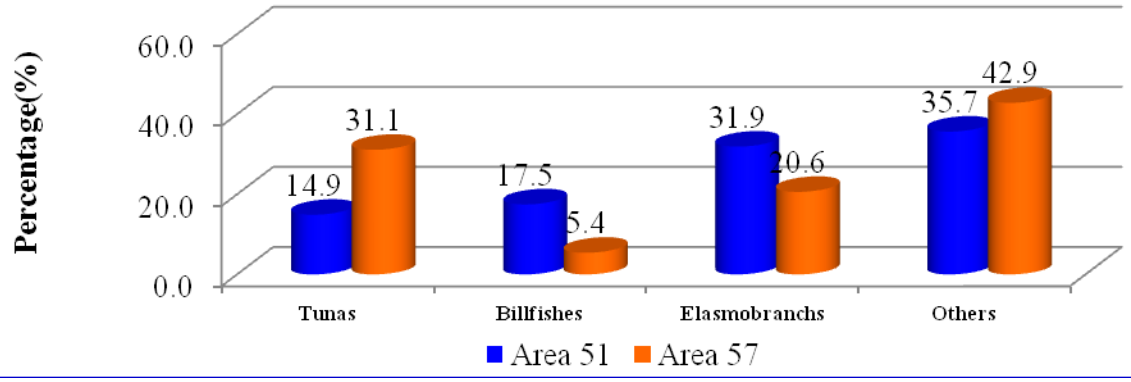

Fig.6.Tuna & allied resources in FAO area 51 & 57(% by weight)

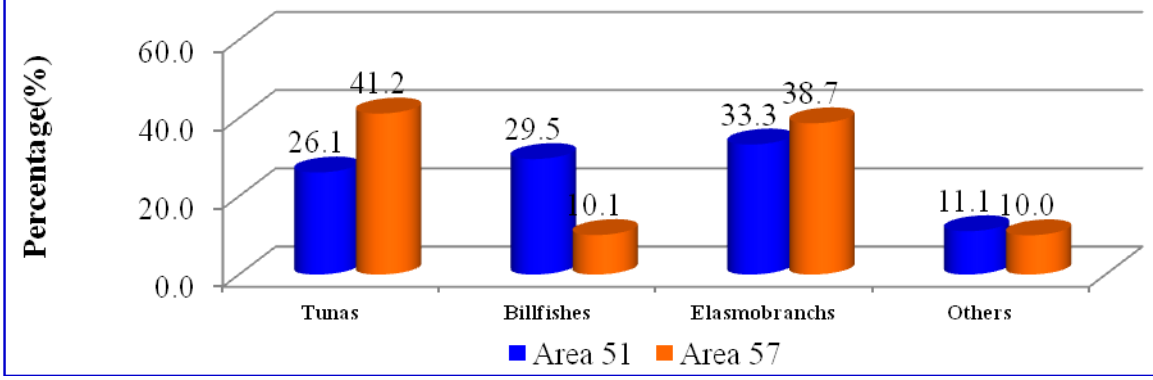

Fig.7. Hooking rate of tuna and bycatch during 2009-19 in the longline survey conducted in the Indian EEZ

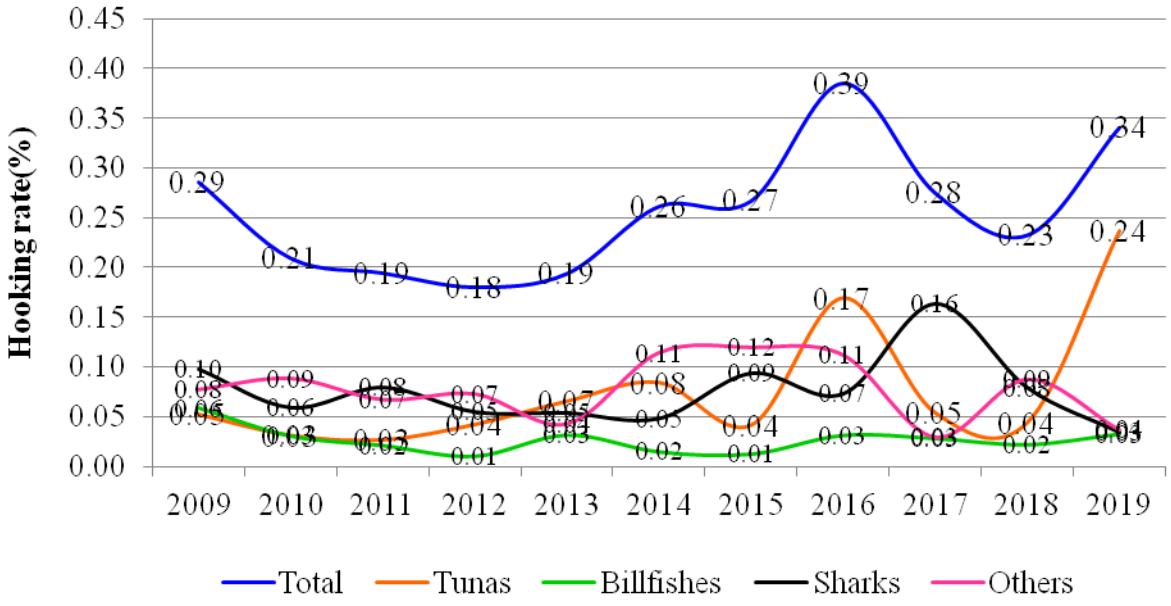

Fig.8.Seasonal variation of various groups in the tuna longline survey