
BYCATCH IN TUNA LONGLINE FISHERY IN THE INDIAN EEZ AROUND ANDAMAN AND NICOBAR ISLANDS

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ABSTRACT

During the exploratory surveys conducted by Fishery Survey of India around Andaman and Nicobar Islands several bycatch species were recorded along with the targeted species of tunas (*Thunnus albacares*, *Thunnus obesus* and *Katsuwonus pelamis*). Among these bill fishes, shark, barracuda, seer fish etc are common. Though the sharks are not the targeted species in the tuna long lining, they constitute a major share of the catch. The exploratory survey reported high hooking rate of pelagic sharks. The dominant species are of the family Alopiidae commonly called as thresher shark viz. *A. pelagicus*, *A. superciliosus* and *A. vulpinus*. The fishes caught by the longliner *M.F.V. Blue Marlin* during 2003-10 were analyzed for catch composition of tuna and the bycatch species, their distribution patterns, abundance, and certain biological aspects. A total of 30 different bycatch species from 12 families were recorded. The targeted species i.e tuna contributed 29% by numbers and 34% by weight where as bill fishes contributed 10% both by number and weight and shark contributed 38% and 54% by number and weight respectively. The aggregate hooking rate for all fishes during the survey period was found to be 0.60%. Among that the hooking rate of shark was found to be 0.23%. The male to female ratio for all the three species viz. *A. pelagicus*, *A. vulpinus* and *A. superciliosus* are found to be 1:0.6, 1:0.4 and 1:0.4 and the dominance was noticed at pre caudal length of 121-140 cm, 141-160 cm and 121-140 cm respectively. The food preference is mainly fishes followed by squids and octopus for all the three species i.e *A. pelagicus*, *A. superciliosus* and *A. vulpinus*.

(Key words: Bycatch, tuna longline, thresher shark, abundance indices, length– weight relationship, food and feeding habits).

Introduction

Pelagic longline is an important method of catching fish worldwide, targeting the oceanic resources such as tuna, bill fishes etc. Due to expansion of fishing activities it has been reported that more than two third of global fisheries being categorized as fully exploited, over exploited or depleted (Botsford et al, 1997). Another concern is the capture of non-targeted organisms that get hooked or entangled in fishing gear, and commonly referred to as bycatch. Sharks are more vulnerable in longline fisheries and worldwide attention is being

paid on the conservation of sharks. The Andaman & Nicobar groups of Islands are situated between lat.6° 45'N -13°41'E and Long.92°57' -93°57'E in the south east Bay of Bengal with a total of 572 islands among which 32 are inhabited. The EEZ of Andaman which is 0.6million Sq. Km is about 30% of the total Indian EEZ. During the exploratory survey conducted By FSI in the Indian EEZ around Andaman & Nicobar (A&N) during the period of 2003-10 a large number of bycatch species were reported. The bycatch species are sharks, bill fishes, barracuda, seer fish, dolphin fish etc. (Bhargava et al., 2007 & John et al., 2005). The pelagic sharks contribute substantially to the bycatches of A & N waters. The sharks are utilized mainly for human foods, ornamental and aesthetic purposes. The dominant species of sharks are of the family Alopiidae commonly called as thresher shark viz. *A. pelagicus*, *A. vulpinus* and *A. superciliosus*.

It is the important to develop this sector for exploiting the vast potential. The biological parameters of the sharks of the family Alopiidae is very little. As the sharks form an important bycatch of tuna longline, detailed study on the biology was felt necessary. In the present paper an attempt has been made to study the distribution pattern and abundance with reference to the hooking rate of the bycatches in tuna long line, catch composition of tuna and bycatch species and also some biological aspects of the species of shark of the family Alopiidae.

Material and Methods

The tuna long line survey data collected by the FSI survey vessel *MFV Blue Marlin* (OAL 35.76m, GRT 310 T) during the period of 2003-10 in the Indian EEZ around A&N Islands (**Fig.1**) are used in the present study. The data was analyzed to study the catch composition, abundance and distribution of bycatch species and also some biological aspects such as length frequency, length weight, sex ratio and food & feeding etc. of the three species of shark viz. *Alopias pelagicus*, *A. vulpinus* and *A. superciliosus*. The hooking rate (number of

specimen caught per 100 hooks) was used as an indicator of abundance as well as spatio-temporal variations in distribution. Length – weight relationship was calculated by the formula $W = a L^b$ (Le Cren, 1951), where ‘W’ is the weight in kg and ‘L’ is the pre caudal length in cm. Sexes were identified by the presence or absence of claspers. A total of 129 specimens of male and 83 specimens of female of *A. pelagicus*, 56 male specimens and 21 female specimens of *A. vulpinus* and 49 specimens of male and 21 specimens of female specimens of *A. superciliosus* were taken for length frequency, sex ratio and length weight studies. Food and feeding studies of the sharks were carried out by examining the gut contents by occurrence method (Pillai, 1952),

Results

Distribution and abundances of bycatches

Elasmobranches formed 7 % of the total catch and 21 % of the estimated potential for elasmobranches and pelagic shark resources of A & N. The landing data during the period 2003-10 is given in **Table 1**. The landings of elasmobranches fluctuated from 52 t to 2,336 t. During the survey period a total of 5, 22,992 nos. of hooks were deployed in 60 squares (1° Lat × 1° Longitude) in the EEZs around Andaman & Nicobar. The bycatches consisted of five species of bill fishes, two species of seer fish, seventeen species of shark, one species each of dolphin fish, barracuda, bigscale pomfret, escolar, oil fish and sun fish.(**Table 2**). During the survey period a total of 3,160 fishes weighing about 85,588 kg were caught of which 911 numbers of tuna, 311 nos of bill fish, 1,193 nos. of sharks and 745 nos. of other varieties were there (**Table 3**). The year wise percentage composition of tuna and the bycatch during the years 2003-10 are shown in **Fig. 2**. It could be seen that the share of bill fishes varied in between 5-21% whereas sharks contributed 31-42% and the other varieties 9-37% of the total catch by number. During the period of survey sharks contributed 38% by number and 54% by weight to the total catch whereas billfish contributed 10% both by number and

weight to the total catch and other varieties like barracuda, seer fish, dolphin fish, bigscale pomfret and escolars contributed 24% by number and 3% by weight to the total catch. The hooking rate of tuna, billfishes and sharks and others during the periods 2003-10 is shown in **Fig. 3**. The average hooking rate of tuna varied from 0.05 to 0.50%. Similarly the hooking rate of billfish varied from 0.03-0.12% and the hooking rate of shark was from 0.11-0.45%. The other species together registered a hooking rate of 0.18 to 0.29%. The billfish catch showed a steady growth while a decline in catch was noted in respect of tuna and shark during the period of survey. The combined hooking rate of all the bycatch species was more than the targeted species (i.e yellowfin tuna, bigeye tuna and skipjack tuna). The month-wise variations of tuna and bycatches are shown in the **Fig. 4**. It could be seen that among the bycatches the hooking rate of billfishes was more during the month of June (0.13%) followed by April. Dominance of shark was noticed during the month of December (0.33%) followed by June (0.28%). The hooking rate of the other varieties varied from 0.05% to 0.18%.

The spatial abundance in 1°Lat× 1°Long of all fishes, billfishes, sharks and others is shown in **Fig. 5**. The billfishes were abundant in the square 7°N-91°N(0.44%) followed by 11°N-90°E(0.19%). The sharks were dominant in the square 9°N-92°E(0.63%) followed by 8°N-92°E (0.55%) and the other varieties were dominant in the square 8°N-92°E(0.74%) followed by 11°N-90°E (0.31%). During the survey period a total of 1193 sharks weighing about 46,436 Kg were recorded.

Length Frequency:

Among the sharks the mean pre-caudal length for the male *A. pelagicus* was 136.4 cm, with a mean weight of 39.6 kg and for the female the mean pre-caudal length was 127.4 cm and mean weight was 36.1 kg (**Table 4**). Similarly for the species *A. vulpinus* male the mean pre-caudal length was 133.5 cm and mean weight was 42.2 kg and for the female it was

122.7 cm and 40.8 kg. The mean pre-caudal length of male species of *A. superciliosus* is 139.8 cm and mean weight 44.7 kg and for the female species it was 151.7 cm and weight 62.1 kg.

The length frequency distribution of the species *A. pelagicus*, *A. vulpinus*, and *A. superciliosus* showed larger size of male in the population (**Table 5**). The dominant length range for *A. pelagicus*(both male and female) was in the range of 121-140 cm. For *A. vulpinus* male and female the abundance was noticed in the size range 141 to 160 cm followed by 121-140 cm. In the case of *A. superciliosus* the dominant length ranges for both male and female was 121-140 cm followed by 141-160 cm.

Sex Ratio

The sex ratio of the three species of thresher sharks is given in the **Table 6**. The male to female ratio for the species *A. pelagicus* is 1:0.6, for *A. vulpinus* as well as *A. superciliosus* it was 1:0.4.

Length-Weight

The length-weight relationship obtained for the pooled data (both male and female) for the three species are as follows.

$$A. \textit{Pelagicus}- \quad W = 0.00002 L^{3.01} (r = 0.96)$$

$$A. \textit{Vulpinus}- \quad W = 0.00569 L^{1.82} (r = 0.91)$$

$$A. \textit{Superciliosus}- \quad W = 0.00013L^{2.58} (r = 0.93)$$

The a, b and r values for both the sexes and pooled data for the three species of thresher sharks are given in the **Table 7**.

Food and feeding

The food and feeding analysis was carried out with 214 stomachs of *A. pelagicus*, 75 species of *A. vulpinus* and 69 species of *A. superciliosus*. It was observed that 34% guts of male and 39% guts of female of the species *A. pelagicus* were found to be empty. Similarly 37% male guts & 31% of female guts of the species *A. vulpinus* were found to be empty. In the case of *A. superciliosus* 36% of male guts and 29% of the female guts were found to be empty. The male of the species *A. pelagicus* showed preference to squids and octopus (44%) and teleost fishes (31%) while semi-digested fish matter formed about 25% (**Fig. 6**).

The preferred food items of female *A. pelagicus* were squid and octopus (34%), teleost fishes (27%), euphausiids (19%), fish larvae (4%), and semi-digested fish matter (16%). The teleost fish included fishes of the family *paralepididae*, *gempylidae*, *leognathidae*, *cluepidae*, and *scombridae* (**Fig.7**).

The gut contents of male *A. vulpinus* were squid and octopus (28%), teleost fish (53%), semi-digested fish matter (16%), and euphausiids (3%)(**Fig.8**). The food items in the guts of the female of *A. vulpinus* were squid and octopus (12%), other teleost fishes (65%), semi-digested fish matter (6%) and euphausiids (17%)(**Fig.9**). The food items in the guts of of *A. superciliosus* were squid and octopus (25%), teleost fish(59%) and semi digested fish matter (16%)(**Fig.10**). whereas the gut content of female specimens showed squid and octopus(11%), teleost fish(67%) and semi digested fish(22%)(**Fig.11**).

Discussion

John and Somvanshi (2000) reported on the distribution and seasonality of sharks and species composition and length frequencies of predominant species occurring in Andaman and Nicobar waters. Presence of bycatch species such as bill fishes, sharks and other varieties

like barracuda and seer fish in longline fishery for tuna indicated abundance of shark species in A & N waters. The pelagic sharks as well as the demersal stock within 30 m was estimated as 11,200 t (John et al, 2005) but the landing figure shows that the annual landings of elasmobranches and pelagic sharks during the year 2003-2010 fluctuated between 52 t to 2336 t (Anon, 2011). This forms only 21% of the pelagic as well as demersal shark potential and 7% of the total landings of A & N. Hence there is ample scope for the optimum exploitation of the shark resources. Sharks constituted 24.18% by number and 29.82% by weight to the total catch from the Bay of Bengal during 2005-06(Varghese et al, 2007) .Sinha et al (2010) reported the percentage of sharks as 41.58% by number and 56.56% by weight from Andaman waters and 14 species of sharks of 4 families including Alopiidae . In the present study also similar results are obtained and shark contributed 38% and 54% by number and weight respectively. During the period 17 species from 7 genera and 4 different families were recorded. 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). In the present study also similar results were obtained and an aggregate hooking rate of 0.60% was recorded for all fishes out of which shark hooking rate was 0.23%.

Bhargava et al (2002) reported a hooking rate of 1.10% for sharks for the period 1983 to 1989 in A&N waters. The month wise variation showed the maximum hooking rate of 0.68% was during the month of October followed by March, December, and November where as the period from May to September is the lean period for sharks. Similar results are also reported by John and Somvanshi (2000).In the present study also similar result is obtained and highest hooking rate obtained was during the month of December followed by

June. The shark catch has steadily increasing from the month of September to March and during the month of December it reached the maximum. This clearly indicates that the period from September to March is the best fishing season for sharks in A & N waters. The annual variation showed that the year 2005 is more productive in terms of shark catch followed by the year 2007.

Sinha et al 2010 reported that the hooking rate of sharks is more in Nicobar waters i.e. more than 1%. The pre caudal length range, mean length and mean weight for the species *A. pelagicus*, *A. vulpinus*, and *A. superciliosus* showed was 53-191 cm, 134.55 cm, and 36.60 kg for *A. pelagicus*, 52-186 cm, 141.22 cm and 40.01 kg for *A. superciliosus*, and 80-175 cm, 137.76 cm, and 36.51 kg for *A. vulpinus*. It shows the pre caudal length of 121-140 cm class interval was dominant for both *A. pelagicus* as well as *A. superciliosus* and 141-180 cm class interval was dominant for *A. vulpinus*. In the present study the hooking rate was also found to be more in Nicobar waters (9 °N/ 92 °E and 8 °N/92 °E) and it could be seen that 121 to 140 cm size range was found to be dominant for *A. pelagicus* and *A. superciliosus* and 141 to 160 cm range was dominant for *A. vulpinus*. In the present observation the mean length and mean weight were 136.4 cm, 39.6 kg, 127.4 cm, and 36.1 kg for male and female of *A. pelagicus*. For *A. vulpinus* it was 133.5 cm, 42.2 kg, for male and 122.7 cm and 40.8 kg for female. For *A. superciliosus* it was 139.8 cm, 44.7 kg for male and 151.7 cm and 62.1 kg for female. From the study it could be inferred that the female specimens of *A. pelagicus* and *A. vulpinus* are smaller than the respective male specimens where as the female specimens of *A. superciliosus* are larger than the male specimens.

The male to female ratio was found to be 1:0.5 for *A. pelagicus*, 1:0.7 for *A. superciliosus*, and 1:2.1 for *A. vulpinus* in Andaman and Nicobar waters (Sinha et al 2010). In the present study, the sex ratio (M:F) obtained was 1:0.6 for *A. pelagicus* 1:0.4 for *A. vulpinus* and 1:0.4 for *A. superciliosus*.

The length weight study for some species such as *Scoliodon laticaudus*, *Carcharhinus limbatus*, and *Rhizoprionodon acutus* was made by Kasim 1991, Kulkarni 1988, and Karim 1991 respectively in the West Coast of India. But the data on the length weight relationship of the thresher sharks in A & N waters is lacking. In the present study it could be seen that the length-weight relationship (pooled data) for *A. pelagicus* was $W=0.00002L^{3.01}$, $r=0.96$, for *A. vulpinus* it was $W=0.00569L^{1.82}$, $r=0.91$, and for *A. superciliosus* it was $W=0.00013L^{2.58}$, $r=0.93$. Majority of the sharks have specific feeding habits and actively hunt their preferred prey in the pelagic and column waters. The grey sharks like *C. limbatus*, *C. sorrah* preferred pelagic fishes like mackerels and sardines (Devadoss 1977 a). Thresher sharks like *Alopias* sp. uses its long caudal fin for herding and stunning the prey before swallowing it (Devadoss, 2000). *C. plumbeus* prefers fish, crustacean, squid, octopus, and cuttle fish, and prefers fresh fish bait than stale or frozen fish (Campagno, 1984).

In the present study it could be seen that the preferred food items of the thresher sharks were squid, octopus, other teleost fishes such as *parallepids*, *gempylids*, *leognathids*, sardines, mackerels, and zoo planktons such as euphausiids and fish larvae, etc.

The bycatch species such as bill fish and sharks contributes 9.8% and 37.8% to the total landings. Among the sharks the species caught in the A & N waters mostly come under the genus *Carcharhinus* and *Alopias* and the hooking rate obtained from the species of *Alopias* is encouraging.

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Table 1. Elasmobranches landings in Andaman and Nicobar Islands.

Year(s)	Total landings(kg)	Elasmobranches landings(kg)
2003-04	31058	329
2004-05	17765	257
2005-06	12053	52
2006-07	28600	1214
2007-08	28855	1222
2008-09	32335	1299
2009-10	33000	2336

• Directorate of Fisheries, A & N Administration.

Table 2. Bycatch species recorded in Andaman and Nicobar waters during 2003-10

FAMILY	GENUS	SCIENTIFIC NAME	ENGLISH NAME
ISTIOPHORIDAE	<i>Makaira</i>	<i>Makaira mazara</i>	Blue Marlin
		<i>Makaira indica</i>	Black Marlin
	<i>Tetrapterus</i>	<i>Tetrapterus audax</i>	Stripped Marlin
	<i>Istiophorus</i>	<i>Istiophorus platypterus</i>	Sail Fish
XIPHIDAE	<i>Xiphias</i>	<i>Xiphias gladius</i>	Sword Fish
CORYPHAENIDAE	<i>Coryphaena</i>	<i>Coryphaena hippurus</i>	Dolphin Fish
SCOMBRIDAE	<i>Acanthocybium</i>	<i>Acanthocybium solandri</i>	Wahoo
	<i>Scomberomorus</i>	<i>Scomberomorus commerson</i>	Narrow- Barred Spanish Mackerel
SPHYRAENIDAE	<i>Sphyrna</i>	<i>Sphyrna jello</i>	Barracuda
CARCHARHINIDAE	<i>Galeocerdo</i>	<i>Galeocerdo cuvier</i>	Tiger Shark
	<i>Rhizoprionodon</i>	<i>Rhizoprionodon acutus</i>	Milk Shark
	<i>Scoliodon</i>	<i>Scoliodon laticaudus</i>	Spade Nose Shark
	<i>Carcharhinus</i>	<i>Carcharhinus limbatus</i>	Black Tip Shark
		<i>Carcharhinus albimarginatus</i>	Silvertip Shark
		<i>Carcharhinus amblyrhyncos</i>	Grey Reef Shark
		<i>Carcharhinus melanopterus</i>	Black Tip Reef Shark
		<i>Carcharhinus macloti</i>	Hard Nose Shark
		<i>Carcharhinus sorrah</i>	Spot Tail Shark
		<i>Carcharhinus longimanus</i>	Oceanic White Tip Shark
LAMNIDAE	<i>Isurus</i>	<i>Isurus oxyrinchus</i>	Short Fin Mako Shark
SPHYRNIDAE	<i>Sphyrna</i>	<i>Sphyrna zygaena</i>	Round Headed Hammerhead Shark
		<i>Sphyrna lewini</i>	Scalloped Hammerhead
		<i>Sphyrna mokarran</i>	Great Hammerhead
ALOPIDAE	<i>Alopias</i>	<i>Alopias pelagicus</i>	Pelagic Thresher Shark
		<i>Alopias superciliosus</i>	Bigeye Thresher Shark
		<i>Alopias vulpinus</i>	Thresher Shark
BRAMMIDAE	<i>Taractichthys</i>	<i>Taractichthys longipinnis</i>	Big Scale Pomfret
GEMPYLIDAE	<i>Lepidocybium</i>	<i>Lepidocybium flavobrunneum</i>	Escolar
	<i>Ruvettus</i>	<i>Ruvettus pretiosus</i>	Oil Fish
MOLIDAE	<i>Mola</i>	<i>Mola mola</i>	Sun Fish

Table 3. Percentage of catch composition (number and weight) of fishes caught onboard MFV Blue Marlin during 2003-10.

Groups	Total Effort (Number of hooks)	Total Numbers	Hooking rate (%)	Percentage	Total weight	Percentage
Tuna	5,22,992	911	0.17	28.80	29,162	33.90
Bill fishes		311	0.06	9.80	8,213	9.50
Sharks		1193	0.23	37.80	46,436	53.90
Others		745	0.14	23.60	1,777	2.70
		3160	0.60	100.00	85,588	100.00

Table 4. Sex wise details of morphometrics of three species of thresher sharks occurring in Andaman and Nicobar waters.

Species	Sex	Pre-caudal length range (cm)	Weight Range (kg)	Mean Length(cm)	Mean Weight(kg)
<i>A.pelagicus</i>	Male	50-165	2-60	136.4	39.6
	Female	53-165	2-70	127.4	36.1
<i>A.vulpinus</i>	Male	100-175	15-61	133.5	42.2
	Female	85-163	13-70	122.7	40.8
<i>A.superciliosus</i>	Male	88-170	20-75	139.8	44.7
	Female	102-205	20-110	151.7	62.1

Table 5. length frequency distribution (%) of *Alopias pelagicus*, *A vulpinus* , *A superciliosus* and in Andaman and Nicobar waters.

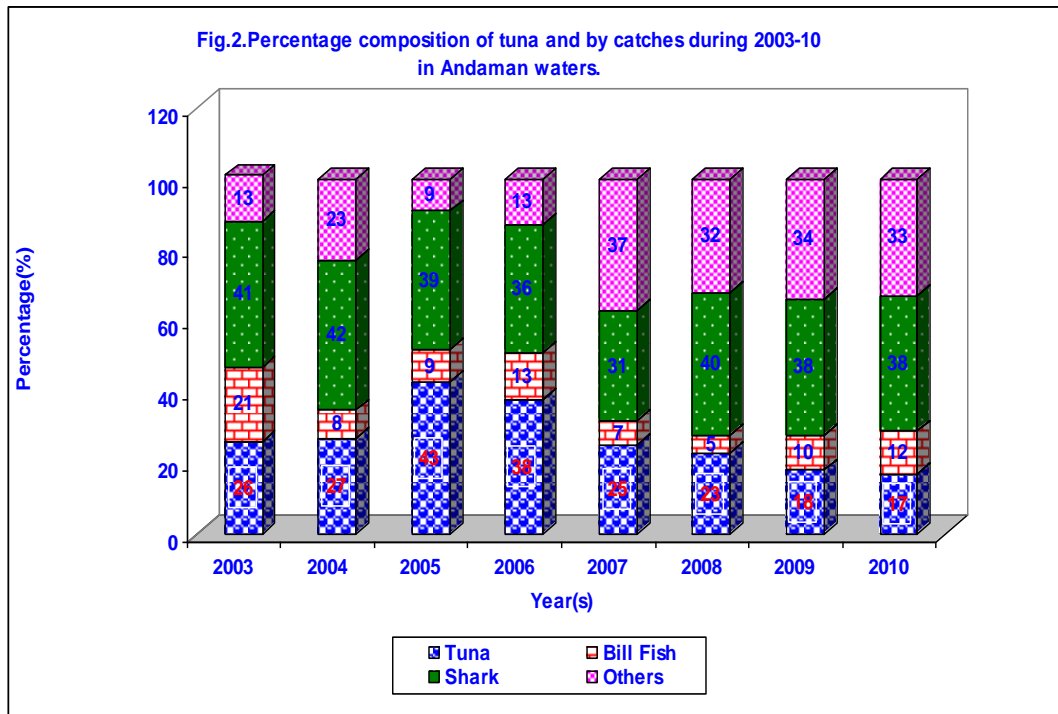
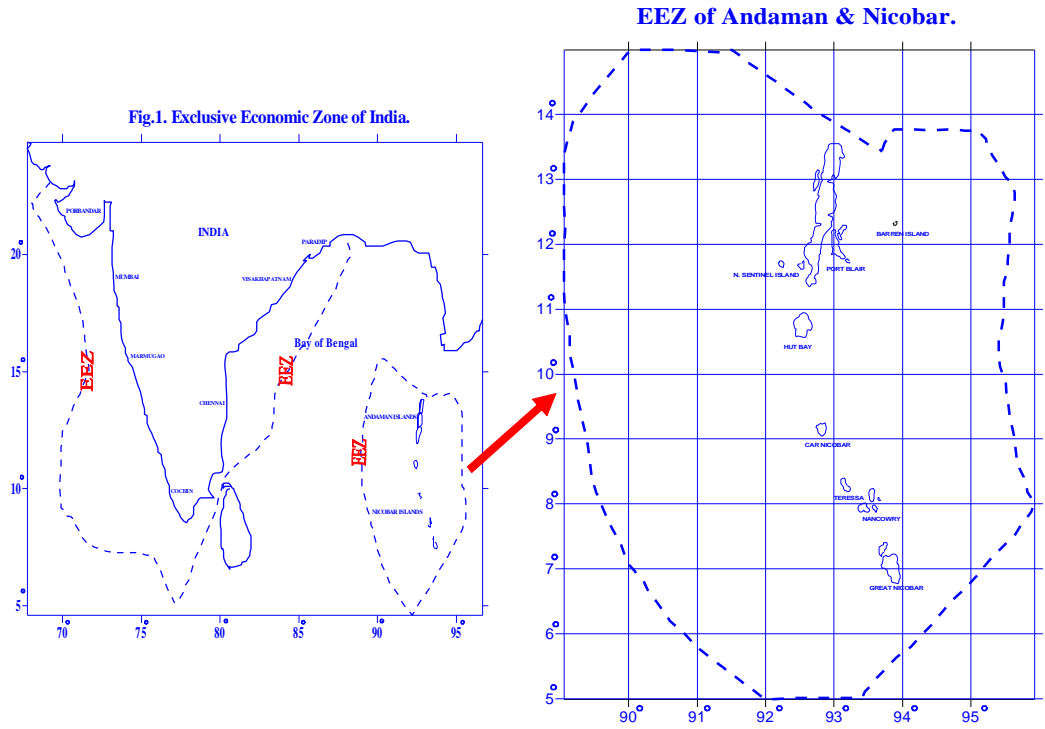
Pre caudal length(cm)	<i>Alopias pelagicus</i>		<i>Alopias vulpinus</i>		<i>Alopias superciliosus</i>	
	Male	Female	Male	Female	Male	Female
41-60	1	1	--	--	--	--
61-80	1	1	--	--	--	--
81-100	--	6	2	5	5	5
101-120	9	22	12	5	5	15
121-140	56	45	23	19	63	38
141-160	32	24	51	42	25	33
161-180	1	1	12	29	2	5
181-200	--	--				5
201-220	--	--				4

Table 6. Size wise sex ratio of *Alopias pelagicus*, *A. vulpinus* and *A. superciliosus* (male: female) in Andaman and Nicobar waters

Pre caudal length(cm)	<i>A. pelagicus</i>	<i>A. vulpinus</i>	<i>A. superciliosus</i>
41-60	1:1	--	--
61-80	1:1	--	--
81-100	--	1:1	1:0.3
101-120	1:1.6	1:0.2	1:1
121-140	1:0.5	1:0.4	1:0.2
141-160	1:0.5	1:0.3	1:0.6
161-180	1:1	1:1.2	1:1
181-200	--	--	--
201-220	--	--	--
TOTAL	1:0.6	1:0.4	1:0.4

Table 7. Length weight relationship (a, b and r value) of *A. pelagicus*, *A. vulpinus* and *A. superciliosus* recorded in the Andaman and Nicobar waters.

Species		a	b	r
<i>Alopias pelagicus</i>	Male	0.00003	2.85	0.94
	Female	0.00001	3.17	0.96
	Pooled	0.00002	3.01	0.96
<i>A. vulpinus</i>	Male	0.0134	1.64	0.92
	Female	0.00208	2.03	0.92
	Pooled	0.00569	1.82	0.91
<i>A. superciliosus</i>	Male	0.0026	2.42	0.94
	Female	0.00013	2.6	0.93
	Pooled	0.00013	2.58	0.93



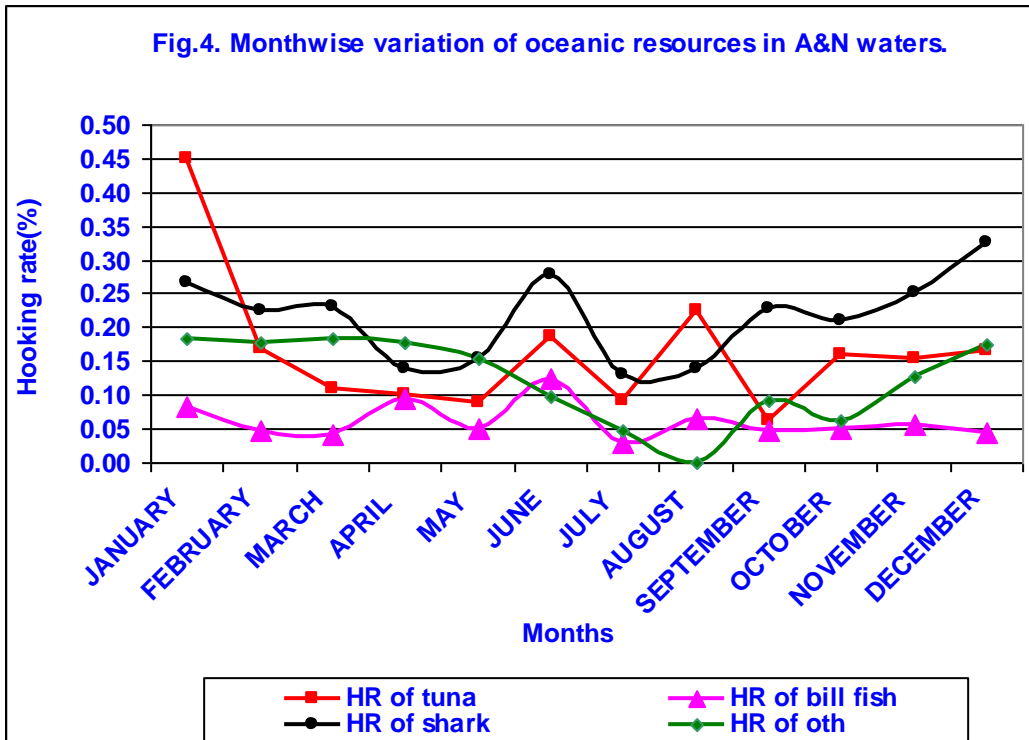
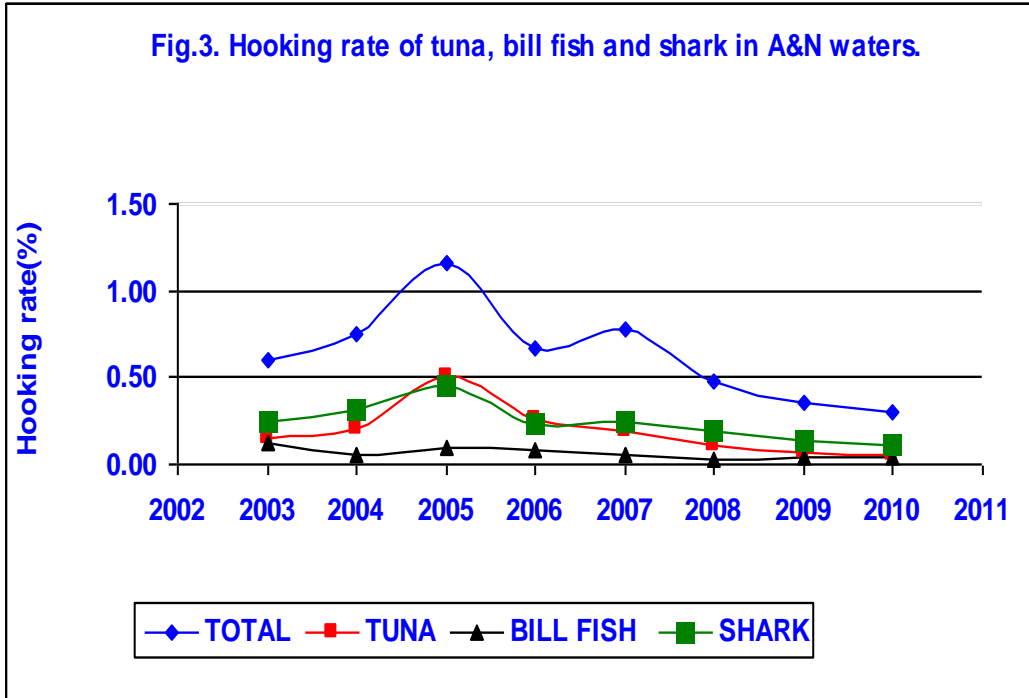


Fig.5. Abundance Indices(hooking rate in %) in 1° lat x 1° Long of all fishes bill fishes, sharks and others during 2003-10.

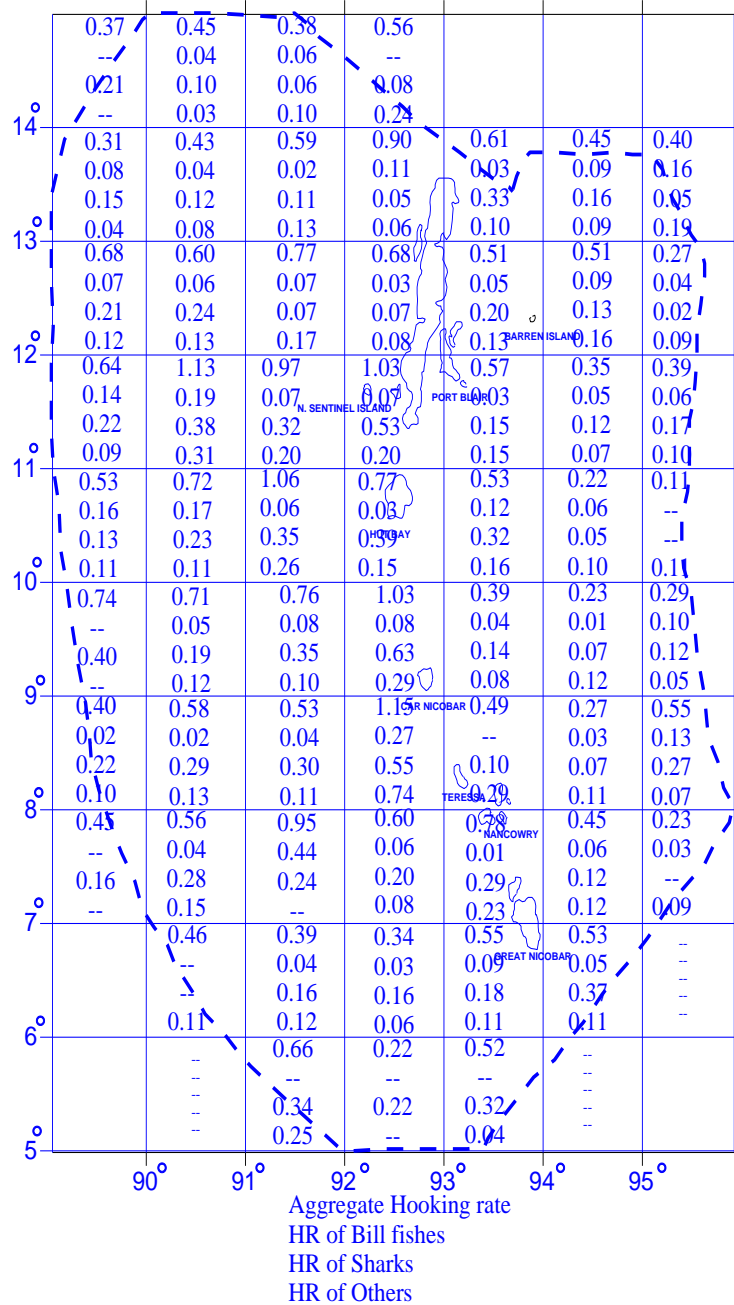


Fig.6. Dietary composition of *A. pelagicus*(male)

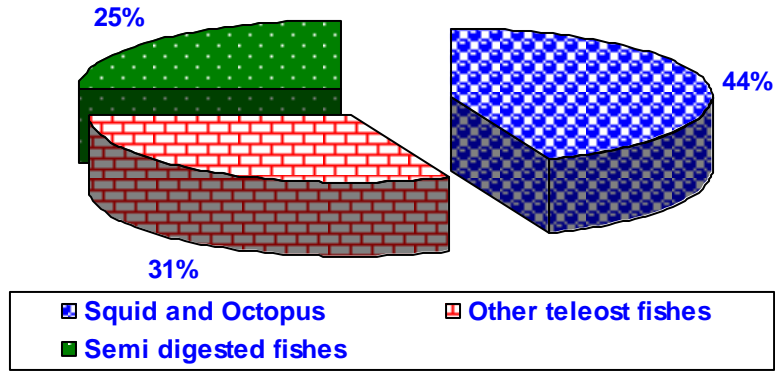


Fig.7. Dietary composition of *A. pelagicus*(female)

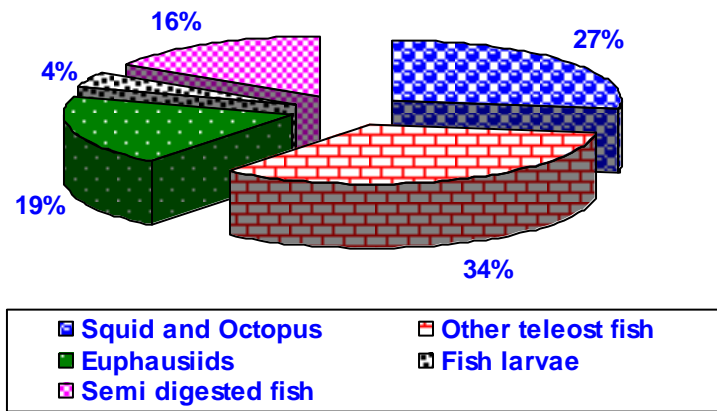


Fig. 8. Dietary composition of *A. vulpinus*(male)

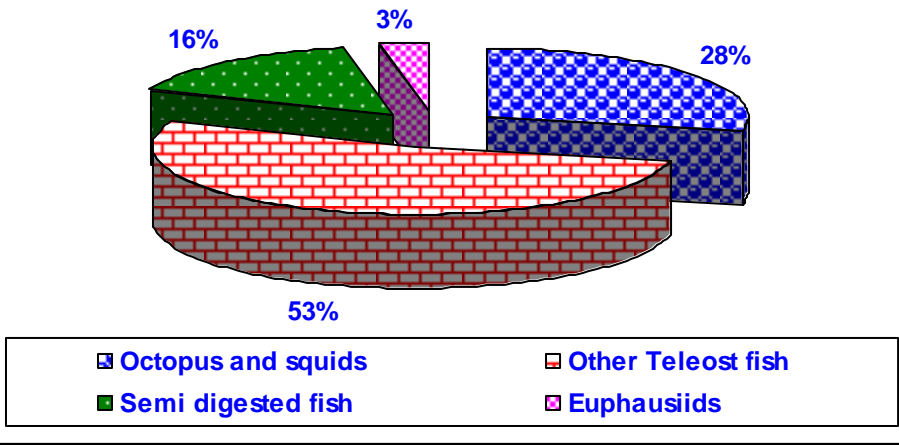


Fig.9. Dietary composition of *A. vulpinus*(female)

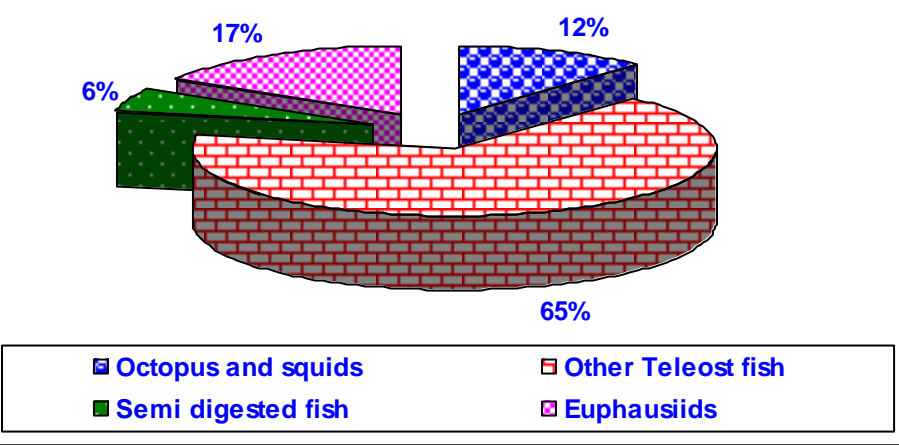


Fig.10. Dietary composition of *A. superciliosus*(male)

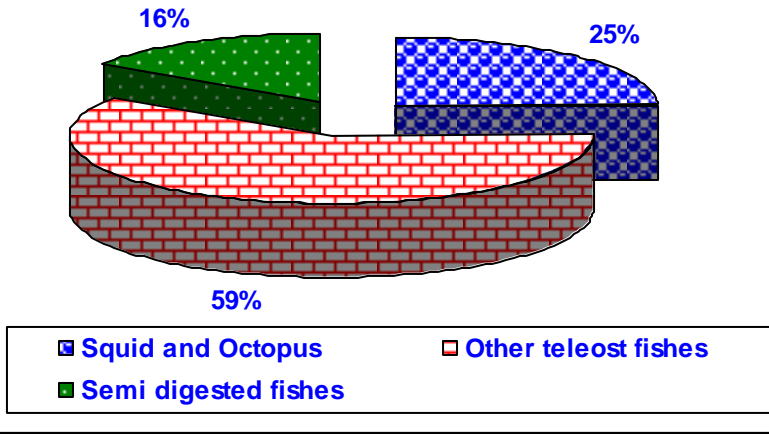


Fig.11. Dietary composition of *A. superciliosus*(female)

