Effect of Lunar Cycle and Monsoon on Abundance of Pelagic Sharks around Andaman and Nicobar Islands

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Abstract

High demand and lucrative value of shark products like shark fin has resulted in an increase in the number of sharks caught worldwide. Pelagic sharks form a major bycatch of tuna longline fishery. The present study attempts to understand the abundance of pelagic sharks in time and space scale around the Andaman and Nicobar Islands. The exploratory tuna longline survey data are fitted using the generalised linear model. The results indicate a significant effect of lunar cycle as well as monsoon on the catch rate of pelagic sharks. The highest catch rates were recorded during new moon period.

Keywords: Lunar cycle, monsoon, pelagic sharks, Andaman & Nicobar islands

Introduction

Shark fishery worldwide has developed since 1980s due to the increased demand from the shark-fin soup industry which has resulted in an increase in the number of sharks caught worldwide. Mean annual shark catches in the EEZs during 2000 - 2009 was 567 787 t and India with 60 609 t tops the list of shark landing nations of the world (Biery et al., 2011). Huge bycatch of sharks from the high sea pelagic fishery, driven by the longline fleets form a major share of the shark landings. In India, especially in Andaman and Nicobar Islands (A & N Islands), shark landings are mainly from the high sea pelagic fisheries. Though India tops the shark landing nations, less information is available on the dynamics of shark fishery in the country.

Sharks act as an ecologically important apex predator of the marine ecosystem (Camhi et al., 2009). Hence, changes in physical, chemical and environmental parameters in the ecosystem have an impact on abundance of the top predator. Pyle et al. (1996) inferred that sea surface temperature, upwelling and lunar illumination likely affect shark behaviour. Although Bigelow et al. (1999) and Poisson et al. (2010) reported that there was no significant lunar effect on the catch rate of blue shark (*Prionace glauca*) they opined that the studies on the effect of lunar illumination on shark catches were rare.

Some vital information on the effect of environment on the abundance of pelagic sharks is available (Damalas et al., 2010; Cao et al., 2011; Carvalho et al., 2011; Bromhead et al., 2012; Rohner et al., 2013). Preliminary information on the spatial variation and seasonality of shark abundance in India was given by John & Somvanshi (2000), John et al. (2005) and Somvanshi et al. (2008).

Information on the factors that affect the distribution and abundance of pelagic sharks is vital in deciding the exploitation strategy. Moreover, the key information on the spatial-temporal distribution of stock can be utilized for deriving management measures and thereby to ensure sustainable exploitation. The present study attempts to understand the effects of spatial difference, monsoon and lunar cycle on pelagic sharks occurring in the Andaman and Nicobar waters.

Materials and Methods

The tuna longline survey vessel, M.V. Blue Marlin (36 m L_{OA}), attached to the Fishery Survey of India (FSI), Port Blair, does exploratory resource survey around A&N Islands. Resource survey data col-

lected by the vessel from January 2006 to December 2008 was the source of this study. Three hundred and two sets of polyester multifilament tuna long line gear (main line 6.7 mm dia and branch line 4.5 mm dia) with five 3.6 sun tuna hooks per basket were operated around the A & N Islands between the Latitudes (Lat.) 06^0N and 14^0N. Each set with 125 baskets was normally shot in the morning before sun rise and hauled in after five to six hours of soaking. A total of 182 235 hooks were operated during the study period. Frozen mackerels and sardines were used as baitfish. Pelagic sharks caught by the gear were identified up to species level by using standard references (Fisher & Whitehead, 1974; Compagno, 2001) and the number of specimens per species caught was recorded separately for further calculations. Catch per unit effort (CPUE) was estimated in catch rate as number of fishes caught (successful hooks) per 1000 hooks. Spatial (geographical) variations of the catch were estimated by determining aggregate catch rate of fishes caught from each 1^0 Lat.

Effect of monsoon on pelagic sharks was estimated by grouping aggregate month-wise catch rates into pre-monsoon (January to April), monsoon (May to August) and post- monsoon (September to December) periods according to Sajeevan & Rajashree (2012). Lunar periodicity in each month, mined from the Indian tide tables 2006 to 2008 (GOI, 2005, 2006, 2007) were pooled into three periods according to the lunar phase as new moon period, waxing & waning period and full moon period. New moon period refers to new moon day ±3 days, full moon period refers to full moon day ±3 days and the days between these two periods were pooled as the waxing & waning period. Aggregated catch rates recorded during these lunar phases in each season and year was separately estimated to evaluate the lunar cycle effect on the catch rate.

During the study period the survey vessel normally commenced its fishing operation around tenth of every month. This operational pattern and non-operation of vessel during some of the days due to various intrinsic reasons resulted in missing data during one lunar period. Missing plot technique (Rangaswamy, 1995) was utilized to find out these values. Generalised Linear Model (GLM) was used to analyze the effect of lunar cycle and monsoon on the catch rates of pelagic sharks using the SYSTAT-13 software. The model fitted by using catch rate as dependant variable and year (three levels), monsoon

(three levels) and lunar cycle (three levels) as independent variables. Standard statistical procedures (Courtney et al., 1996; McDonald, 2009) were also employed for the analysis.

Results and Discussion

Pelagic sharks, which form the major bycatch in tuna longline fisheries, dominated the total catch. A total of 462 pelagic sharks were caught during the study and they constituted 34% of the total fishes by number. Out of total 27 species of fishes hooked, 15 species were sharks (Table 1). Families Carcharhinidae (three genus and eleven species), Alopiidae (one genus and three species) and Lamnidae (one species) were recorded. This phenomenon of dominance of pelagic sharks over tunas in species composition of the total catch was earlier reported by John & Somvanshi (2000), John et al. (2005) and Somvanshi et al. (2008). This is an indication of the richness of shark species and its abundance around A & N Islands. A shark fishery particularly for the shark fin, exists to tap these resources around A & N Islands (Sajeevan & Rajashree, 2012).

An aggregated catch rate of 2.52 individuals per thousand hooks was recorded for sharks. In the latitudinal scale, better catch rates were recorded from the area between Lat. 08^0 N and 12^0 N with maximum catch rate from the Lat. 09^0 N followed by 11^0 N (Table 2). Year wise aggregate catch rate during the study period is furnished in Table 3. Catch rate recorded during the period though showed an increase during 2007 reduced to the lowest during 2008. Aggregated catch rate of pelagic sharks recorded during the present study (2.52) was less than the catch rates (3.40 to 10.6) recorded earlier (John & Somvanshi, 2000; John et al., 2005; Somvanshi et al., 2008). As these catch rates are based on the resource survey carried out in the same area, the results can be compared. Hence it can be inferred that catch rates have decreased since 1989. Present study too recorded a decreasing trend of catch rate during the study period. An in-depth and long term study to find out the various reasons for this decrease in catch rate and necessary management measures for ensuring sustainability of the stock are necessary.

Aggregated catch rates recorded during different seasons are summarized in Table 3. Substantially lower aggregated catch rates were recorded during

Table 1. Checklist of fishes caught in long line around Andaman and Nicobar Islands during 2006 to 2008

Sl. No.	Name of Class / Sub class /Order/Famiy/ Species
	Class Chondrichthyes; Sub class Elasmobranchii; Order Carcharhiniformes
I	Family Carcharhinidae
1	Oceanic whitetip shark, *Carcharhinus longimanus* (Poey 1861)
2	Silvertip shark, *Carcharhinus albimarginatus* (Ruppel 1837)
3	Whitecheek shark, *Carcharhinus dussumieri* (Valencieness in Muller & Henle 1839)
4	Spottail shark, *Carcharhinus sorrah* (Valencieness in Muller & Henle 1839)
5	Blacktip reef shark, *Carcharhinus melanopterus* (Quay & Gaimard 1824)
6	Hardnose shark, *Carcharhinus macloti* (Muller & Henle 1839)
7	Blacktip shark, *Carcharhinus limbatus* (Valencieness in Muller & Henle 1839)
8	Tiger shark, *Galeocerdo cuvieri* (Peron &Le Sueur in Le Sueur 1822)
9	Scalloped hammerhead shark, *Sphyrna lewini* (Griffith & Smith in Cuvier, Griffith & Smith 1834)
10	Great hammerhead shark, *Sphyrna mokarran* (Ruppel 1837)
11	Smooth hammerhead shark, *Sphyrna zygaena* (L. 1758)
II	Order Lamniformes; Family Alopiidae
12	Thresher shark, *Alopias* vulpinus (Bonnaterre 1788)
13	Pelagic thresher shark, *Alopias pelagicus* (Nakamura 1936)
14	Bigeye thresher shark, *Alopias superciliousus* (Lowe 1839)
III	Family Lamnidae
15	Shortfin mako shark, *Isurus oxyrinchus (*Rafinesue 1810)

monsoon period while catch rates during post and pre monsoon periods were almost equal. John & Somvanshi (2000), John et al. (2005) and Somvanshi et al. (2008) reported better catch rates during, October, November and January. Generalised linear model established in the present study categorically proved that the catch rates recorded during monsoon are significantly different from that of pre monsoon and post monsoon catch rates (p<0.01). Hence it can be inferred that monsoon plays a major role on the catch rates of pelagic sharks.

Catch rates of pelagic sharks were more during new moon days, followed by waxing & waning period (Table 3). Lower catch rates were obtained during full moon period and there was a decreasing trend of catch towards the illuminated phase of the moon (full moon period). Results of general linear model ANOVA revealed that there were significant differences in the catch rates of pelagic sharks recorded during the different phases of the moon (p<0.05). The cumulative effect of season and lunar cycle (p<0.01), year and season (p<0.01) and year and lunar cycle (p<0.01) also showed significant differences (Table 4).

Turkey's Honestly-Significance–Difference test of aggregate catch rates showed that the full moon catch rate was significantly different at 5% level (Table 5) from the catch rate recorded during new moon period (p<0.01). However, there was no

Table 2. Latitude-wise aggregate catch rate recorded in longline during 2006 to 2008

Latitude	Catch rate (Number per 1000 hooks)	
	Total	Pelagic sharks
06^0 N	6.37	2.30
07^0 N	7.79	1.73
08^0 N	8.41	2.99
09^0 N	8.58	3.91
10^0 N	6.7	2.04
11^0 N	8.61	3.53
12^0 N	7.52	1.83
13^0 N	5.29	1.54
14^0 N	4.11	1.83
Average	7.39	2.52

Table 3. Year-wise, season-wise and lunar cycle-wise catch rate recorded during 2006 to 2008

Independent variables	Catch rate (number per 1000 hooks)			Standard
Year	Minimum	Maximum	Average*	error
2006	7.54	9.08	8.33	0.312
2007	8.32	9.58	9.02	0.265
2008	7.06	8.57	7.84	0.312
Season				
Pre-monsoon	8.58	10.08	9.32	0.312
Monsoon	5.6	6.86	6.28	0.265
Post monsoon	8.86	10.38	9.58	0.312
Lunar cycle				
New moon	8.54	10.09	9.30	0.312
Waxing and Waning moon	7.76	9.34	8.56	0.312
Full moon	6.68	7.97	7.33	0.265

(* R = 0.988, R^2 =0.976)

Table 4. Effect of monsoon and lunar cycle- Generalised linear model -Analysis of variance

Source	Type III Sum of Square	Degrees of freedom	Mean square	F-Ratio	p- value
Year	5.413	2	2.707	4.272	0.070
Season	53.133	2	26.566	41.929	0.000*
Lunar cycle	15.358	2	7.679	12.119	0.008*
Season*Lunar cycle	42.773	4	10.693	16.877	0.002*
Year*season	34.907	4	8.727	13.773	0.004*
Year*Lunar cycle	23.749	4	5.937	9.371	0.009*
Error	3.802	6	0.634		

* Significant at 5% level

Table 5. Turkey's Honestly-Significance -Difference test of catch rates

Lunar cycle	Lunar cycle	Difference	p- value	95% confidence interval	
				Lower	Upper
New moon	Waning & Waxing moon	0.743	0.275	-0.479	1.964
New moon	Full moon	1.975	0.007*	0.788	3.161
Waning & Waxing moon	Full moon	1.232	0.054	0.045	2.419
Pre monsoon	Monsoon	3.043	0.001*	1.856	4.230
Pre monsoon	Post monsoon	-0.262	0.822	-1.484	0.959
Monsoon	Post monsoon	-3.306	0.000*	-4.492	-2.119

* Significant at 5% level

significant difference among the catch rates between new moon and waxing and waning moon. Similar relationship was observed in the case of waxing and waning moon and full moon catch rates. Catch rates recorded during pre monsoon and monsoon (p<0.01) and monsoon and post monsoon (p<0.01) were found significant at 1% level, but the difference between pre monsoon and post monsoon catch rate was not significant. Results of the present study indicate that the illumination of moon is having an inverse effect on the catch rate of sharks. A reduced catch rate of shark during full moon period was reported by Lowry et al. (2007). Pyle et al. (1996) opined that lunar cycle affects shark behaviour and reported increased appearance of shark during the new moon period at the Farallon Island, California.

Pelagic sharks mainly feed on fishes available on the surface and study on white sharks indicate that they are mainly being diurnal predators (Grubber & Cohen, 1985; Klimley et al., 1992; Strong et al.,1992). During new moon days, concentration of forage organisms on the surface layers occurs due to their diurnal migration. Increased availability of prey organisms on the surface attracts more sharks to the area resulting in increased catch rates of sharks in the tuna longline gear. This pattern of feeding behaviour may be reflected as better catch rate during new moon period and consecutive reduction towards the illuminating phase of the moon. However, Bigelow et al. (1999) and Poisson et al. (2010) reported that there was no significant lunar effect on the catch rate of blue shark. Geographical difference in the study area, changes in the fishing method and species of study may be the reasons for this variance.

The present study indicated the abundance of pelagic sharks in Andaman waters and provided the distribution pattern in time and space. Better hooking rates recorded during the new moon periods indicated that lunar cycle played a significant role in the catch rate of pelagic sharks. The results suggest that monsoon too plays a significant role in the catch rate of pelagic sharks. Present study thus establishes the significant effect of the lunar cycle on the catch rate of pelagic sharks in tuna longline fishery.

Acknowledgements

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