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EVALUATION OF THE EFFECT OF LUNAR CYCLE AND MONSOON ON THE DISTRIBUTION AND ABUNDANCE OF SKIPJACK TUNA AROUND ANDAMAN & NICOBAR ISLANDS

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Abstract: Skipjack Tuna is an important constituent of Tuna longline fishery around Andaman and Nicobar Islands. Longline survey data collected from the area was utilized for the study. The General Linear Model has been fitted by using variables like catch rate, year, season and lunar cycle. The results indicated that the catch rate varied with the latitude, monsoon and lunar cycle. Aggregate catch rates recorded from Nicobar waters (Lat. 06^0 N to 10^0 N) was 0.30 and the rate was higher than the aggregate hooking rate (0.19) recorded from A& N waters. Better aggregate catch rate was recorded during the pre monsoon period and catch rates showed reducing trend towards the post monsoon period. Results indicated that catch rates of Skipjack Tuna were more during full moon days, followed by waxing & waning period and the new moon period. Analysis of year wise catch rate has shown a decline in catch rate during the recent year. The results were analysed and likely reason for the variations in the catch rates were elucidated in the text.

Key words: Lunar effect, Monsoon effect, Distribution, Abundance, Skipjack Tuna, Tuna fishery

INTRODUCTION

Skipjack Tuna *Katsuwonus pelamis* (Linnaeus, 1758), a cosmopolitan pelagic fish is the most abundant tuna among the seven principal tuna species. With the reported landings of 2.52 million tones, it was world's second most important capture fish species during 2010 (FAO, 2012). It is an important commercial and game fish caught mainly by purse seine, pole and line, hook and line and tuna long line (Langley *et al.,* 2002). In India Skipjack Tuna is mainly caught by pole and line fishery at Lakshadweep and by a variety of gears like gill net, tuna longline, hook and line and purse seine (Pillai and Ganga, 2008).

Skipjack Tuna exhibit high natural population variability driven by broad scale environmental changes like El Nino and decadal Oscillations in Pacific Ocean (Langley *et al*., 2002; WCPFC, 2008). Evidences suggest that El Nino impacts on juvenile recruitment are greater when El Nino rapidly follows a period of La Nina (DEH, 2005). In India, Indian Ocean Dipole (IOD) is the one aspect of the general cycle of global climate similar to the El Nino in the Pacific Ocean. IOD also affects the strength of Monsoon in the sub continent(Saji *et al.*,1999).In addition, various other environmental factors like sea water temperature, season, water movements, lunar cycle, etc., play a major role in the distribution and abundance of Skipjack Tuna. There are scientific evidences that the water movement and lunar cycle play a major role in feeding, spawning and migratory movements of the fishes (Carey and Robinson, 1981; Luecke and Wurtsbaugh, 1993; Millar *et al.,* 1997; Taylor, 1984).

A preliminary study on effect of the lunar cycle on bait- fish & tuna catches of pole and line fishery at Minicoy Island (Lakshadweep), India reported that lunar cycle plays a major role on the abundance of skipjack tuna (Mohan *et al.*, 1987). However, statistical analysis to substantiate the findings was lacking in the above study. Except this solitary study, no attempt has been made to understand the lunar effect on the Skipjack tuna.

Results of exploratory resource survey (John and Somvanshi, 2000; John *et al.*, 2005; Somvanshi *et*

al., 2008) provided information on spatial variation and seasonality in catches of the longline fishery around Andaman & Nicobar (A & N) Islands. The above studies too lack statistical significance test and no attempt has been made to correlate the effect of the monsoon and the lunar cycle on longline caught pelagic fishes.

Among the major environmental factors, lunar cycle and monsoon play a key role in fish distribution and abundance. However, no attempt has been made to understand its effect on catch rate of Skipjack Tuna. The present study is an attempt to understand the distribution, abundance and the effect of monsoon and the lunar cycle on the catch rate of skipjack tuna.

MATERIALS AND METHODS

Exploratory tuna longline survey data collected by *M.V. Blue Marlin*, survey vessel attached to the Fishery Survey of India (FSI), Port Blair, A & N Islands, during the period from January 2006 to December 2008 was used for this study. Resource survey carried out following FSI (2006) recorded the Skipjack tuna caught during the fishing operation. Survey was operated around A & N Islands between the Latitude 06^0N and 14^0N. There were total 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 hooks (3.6 sun) per basket were operated.

Each set with 125 baskets was normally shot in the morning before sunrise and hauled in after five to six hours of immersion time. A total 182235 hooks were operated during the study period. The number of specimens 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.

Month-wise aggregate catch rates were estimated to understand the variation of fish abundance in time, subsequently the effect of monsoon on the Skipjack Tuna was estimated by grouping the months into Pre-monsoon (January to April), Monsoon (May to August) and Post- monsoon (September to December) periods (Sajeevan and Rajashree, 2012). During Pre monsoon period, total 78311 No. of hooks, during monsoon period 40090 hooks and during post monsoon period a total of 63834 no. of hooks were operated. Aggregate catch rates recorded during these periods in each year were utilized to understand the effect of the monsoon on Skipjack Tuna.

Lunar days since January 2006 to December 2008 were mined from the Indian tide tables published by the Surveyor General of India, Govt. of India (GOI, 2005, 2006, 2007). The lunar periodicity in each month was pooled into three periods according to the lunar phase as new moon period, the 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 in between periods were pooled as the waxing & waning periods. Aggregate catch rates recorded during these lunar phases in each season and year was separately estimated to evaluate the lunar cycle effect on Skipjack Tuna. During New moon period 40500 No. of hooks , during waxing and waning (combined) period total 92968 no. of hooks and during full moon period 48767 no. of hooks were operated,

Standard statistical procedures (McDonald, 2009; Courtney *et al*., 1996) were followed for the analysis of data. Fishery data of the tuna longline gear was used for the study and modelled by using general linear model. The statistical significance of the effects was analysed following general linear model using SYSTAT-13 software.

RESULTS AND DISCUSSION

Catch rate in space and time

Skipjack Tuna constituted 9 % by number of the total tuna caught during the period of study. Aggregate catch rates recorded from Nicobar waters (Lat. 06^0 N to 10^0 N,) was 0.30 and the rate was higher than the aggregate hooking rate (0.19) recorded from A& N waters.

The aggregate catch rate of Skipjack Tuna recorded during the present study was (0.19), which is less than catch rates (0.20 to 0.56) recorded by earlier workers (John and Somvanshi, 2000; John *et al*.,2005; Somvanshi *et al.*, 2003; Somvanshi *et al.*, 2008) . As the results are based on the resources survey carried out by the FSI fleet since 1989, the results can be compared and it can be inferred that catch rates have decreased since 1989. Present study

recorded a lower catch rate during 2008 than that of 2006 (Fig. 3).

Month wise analysis of catch rates shown a better catch rates during the month of March, followed by April. Subsequently, monthly catch rates were pooled according to the season and analysed the effect of monsoon on the catch rate. The result is furnished as Fig. 1. As shown in Fig. 1. the best aggregate catch rate was recorded during the pre monsoon period. Catch rates shown a reducing trend towards the post monsoon period.

The result contradicts with Somvanshi and Varghese (2005) and Somvanshi *et al.* (2008) as they reported better catch rates during monsoon. But both the studies have not done any statistical analysis to substantiate the result, hence cannot be compared. General linear model, established in the present study, categorically proves that the catch rates recorded during pre-monsoon is significantly different from that of monsoon and post monsoon. Hence, it can be inferred that monsoon plays a major role in the catch rate of Skipjack Tuna.

Aggregate catch rates recorded during the new moon period, waxing and waning period and full moon period are shown in Fig. 2. As shown in Fig. 2. aggregate catch rates of Skipjack Tuna were more during full moon days, followed by waxing and waning period. Precisely, lower catch rates were obtained during the new moon period.

Skipjack Tuna generally preys on surface organisms and mostly remain at surface layers as a part of their feeding strategy (Allain, 2005) . Bright light during full moon night results in aggregation of the prey organism in the surface layers during the night and the reverse occurs during the day time due to diurnal migration of prey organism. The less abundance of prey organisms at the surface layer during the day time of full moon period may lead the Skipjack Tuna to sub surface. This diving down to sub surface results in attraction to the bait fishes, thus lead to more hooking rate. Abundance of natural food organisms in the surface layers during new moon days may keep them in the surface layer and result in less attraction towards the bait fishes during new moon days.

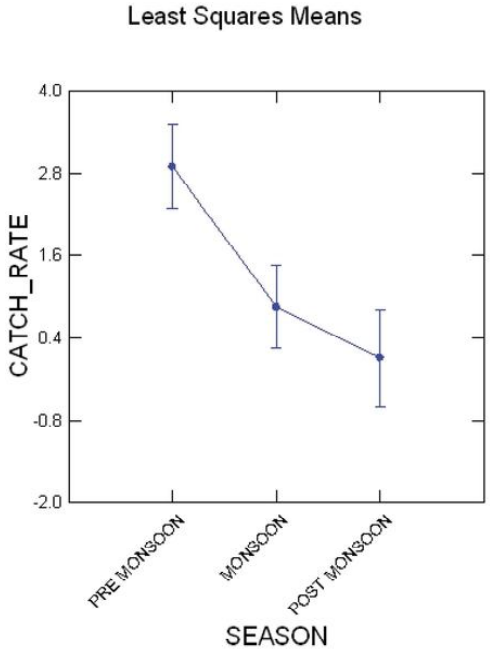

Fig. 1. Effect of Monsoon on Skipjack Tuna catch rate

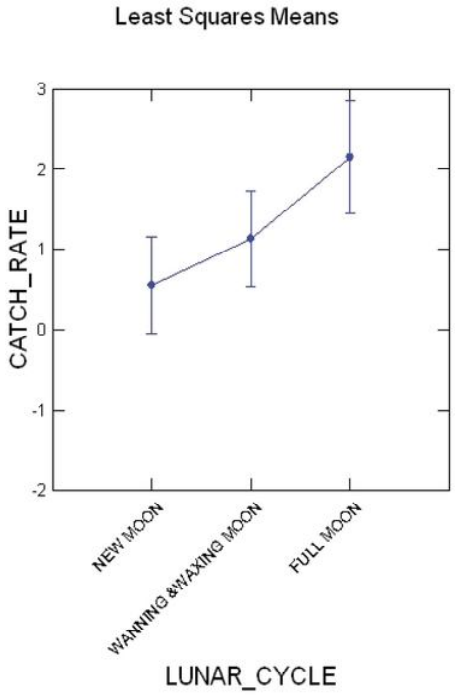

Fig. 2. Effect of lunar cycle on Skipjack Tuna catch rate

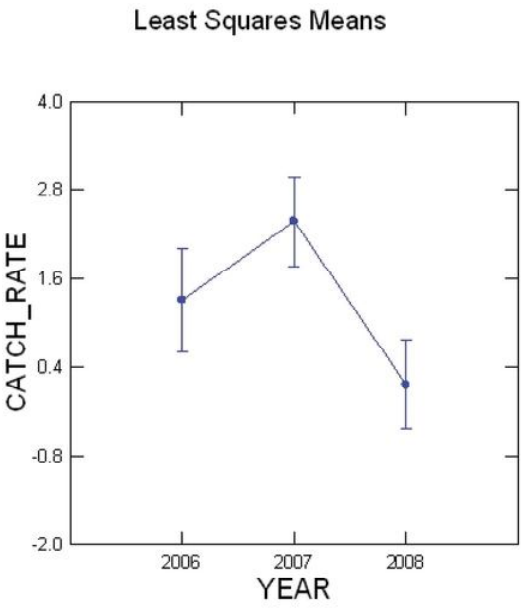

Fig. 3. Skipjack Tuna catch rate year wise from 2006-08

Statistical significance of lunar and monsoon effect

Result of general linear model ANOVA is furnished as Table 1. As revealed from the Table. 1, there are significant differences in the catch rates of Skipjack Tuna recorded during the different phases of the moon. A similar trend was noticed in the case of catch rates recorded during different seasons of the year. However, no cumulative effect of season and lunar cycle was found significant in the case of Skipjack Tuna.

Turkey's honestly- Significance –Difference test of aggregate catch rates showed that the full moon catch rate is significantly different from the catch rate recorded during new moon period (Table 2). Catch rate recorded during pre monsoon and monsoon and pre monsoon and post monsoon was found significant, but the difference between monsoon and post monsoon catch rate was not significant. A difference in catch rate recorded during the year 2007 and 2008 was found significant.

Table 1. Effect of Monsoon and Lunar cycle- General linear model -Analysis of variance table

Source	Type III Sum of Square	Degrees of freedom	Mean square	F-Ratio	p- value
YEAR	21.926	2	10.963	18.788	0.002*
SEASON	33.735	2	16.867	28.906	0.000*
LUNAR CYCLE	9.707	2	4.854	8.318	0.014*
SEASON*LUNAR CYCLE	3.969	4	0.992	1.7	0.253
YEAR*SEASON	9.571	4	2.393	4.101	0.051
YEAR*LUNAR CYCLE	20.399	4	5.1	8.74	0.007*
Error	4.085	7	0.584		

* Significant at 5% level

Table 2. Turkey's Honestly- Significance –Difference test of catch rates of lunar cycle

Lunar cycle	Lunar cycle	Difference	p- value	95% confidence interval	
				Lower	Upper
NEW MOON	WANING &WAXING MOON	-0.579	0.304	-1.639	0.482
NEW MOON	FULL MOON	-1.596	0.012*	-2.69	-0.503
WANING &WAXING MOON	FULL MOON	-1.018	0.081	-2.111	0.076
PRE MONSOON	MONSOON	2.046	0.002*	0.985	3.106
PRE MONSOON	POST MONSOON	2.785	0.001*	1.692	3.878
MONSOON	POST MONSOON	0.739	0.213	-0.354	1.832
2006	2007	-1.067	0.068	-2.16	0.026
2006	2008	1.14	0.053	0.047	2.233
2007	2008	2.207	0.001*	1.146	3.268

Year wise aggregate catch rate during the study period is shown as Fig. 3. The statistical test proved that there are significant differences in the aggregate catch rates recorded in different years. Catch rate recorded, during the period shown, indicates an increase during 2007 and reduced to the lowest during the year 2008.

Mohan and Kunjikoya (1987) reported month wise variation in the effect of the lunar cycle on tuna hooking rates of Skipjack Tuna in the pole and line fishery of Lakhshadweep Islands. They reported better hooking rates during full moon days of March and November and overall better hooking rate during new moon days. However, it has been reported the appearance of Skipjack Tuna shoals in the surface layers during new moon days. Pole and line fishery is a live bait fish based surface fishery, hence, the variation of catch rate in comparison to sub surface tuna long line fishery is possible.

The results of the present study indicated that Skipjack Tuna is available in Andaman waters in commercial quantity. Better hooking rates, recorded during the full moon periods, indicated that the lunar cycle plays a significant role in the catch rate of Skipjack Tuna. The results also suggest that the monsoon plays a significant role in the catch rate of Skipjack Tuna.

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