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Interannual and geographic variations in the abundance indices of yellowfin tuna, billfishes and sharks in the Indian EEZ

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ABSTRACT

Abundance indices of large pelagic predators in space and time were studied using data from longline survey conducted in the Eastern Arabian Sea, Western Bay of Bengal and the Andaman and Nicobar waters. During the study period (1984-2008), the entire Indian EEZ was surveyed by expending a fishing effort of 1711087 hooks. The trends in the abundance indices revealed drastic reduction in the abundance indices of sharks, yellowfin tuna and billfishes. The study calls for immediate adoption of management measures for maintaining healthy stocks of these resources in the Indian Ocean with the cooperation of other nations engaged in the fishery of large pelagic in the Indian Ocean. The study emphasises the importance of continuous monitoring of the stock status of these resources by fishery independent surveys.

INTRODUCTION

Tunas, sharks and billfishes are apex predators in the oceanic waters of the world oceans, playing a major role in the food web of marine ecosystem. Excessive removal of top predators could have repercussions on the structure of the food web through top-down, trophic cascades, a domino effect whereby species throughout the trophic layers are affected (Kitchell *et al*., 1999; Essington *et al*., 2002). All these species are highly valued food fishes and most sought after world over. Tuna fishing and fisheries have become a focal point while addressing issues of development, utilization and management of fisheries in the Indian Ocean in the light of expanded EEZ in the new maritime regimes.

Though traditional fisheries for tuna existed for tropical oceanic tuna species in Maldives and Lakshadweep Islands for centuries, the industrial tuna longline in the Indian Ocean commenced in 1952 and purse-seine fishery started in mid-eighties. Currently tuna production from the Indian Ocean is over 1.1 million tonnes per year with an estimated value of over US$ 2 billion, making the fishery the largest and most valuable among the tuna fisheries of the world. Although bulk of the tuna catches from the Indian Ocean are harvested by the distant water fishing nations (DWFN), the food security and livelihood of many coastal communities depend on the these resources.

In recent years there have been concerns expressed about the status of the large pelagic predators of Indian Ocean. The total fishing effort has been increasing rapidly and a large

fishery has developed on purse-seine fishing with fish aggregation devices (FAD's) in the Western Indian Ocean. Simultaneously, the Indian Ocean Coastal States are also strongly committed to increase their direct stake in fishing for tropical tuna species (Skipjack, Yellowfin and Bigeye tunas). This situation warrants constant monitoring of these stocks for adopting management measures for keeping the harvests at maximum sustainable yields (MSY).

Interpretation of status of the stocks from catch rates of commercial fisheries as indices of abundance is notorious for potential biases because fishery data do not provide representative sampling and because of the large number of factors beside abundance that can affect catch rates (Polacheck, 2006). In multispecies fisheries, such as pelagic longline, interpretation can be further confounded by changes in targeting in response to market and related economic considerations. In most instances, fishery biologists are concerned that declines in catch rates will underestimate the actual declines in abundance because fishermen will compensate for the declines in abundance through increased knowledge, technological improvements and shifts in fishing grounds. In this context, fishery independent surveys are the best option for monitoring the stock status of fishes. In the light of growing concern over the stock status of large pelagic predators of Indian Ocean, an attempt is made in the present paper to analyse the trends in the abundance indices of the large pelagic predators of the Indian EEZ using the data from longline research/survey vessels of Fishery Survey of India.

MATERIALS AND METHODS

Data from six longline survey vessels of FSI (OAL 31.5-37.5m, GRT 245.8-465.0) collected during the period from 1984 to 2008 are used for this study. Three vessels operated along the West Coast of India (Eastern Arabian Sea), two vessels operated off the East Coast (Western Bay of Bengal) and one in the Andaman and Nicobar (A&N) waters. Four vessels used multifilament longline gear for the survey, while the remaining two vessels, added recently to the fleet, operated monfilament longline gear. The survey strategy adopted was to undertake one cruise of 20 days duration in a month, and about 15 longline operations are conducted in each cruise, operating about 9000 hooks.

The general method of operation was that the shooting of the line commences before sunrise and completed in about 2 to2.5 hours. The hooking depth is adjusted in accordance with the thermocline depth. A variety of finfish species like threadfin breams (*Nemipterus* spp.), round

scad (*Decapterus* spp.), sciaenids, mackerel (*Rastrelliger kanagurta*), spotted sardinella (*Amblygaster sirm*) and occasionally squids (*Uroteuthis duvauceli*) were used as bait depending on availability. The baitfishes were collected from sister vessels in the survey fleet, frozen and stored onboard before commencement of voyages. On an average 575-625 hooks were operated per set. Immersion time of 5-6 hours was allowed and hauling was done in the afternoon starting from the initially shot line.

Onboard, the fish were identified using standard literature and online resources (Compagno 1984; Goode and Bean, 1895; Fischer and Bianchi, 1984; Smith and Heemstra, 1986; Froese and Pauly, 2004) and data on length, weight and sex of all the specimens were noted. For the purpose of data analysis, Indian EEZ is divided in to three regions *viz*., West Coast (Eastern Arabian Sea), East Coast (Western Bay of Bengal) and Andaman and Nicobar waters and the data gathered during the period 1984 to 2008 were pooled separately for these three regions and the abundance indices were calculated for different regions. Abundance index is expressed in terms of hooking rate (HR), the number of fish caught per 100 hooks and catch rate (CR), the weight of fish per 100 hooks.

RESULTS

During the study period (1984-2008), these six vessels surveyed the Indian EEZ for oceanic resources by operating 1.71 million hooks. Maximum fishing effort was expended during 1987, while the minimum was during 2004. Distribution of sampling effort revealed that the Arabian Sea and Andaman and Nicobar waters were the most surveyed, while the Western Bay of Bengal was the least surveyed.

In the Eastern Arabian Sea, survey was conducted expending 677411 hooks. Yellowfin tuna was the main component of the catch recorded during the survey. This species was caught at a HR of 1.92, and a catch rate of 46.87 kg. There were wide fluctuations in the abundance indices of this species in the Arabian Sea. Maximum hooking rate was recorded during the year 1986 (9.9), while the survey conducted during 1994 yielded minimum HR. There was no clear manifestation of reduction in abundance over the years, as the abundance indices fluctuated widely. However, linear regression analysis of the hooking rates against the years resulted in a negative slope indicating significant reduction in the abundance of yellowfin

tuna in the area over the years (slope: -0.117; R^2 : 0.193). Higher HRs were recorded during the initial years, thereafter a sharp fall followed by stabilisation was observed (Fig. 1).

Total number of sharks caught from the Arabian Sea during the study period was 8967, registering a HR of 1.32. The blacktip shark (*Charcharhinus limbatus)* dominated catch; followed by silky shark (*C. falciformis)* and thresher shark (*Alopias pelagicus).* Total weight of the hooked sharks was 201 t (CR – 29.72 kg). The trends in the abundance indices revealed gradual loss of shark abundance in the survey area over the years. The abundance indices recorded during the 80's and early 90's were impressive, and hereafter there was drastic reduction in the abundance indices (linear regression; slope - -0.124; R^2 – 0.41).

Billfishes, including sailfish, marlins and swordfish were caught from the Arabian Sea at a catch rate of 13.26 kg, while their aggregate HR was 0.46. The highest hooking rate was recorded during 1994 (2.36), while the lowest HR (0.13) was recorded during 1996. Over the years, there was slight reduction in the abundance indices of billfishes in the survey area (linear regression; slope: -0.002; R^2:0.002).

In the Western Bay of Bengal, total number of hooks operated was 371706. The distribution of effort was not uniform in this area due to several logistic reasons. Survey was suspended during the years 1993, 1994, 2000, 2003 and 2004. Yellowfin tuna was the main component of the catch recorded from this area also. The HR recorded for this species was of 1.07, while the catch rate recorded was 28.34 kg. The fluctuations in the abundance indices of this species in this survey area was not significant. The highest hooking rate was recorded during the year 2007 (1.98), while the lowest HR (0.4) was observed during 2001.. There was no clear manifestation of reduction in abundance over the years, as the abundance indices fluctuated in the range of 0.4-1.98. The linear regression analysis of the hooking rates against the years revealed no visible trends (slope - -0.001; R^2 – 0.00).

Total number of sharks caught from the Bay of Bengal during the study period was 5137, registering a HR of 1.38. Pelagic thresher shark, *A. pelagicus* was the dominant species, followed by blacktip and silky sharks. Total weight of the sharks hooked from this area was 102 t (CR – 27.63 kg). The trends in the abundance indices revealed drastic decline of shark in the Bay of Bengal over the years (linear regression; slope: -0.141; R^2: 0.36). The highest HR (8.14) was recorded during 1985, while the recent years (2005-2008) recorded the lowest (0.03-0.25) HR.

Total quantity of billfishes caught from the Bay of Bengal was 1553 numbers, weighing 45.6 t, recording HR of 0.42 and CR of 12.52. The hooking rate was maximum during 1985 (1.24), while the survey conducted in the recent years (2005-2008) revealed drastic reduction in the abundance indices of billfishes also. The linear regression analysis of the hooking rates against the years also revealed similar trends (slope: -0.023; R^2: 0.39).

Total number of hooks operated in the Andaman and Nicobar waters was 661970 hooks. Although the survey in this area was initiated during 1984, regular surveys were conducted in this area from 1989 only. Abundance indices showed that of the three areas surveyed in the Indian EEZ, abundance of yellowfin was minimum in Andaman and Nicobar waters. The HR recorded for this species was 0.82, while the catch rate recorded was 25.19 kg. The time series of abundance indices revealed drastic decline of the species in the survey area. Better HRs were obtained pre-1995 period which declined to 0.3-0.4 during recent years. The simple regression of the hooking rates against the years also revealed similar trends (slope: -0.024; R^2: 0.17).

Sharks formed one of the main components of the total catch in the Andaman and Nicobar waters. Total number of sharks caught from this area was 8056, registering a HR of 1.22. Pelagic thresher shark, *A. pelagicus* was the dominant species recorded from this area, followed by tiger shark and hammerhead shark. Total weight of the sharks hooked from this area was 316.8t (CR – 47.08 kg). There was wide fluctuation in the abundance indices of this species in the A&N waters over the years. The highest hooking rate was recorded during the year 1993 (3.5), while the survey conducted during 1999 yielded lowest HR (0.36). There was no clear indication of reduction in abundance over the years, as the abundance indices fluctuated over the years (linear regression; slope:-0.040; R^2: 0.15).

The billfishes caught from the Andaman and Nicobar waters was totalled 1382 numbers, weighing 44.01 t, recording HR of 0.21 and CR of 6.66. The hooking rate was highest during 1993 (0.47), while the lowest HR (0.09) was recorded during 1991. The time-series showed not much variation in the abundance indices of billfishes from the Andaman and Nicobar waters (linear regression; slope: -0.040; R^2: 0.15).

DISCUSSION

A study by Pauly and Watson (2003) showed that due to overfishing and food chain interactions in important fishes, the trophic level has dropped by more than one level in the

Arabian Sea and to 0.5 in the Bay of Bengal. Removal of top predators could have repercussions on the food web structure through top-down, trophic cascades (Kitchell *et al*., 1999; Essington *et al*., 2002). Therefore, it is necessary to assess the impact of the tuna and allied resources fisheries on the pelagic ecosystems of the seas around India. Catch-per-unit-effort (CPUE) has been traditionally used to determine the availability of fish and to analyse trends in stock status. Fishery independent surveys has been recognised the best option for monitoring the stock status of fishes as the interpretation of catch rates of commercially fishery as indicators of their stock status are proved to be notorious for potential biases (Polacheck, 2006).

The present study revealed a declining trend in the abundance of the large pelagic predators of the Indian EEZ, particularly after the mid nineties when the purse seining for tunas were increased in the Western Indian Ocean. Decline in the abundance indices of the sharks was alos notable. As observed by John (2009), the trend in the CPUE of sharks is a clear indication of the decline in the abundance of sharks in all the three regions, the most alarming scenario being in the West Coast as well as the East Coast where the average HR recorded during the last five years was less than 0.1. Abundance indices of other fishes also declined over the years, the catch rate recorded from the entire Indian EEZ has reduced from 213.39 (1986) to 19.29 (2008).

Since large predatory fishes are highly migratory, the over exploitation in one region will influence the abundance in other regions and therefore, the management of these fish stocks needs the cooperation of all the nations engaged in fishing. India's contribution to total oceanic tuna and associated species from the Indian Ocean during 2006 was 2.01%. Our oceanic tuna catches are far below the potential estimated. India is conscious of precautionary approach while imposing a fishing ban for a period of 65 days coinciding the monsoon season.

Intensified longline fishery and Purse seine fishery using drifting FAD's developed in the Indian Ocean during mid 90's mainly by Distant Water Fishing Nations (DWFN's) may be one of the probable reasons for the reduction of abundance indices of large pelagic predators in the Indian Ocean. The aggregating capacity of FADs increases the ability of large purse-seine vessels to capture all fishes including large quantities of small fishes. It is feared that this will have negative effect if excessive fishing using FADs is continued. The main concerns raised by the Scientists are:

a. FAD-based fisheries significantly increase the risks of recruitment and growth overfishing of tropical tuna species

b. The FAD-based fisheries will complicate fisheries assessments and the ability of scientists to determine the effects of this fishery upon stock status.

c. Purse seine sets on FADs catch a significantly greater and more diverse level of bycatch than do sets on free-schooling tuna

d. Advent of FADs means some species now caught by multiple gears, both as young and adults.

e. Significant differences in fish plumpness and individual growth rates of tunas caught under FAD's are documented, suggesting that individuals associated with drifting FADs were less healthy than those in free schools.

f. For each species, significant changes in migratory direction and displacement rates were observed in the presence of drifting FADs.

These findings support the hypothesis that FADs act as a super-stimulus, ecological traps, misleading tunas to make inappropriate habitat selection (Hallier and Gaertner, 2008).

Since large predatory fishes are highly migratory, the management of these fish stocks needs the cooperation of all the nations engaged in tuna fishing. Immediate management measures are to be adopted for maintaining healthy stocks of these resources in the Indian Ocean with the cooperation of other nations engaged in the fishery of Indian Ocean.

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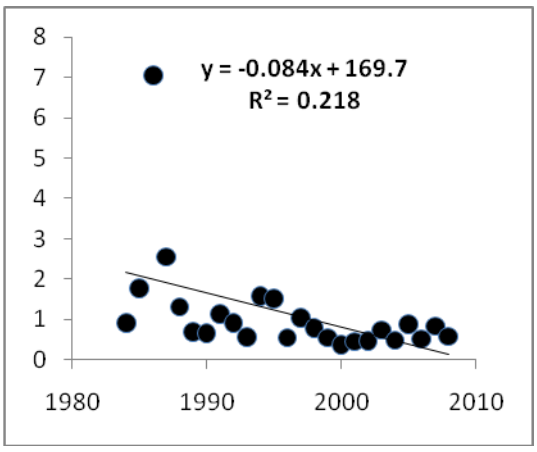
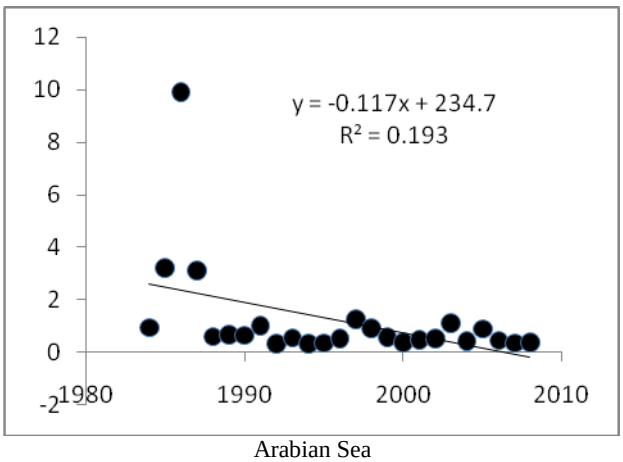
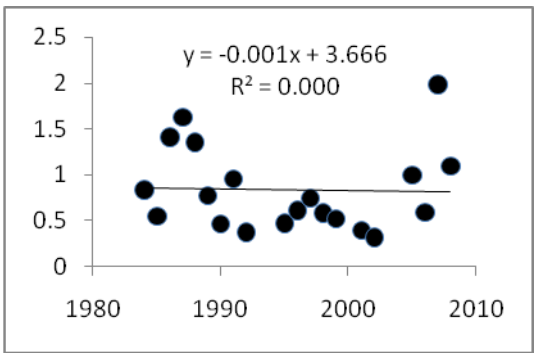
A. Yellowfin tuna



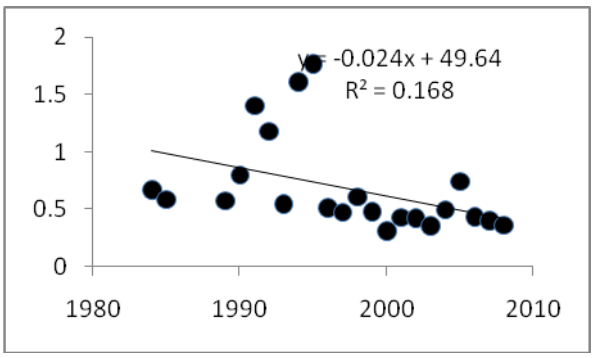
Entire EEZ



Arabian Sea

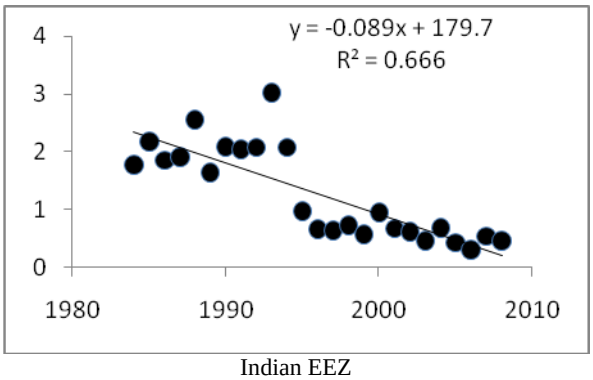


Bay of Bengal

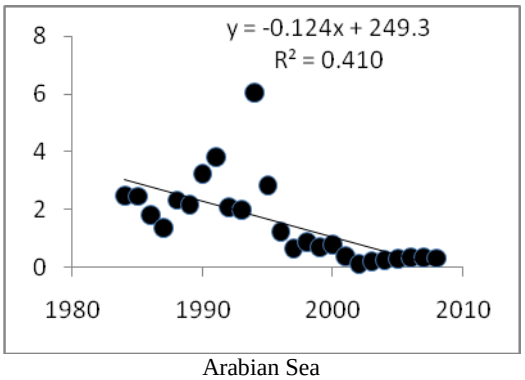


A&N waters

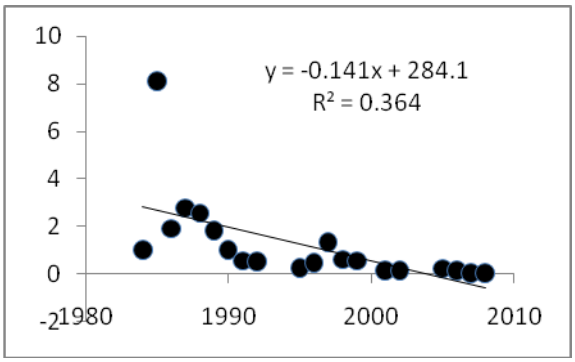
A. Pelagic sharks



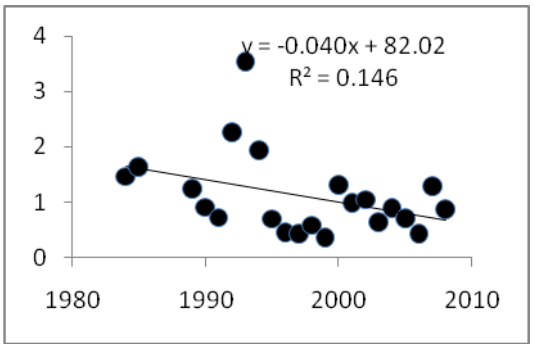
Indian EEZ



Arabian Sea



Bay of Bengal



A&N waters

c. Billfishes

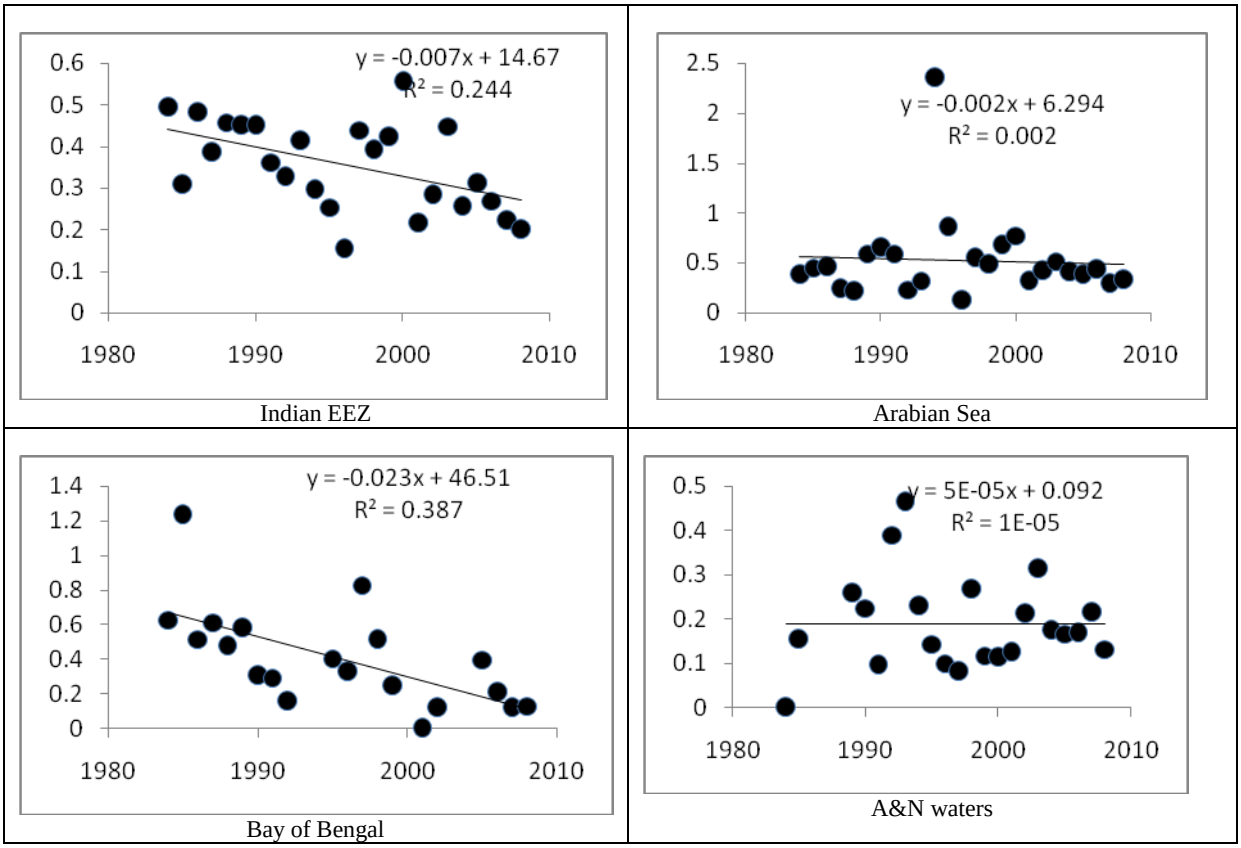


Fig. 1. Scatter plots showing the results of linear regression of Hooking rates on year of (a) yellowfin tuna, (b) Sharks and (c) Billfishes in the Indian EEZ.