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Validation of Potential Fishing Zone (PFZ) Forecasts from Andaman and Nicobar Islands

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Abstract

The annual exploitable fisheries of Andaman and Nicobar Islands are estimated to be 1.48 lakh t of which a meagre 22% is harvested currently. Potential Fishing Zone (PFZ) forecasts based on remotely-sensed chlorophyll concentration and sea surface temperature were applied for harvesting the unexploited marine fishery resources. Simultaneous validation experiments (n = 87) synchronizing with PFZ forecasts within (PFZs) and outside (non-PFZs) the demarcated zones employing different vessel categories *viz.,* gillnetters (n = 50), trawlers (n = 22) and longliners (n = 15) were carried out. Significant disparity in fish catch was observed within and outside PFZs. Fish catch from gillnetters composed of carangids, clupeids, scombrids with *Megalaspis cordyla* being dominant at PFZ. Carangids, sphyraenids, serranids, lutjanids, thunnids, lethrinids and carcharhinids were reported from trawlers with significantly higher CPUE from PFZs except nemipterids. Fish catch from longliners constituted mainly of carcharhinids and serranids, where the catch of former was found to be significantly higher at PFZs. *Alopias* spp. (Carcharhinidae), *Istiophorus platypterus* and *Makaira indica* (Istiophoridae) chiefly contributed to the fish catch composition during validation of tuna fishery forecasts by longliners which suggests that the productive surface waters favouring pelagic fish aggregation at PFZs has also contributed to the benthic fishery resources of various trophic levels. Gut contents of pelagic fishes harvested from both zones were analyzed and compared. Further, the study investigates the validity of PFZ forecasts based on depth, ecology and area of operation.

Keywords: Andaman and Nicobar Islands, chlorophyll, Potential Fishing Zone, sea surface temperature, validation

Introduction

Identification of Potential Fishing Zones (PFZ) involves an understanding of oceanic processes and interaction of hydro-biological parameters (Desai et al., 2000). Indian Remote Sensing Satellite P4 Ocean Colour Monitor (IRS P4 OCM) derived chlorophyll concentration and National Oceanographic Aerospace Administration Advanced Very High Resolution Radiometer (NOAA AVHRR) derived Sea Surface Temperature (SST) images have been used to characterise the relationship between biological and physical variables in coastal waters and it was observed that both chlorophyll concentration and SST were inversely correlated (Solanki et al., 1998). The relationship between these two parameters was estimated by a clustering technique called ARNONE (NCAER, 2010) and the matching features were selected for generating integrated PFZ forecasts from composite images on the basis of latitude and longitude (Solanki et al., 2005; NCAER, 2010).

Validation of PFZ forecasts have inferred substantial increase in fish catch along northwest coast of Gujarat (Solanki et al., 2001 & 2003; Nayak et al., 2003; and Dwivedi et al., 2005) and all over the country (Choudhury et al., 2002). Remotely-sensed

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oceanic features translated as PFZ forecasts in near-real time indicating the likely availability of fish stocks for the next 2-3 days are disseminated by Indian National Centre for Ocean Information Services (INCOIS) to about 225 nodes for operational use (Nayak et al., 2003).

Andaman and Nicobar Islands (ANI) situated between 6^0 45′ N and 13^0 41′ N and 92^0 12′ E and 93^0 57′ E, has 0.6 million km^2 of Exclusive Economic Zone (EEZ) and 1192 km of coastline. The continental shelf around the Islands is very narrow and is estimated to be around 35 000 sq km (ANDFISH, 2004). ANI is unique in possessing high magnitude of harvestable fishery resources of more than 1.48 lakh t per annum (Dam Roy & Grinson, 2010). There are 97 fishing villages with over 7200 registered fishers. The total number of registered fishing crafts is 2813 comprising of country crafts (52%), motorized boats (46%) and mechanized boats (2%) (http://DOF2012www.and.nic.in/fisheries/fishery.htm). However, the present level of marine fish production constitutes a meagre 33 159 t (22%) of the estimated potential and this wide gap could be attributed to the lack of strategy for promoting marine fish production in the Islands (Grinson et al., 2011).

A significant increase in total catch by following PFZ forecasts has been documented from ANI (Grinson et al., 2011). The present investigation reports the species composition and food and feeding habits of fishes harvested within and outside PFZs. It also discusses the validity of the PFZ forecasts based on depth, ecology and area of operation and their utility for optimally harvesting the underutilized fishery resources of the Islands.

Materials and Methods

For disseminating PFZ forecasts, 17 sites from Andaman and 25 sites from Nicobar were used as reference points. Along with PFZ maps, technical details *viz.*, Global Positioning System (GPS) coordinates of the demarcated zones, direction, angle in degrees, and distance in kilometres and depth in metres from the reference points were also provided by INCOIS.

The PFZs forecasts were disseminated through different modes *viz.*, Digital Display Boards, e-mail, telephoning/text messaging, radio, community networking and distribution of print-outs in person to the targeted fishermen. Identical vessels of three categories *viz.*, gillnetters, trawlers and longliners were used for conducting simultaneous validation experiments within and outside PFZs. Log books were provided for entering catch details. A total of 87 validation experiments were carried out during 2009-12 in different seasons. Details pertaining to the technical specifications of craft and gear employed for validating the PFZ forecasts were summarised in Table 1. Feedback data was collected from fishing vessels in a standard format.

Gut contents of pelagic fishes that significantly contributed to fish catch within and outside PFZ *viz.*, *Sardinella* spp. (Clupeidae) *Rastrelliger* spp.

Table 1. Technical specifications of the craft, gear and validation experiments

Category	LOA* (m)	Engine (hp)	Gear	Validations	Duration of fishing	Depth of fishing (m)
Gillnetter	3-7.5	8-25	21-27 mm mesh (sardine) 57 mm (mackerel)	50	7-9 h	>100
Trawlers	14.5-15.5	108-151	40 mm stretched mesh	22	3-4 days with 4-5 hauls/day	200-700
Longliner†	16.8-18.3	320- 402	35-60 km line, 900-1400 hooks, baskets (4-36), branchline rigged with galvanized circle hooks (14/0-16/0)	15	5-6 days	< 1000

*LOA= Length overall of the fishing vessel

†Whole frozen finfishes (*Sardinella* spp., *Rastrelliger* spp. and *Chanos chanos*) were given as bait in longliners

(Scombridae) and *Megalaspis cordyla* (Carangidae) were analyzed and compared. Gut contents were thoroughly homogenized with 4% formalin and poured into a petri dish. Segregation of larger prey items which can be visualized with naked eye was carried out using forceps. The sub samples were observed under microscope and prey items were identified as precisely as possible according to the keys (Kasturirangan, 1963).

The data obtained in the present experiment were subjected to Mann-Whitney U test using statistical package, SPSS version 16 to find out the differences in the value of the statistic $p<0.05$.

Results and Discussion

Fish catch: PFZ *vis-à-vis* non-PFZ: Simultaneous validation experiments showed a significant ($p<0.01$) percent increase of 36.50 ± 1.97, 33.82 ± 2.42 and 30.41 ± 3.58 in total catch for gillnetters, trawlers and long liners respectively. Results of statistical analysis carried out for the total fish catch within and outside PFZ are given in Table 2. The results revealed a significant increase ($p<0.01$) in total catch for PFZ users against their respective non-PFZ users.

Species contribution: The family-wise catch per trip for common fish species was calculated and compared between, within and outside PFZs. Validation experiments employing gillnetters indicated a significant ($p<0.01$) increase in catch of *Megalaspis cordyla* and *Carangoides ciliarius* (Carangidae), *Rastrelliger* spp. (Scombridae) and *Sardinella* spp. (Clupeidae) within PFZs (Fig. 1). Ocean features *viz.,* fronts, eddies and upwelling favour the aggregation of pelagic fishes (Nayak et al., 2003; Solanki et al., 2001; 2003 and 2005) since they are directly linked to phytoplankton in the oceanic food web (Ware & Thomson, 2005). Since *Megalaspis cordyla* constituted more than 35% of the total fish catch composition among all the pelagics, species-specific gears such as gillnets with mesh size 57 mm for horse mackerels are suitable for optimal harvest at PFZs. Few *ad hoc* validation experiments at PFZs in depths within 100 m deploying hand-liners were not yielding good catch as gill nets could have been the appropriate gear for the pelagic fishes available at these PFZs.

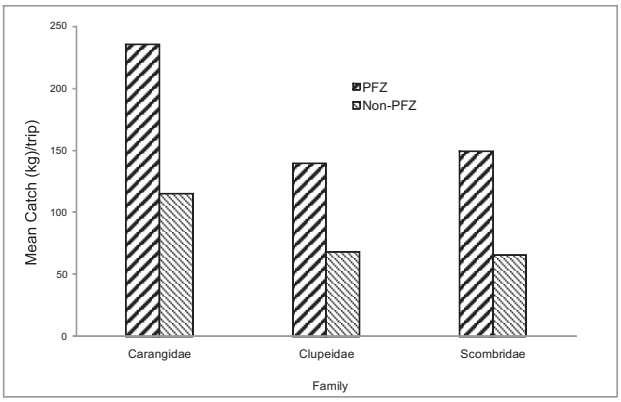

Fig. 1. PFZ vis-à-vis Non PFZ from gillnetters

Fish catch from trawlers was indiscriminate. The catch of *Katsuwonas pelamis, Euthynnus affinis* (Thunnidae), *Scomberomorous* spp. (Scombridae) and *Sphyraena* spp. (Sphyranidae) within the PFZs was significantly ($p<0.01$) higher than that from non-PFZs. While the increase in catch of Leiognathids within PFZs was marginal, the catch of Nemipterids was observed to be lower at PFZs (Fig. 2), which

Table 2. Descriptive statistics for the total fish catch

Particulars	Gillnetters		Trawlers		Longliners	
	PFZ	Non-PFZ	PFZ	Non-PFZ	PFZ	Non-PFZ
Mean	518.38	248.84	3753.13	1907.54	4846.66	2591.60
Standard Deviation	120.88	86.33	1393.73	976.77	1417.69	646.29
Test Statistics (Non PFZ-PFZ)						
Mann-Whitney U	85.00		43.00		15.00	
Wilcoxon W	1360.00		296.00		135.000	
Z	-8.032		-4.672		-4.046	
Asymp. Sig. (2-tailed)	0.00		0.00		0.00	

could be attributable to their demersal habitat. Though engine capacity and trawling speed of the trawlers are not ideal for harvesting tunas, high catch in PFZ might be attributed to its abundance in PFZ. Higher catch of predatory fishes of various trophic levels while employing trawlers indicates high ecosystem diversity at PFZ (Solanki et al., 2005).

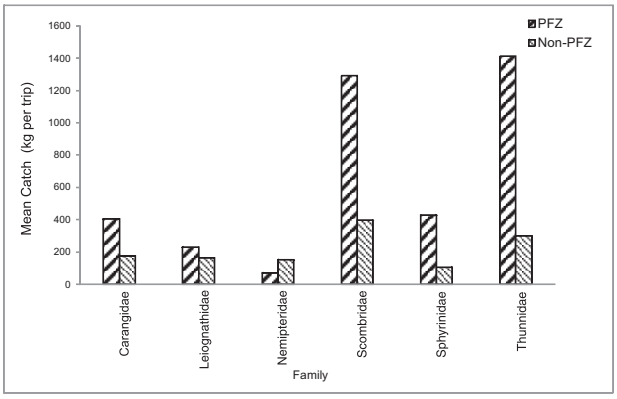

Fig. 2. PFZ vis-à-vis Non PFZ from trawlers

Fish catch from longliners constituted Carcharhinids and Serranids, where the catch of former was found to be significantly ($P<0.01$) higher in the PFZs (Fig. 3). A total of 15 forecasts were validated employing longliners, of which 4 were tuna fishery forecasts. It was observed that *Alopias* spp. (Carcharhinidae), *Istiophorus platypterus* and *Makaira indica* (Istiophoridae) constituted major catch while validating tuna fishery forecasts, indicating a trophic link not only attracting the pelagics to PFZs rich in chlorophyll, but also the benthic predatory carnivores.

Gut contents of fishes within and outside PFZ: A total of 461 fish specimens including 155 clupeids, 190 scombrids and 116 carangids were considered for comparative analysis of gut contents within and outside PFZ. Gut content analysis revealed significant variation between the PFZ and Non-PFZ (Table 3). For sardines (*Sardinella* spp.), 92% of the fishes from PFZ had full stomach distension indicating better availability of food at PFZ with fully digested greenish mass as major diet while only 46% from non-PFZ had full-stomach distension. Scombrids (*Rastrelliger* spp.) and *Megalaspis cordyla* (Carngidae) harvested from PFZ fed extensively on smaller pelagics as cycloid scales and partially digested teleosts were visible. Copepods and larval appendages were the major diet for the fishes harvested from Non-PFZ.

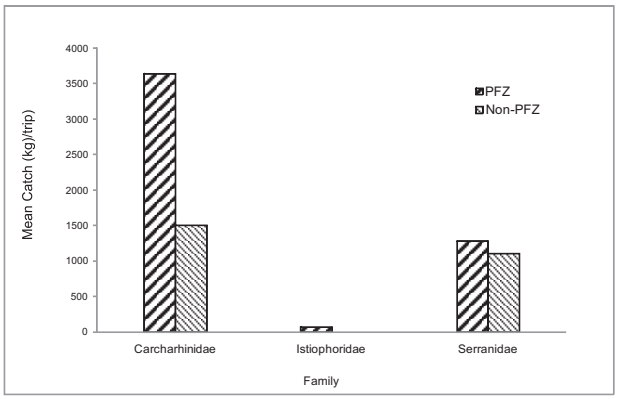

Fig. 3. PFZ vis-à-vis Non PFZ from longliners

Validation experiments conclude that satellite based fishing is advantageous in ANI with proven increase in total fish catch in PFZs. Fisheries of ANI are underdeveloped attributable to operation of vessels with decreased far-sea endurance, underdeveloped infrastructure facilities such as harbour, cold storage and processing and transportation costs. Further, vessel size and the gears are not adequate for operating in deep waters and there is no organized offshore fishing from Andaman base.

Table 3. Major gut contents of pelagic fishes

Family	Species	PFZ	Non-PFZ
Clupeidae	*Sardinella longiceps* *Sardinella sirm*	Fully digested greenish algal mass *Thallasiothrix* spp.	*Pleurosigma* spp. *Coscinodiscus* spp.
Scombridae Carangidae	*Rastrelliger kanagurta* *Megalaspis cordyla*	Cycloid scales Partially digested teleosts *Calanus* spp.	Copepods Broken appendages Zoea larvae

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