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Integrated Potential Fishing Zone Forecasts: A Promising Information and Communication Technology Tool for Promotion of Green Fishing in the Islands

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I

INTRODUCTION

Andaman and Nicobar Islands (ANI) have an estimated fisheries potential of 2.4 lakh tonnes/annum (John *et al*., 2005). But, the fish harvest has always been far below the maximum sustainable yield (MSY) with an average harvest of around 30,000 tonnes for the last decade (Roy and George, 2010). The islands have witnessed an array of extreme events and inclement weather prevails during incessant rains rendering fishing vulnerable to occupational hazards. Infrastructure and accessibility within the islands are inadequate, resulting in poor fishing operations. The fishing vessels mostly operate from Port Blair in South Andaman. Developmental departments have provided subsidies for augmenting the fishing efforts, but the fishing vessels available in the islands are diverted for tourism and related works. Given the level of exploitation in the islands, it can be presumed that the natural death (M) contributed more to the total mortality of fishes (Z) than fishing mortality (F) in contrast to the average global scenario.

For the islands with a total fishing craft strength of 2,808, the ideal intervention to harness the under-utilised resources would be to enhance the fish catch per unit effort (CPUE) without disturbing the fragile ecosystem than increasing the fishing effort. This strategy to harvest more fish with the existing efforts by spending less non-renewable resources can be termed 'green fishing'. Depending on the type of the fishing vessel in operation, the fishing activity in the islands extends from 6 hours to 25 days with a major time being spent on scouting for the fish shoals or fishing grounds. A faster location of the fishing shoals or fishing grounds should minimise the time of operation and improve the CPUE. With the advent of remote sensing techniques, the fish shoals could be predicted for 3 days in advance.

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Integrated Potential Fishing Zone (IPFZ) forecasts based on Indian Remote Sensing Satellite P4 Ocean Colour Monitor (IRS P4 OCM) derived chlorophyll data and National Oceanographic Aerospace Administration Advanced Very High Resolution Radiometer (NOAA AVHRR) derived Sea Surface Temperature (SST) are generated thrice a week by Indian National Centre for Ocean Information Services (INCOIS). These forecasts are disseminated with an objective to exploit the fishery resources of ANI in a sustainable manner and to bridge the gap between the estimated and harvested potential for the islands. The effectiveness in the dissemination of the forecasts, prediction of the fishing grounds and cost-benefit advantage of the technology are analysed in this paper.

II

STUDY AREA AND FISHING POTENTIAL

ANI, located between 6^0 45' N and 13^0 41' N Latitude and 92^0 12' E and 93^0 57' E Longitude in the southern reaches of Bay of Bengal (BOB) comprises 572 islands with an aggregate coastline of 1,192 km. The islands are typically oceanic in nature and encompass an Exclusive Economic Zone (EEZ) of 0.6 million km^2, which is 28 per cent of the total EEZ of India. The continental shelf area is 16,000 km^2 only, as the sea is very deep near the shore (Nithyanandan, 2009). There is no traditional fishing population in ANI. Fishermen and other settlers from Andhra Pradesh, Tamil Nadu, Kerala and West Bengal in the islands are engaged in fishing. In few islands, fishing is carried out by tribes using traditional methods of bow and arrow, seines and spears. The exploitation of fishery resources at present is restricted to coastal waters (Pillai and Abdussamad, 2009). The vessel size and gears are not adequate for operating in deep waters and there is no organised offshore fishing from Andaman base (Roy and George, 2010). There are 97 fishermen villages with a population of 15,320. Around 5,617 full-time and 718 part-time fishermen are engaged in marine fishing activities. The registered fishing crafts in operation are about 2,808 of which 1524 are non-motorised/traditional crafts, 1279 motorised crafts and 10 mechanised boats. There are 57 beach landing centres. The main fishing gear used is drift gillnet which contributes to over 40 per cent of the marine fish landings. Other fishing gears commonly used are shore seine, hook and line and cast net (Nithyanandan, 2009). Earlier studies have estimated the marine fishery potential in the EEZ of ANI based on assumptions derived from scanty data. According to John *et al*. (2005), 1,39,000 tonnes of pelagic, 22,500 tonnes of benthic and 82,500 tonnes of oceanic fishery resources are estimated to be available for exploitation. Roy and George (2010) estimated 1.48 lakh tonnes of fishery resources available for exploitation in the islands. The present average annual harvest is 19 per cent of the estimated potential. This wide gap between the estimated and harvested potential could be attributed to the lack of strategy to promote marine fish production in ANI.

III

MATERIALS AND METHODS

With the objective of helping the fisher-folk in identifying fish stocks and in designing successful harvesting strategies, IPFZ forecasts were disseminated across the islands during 2010-11 through various modes and feedback data were collected in a standard format from fish landing centres (FLCs) of ANI.

Dissemination of IPFZ Forecasts: For disseminating PFZs, 16 sites from Andaman and 17 sites from Nicobar were used as reference points. Along with PFZ maps, technical details such as direction, angle in degrees, distance in kilometers, depth in metres (depth is demarcated only if cloud-free satellite data is available) from the reference points and Latitude/Longitude of the fishing grounds to guide the fishers to the PFZs were also provided separately. IPFZ forecasts were disseminated through Digital Display Boards (DDBs) installed at three stations (Table 1) for disseminating IPFZ forecasts and other ocean features in near-real time.

TABLE 1. DETAILS PERTAINING TO DDB INSTALLATION

Location (1)	GPS coordinates (2)	Sector (3)	Date of installation (4)
Fisheries sub-station, Rangat	$12^0$29’56” N $92^0$57’18” E	MA	27 April 2010
FLC, Junglighat	$11^0$39’25” N $92^0$43’30” E	SA	21 April 2010
Fisheries sub-station, Hut Bay	$10^0$35’30” N $92^0$32’12” E	LA	24 April 2010

MA, SA, LA-Middle, South and Little Andaman.

Free distribution of PFZ maps in person was another mode of dissemination. In addition, telephone/text messages were also used for conveying PFZ messages through heads of the fishermen associations and regional staff of development department.

Validation Experiments: For conducting validation experiments, data from similar crafts were compared among three major fishing operators, *viz.*, gillnetters, trawlers and longliners. Each fishing operation executes a unique harvesting technique and thus vary in terms of number of crew, duration of fishing, depth of operation, type of gear deployed and species/quantity of fish harvested (Nayak *et al.*, 2003) The technical specifications of the crafts employed are detailed in Table 2.

A total of 20 feedbacks were collected from validation experiments (10 experiments employing gillnetters, 5 experiments each employing trawlers and longliners) carried out within and outside PFZs simultaneously with similar vessels during 2010-11 covering different seasons. Fishermen used Global Positioning System (GPS) and the pre-identified reference points to locate the PFZs demarcated in the forecasts.

TABLE 2. TECHNICAL SPECIFICATIONS OF THE CRAFTS AND GEARS EMPLOYED

Vessel (1)	OAL* (feet) (2)	Engine capacity (Hp) (3)	Gear specifications (4)	Depth of operation (m) (5)
Gillnetters	10-24	8-25	Mesh size: 21-27 mm (for sardine) and 57 mm (for mackerel)	<50
Trawler	47-51	108-151	Mesh size: 40 mm stretched mesh	50-100
Longliner	55-60	320- 402	35-60 km longline with 900-1400 hooks. Baskets ranged from 4-36 branchlines rigged with galvanised circle hooks with sizes 14/0-16/0.	>100

*OAL= overall length of the fishing vessel. Whole frozen finfishes (*Sardinella* spp, *Rastrelliger* spp and *Chanos chanos*) are given as bait in longliners and no bait in other vessels.

Data Collection and Analysis: The major FLCs of ANI (Table 3) were visited periodically and feedback data with respect to fishing grounds, crafts and gears employed, baits used, major landings and economics of operation were collected.

TABLE 3. FISH LANDING CENTRES VISITED FOR DATA COLLECTION

Sector (1)	Location (2)	FLC (3)	GPS Coordinates (4)
North Andaman (NA)	Diglipur	Aerial Bay	$13^0$25' N $93^0$06' E
		Durgapur	$13^0$16' N $93^0$03' E
		Kalipur	$13^0$13' N $93^0$02' E
	Mayabunder	Machidera	$12^0$55' N $92^0$54' E
Middle Andaman (MA)	Rangat	Rangat Bay	$12^0$30' N $92^0$57' E
South Andaman (SA)	Port Blair	Baratang	$12^0$18' N $92^0$47' E
		Chatham	$11^0$41' N $92^0$43' E
		Dignabad	$11^0$41' N $92^0$45' E
		Guptapara	$11^0$33' N $92^0$39' E
		Havelock	$12^0$03' N $92^0$59' E
		Junglighat	$11^0$39' N $92^0$44' E
		Kadamtala	$12^0$19' N $92^0$47' E
		Neil	$11^0$50' N $93^0$02' E
		Panighat	$11^0$42' N $92^0$44' E
		Wandoor	$11^0$36' N $92^0$36' E
Little Andaman (LA)	Hut Bay	Hut Bay	$10^0$34' N $92^0$33' E
		V.K. Pur	$10^0$44' N $92^0$34' E
Nancowrie Group (NG)	Kamorta	Kamorta	$08^0$02' N $92^0$33' E
Great Nicobar (GN)	Campbell Bay	Campbell Bay	$06^0$60' N $93^0$56' E

PFZ users from all the major FLCs were estimated based on the feedback survey. A total of 263 visits were made throughout the islands. Visits to the remote islands were generally based on the frequency of accessible PFZs from respective islands. The benefit/cost analysis was carried out considering all the possible operational and capital investment encountered by the boat owners including the maintenance charges worked out on an average for a trip. The PFZ maps are provided free of cost including the installation charges and dissemination through centrally financed schemes and the cost is not considered for the analysis.

IV

RESULTS AND DISCUSSION

The study indicates that the technology has disseminated to different islands, but in varying intensities. The dissemination modes and the number of users per forecast are summarised in Table 4. Downstream dissemination of the technology indicates its suitability to operate through developmental departments on an operational mode in island conditions where accessibility to different regions is comparatively poor.

TABLE 4. AVERAGE NUMBER OF USERS PER PFZ FORECAST

Mode of dissemination (1)	Average number of users per forecast (2)
Digital Display Boards	30
Free distribution of PFZ maps in person	35
Telephone/Text messages	72
E-mail	15
AIR, Port Blair Kendra	Transmitted all along the islands
AMFU, Port Blair	local news papers

There was significant ($P<0.01$) variation in the number of operational IPFZ advisories received per month. Forecasts were not disseminated for ANI from 15 April 2010 to 31 May 2010 due to the ban imposed on Marine Fishing by Government of India. Due to non-availability of cloud-free data, the number of PFZ forecasts were received during the later-half of 2010 was scant. During the month of January 2011, a maximum of 9 forecasts received followed by February and March 2011 in which 8 forecasts each were received.

A total number of 22 and 3 PFZ forecasts were validated and from Andaman and Nicobar sectors respectively. On an average, 35.5 per cent of the received forecasts were validated during 2010-2011 in ANI. As far as Nicobar sector is concerned, only 3 of the 20 received PFZ forecasts could be validated and it can be attributed to remoteness of the PFZs, vessels with reduced far-sea endurance and under-developed infrastructure facilities such as harbour, cold storage and processing in Nicobar sector. Details of the number of PFZ users from major FLCs of ANI is shown in Table 5. Among the validated forecasts only similar vessels with fish catch from PFZ and non-PFZ were considered for the catch and cost benefit analysis.

TABLE 5. AWARENESS OF PFZ IN MAJOR FISHING VILLAGES IN ANI

Sector (1)	Major FLC (2)	Total number of fishermen (3)	Number of PFZ users (4)	Per cent (5)
NA	Diglipur	300	175	58.3
	Mayabunder	245	60	24.4
MA	Rangat Bay	400	210	52
SA	Guptapara	100	22	22
	Junglighat	850	350	41.1
	Wandoor	160	35	21.8
LA	Hut Bay	200	75	37.5
NG	Nancowrie group of Islands	150	30	20
GN	Campbell Bay	300	250	83.3

Validation experiments employing gillnetters (*n*=10), trawlers (*n*=5) and longliners (*n*=5) were carried out within <50, 50-100 and >100m depth of the continental shelf respectively. The duration of fishing ranged from 7-9 h, 2-3 days and 10 to 12 days for each operation respectively. An average increase of 30.37 ± 2.27 per cent was reported in gillnetters, 30.03 ± 2.15 per cent in trawlers and 23.80±1.30 per cent in longliners. The study indicated that the fish catch can be significantly (P<0.01) increased by following PFZ advisories. The significant (P<0.01) variation in the extent of increase in catch among the three different fishing operations could be attributed to variation in the fisheries resource, species targeted and depth of operation. The summary of benefit/cost analysis for the different crafts employed for validation experiments is detailed in Table 6.

TABLE 6. SUMMARY OF BENEFIT/COST ANALYSIS

Vessel type	Average cost of operation per trip (₹)	Average receipt (₹)		Benefit/cost (₹)	
		without PFZ forecast	with PFZ forecast	without PFZ forecast	with PFZ forecast
(1)	(2)	(3)	(4)	(5)	(6)
Gillnetter	3758	5911	12850	1.68	2.70
Trawler	60000	94864	225560	1.58	3.47
Longliner	80000	145020	277440	1.81	3.26

The better benefit with trawlers is due to the type of wide variety of fishes coming along with the hauls. The other groups are species-specific and longliners benefit from the significantly (P<0.01) higher catch of groupers, snappers and sharks which fetch significantly (P<0.01) higher price compared to the other fishes. Gill netters generally end up with low valued pelagic fishes like sardines and mackerels which yield only ₹40 per kg. As the cost of generation of IPFZ advisories were not factored-in while calculating the BC ratio, the increase in BC ratio was significantly (P<0.01) higher for the fishing operations in the islands compared to those reported from mainland (2.12-2.14; Nayak *et al.,* 2003). The improvement in catch for an offshore fishery along the coastal waters of Gujarat for a similar validation exercise indicates that the results can be better for deep sea trawling where longliners can also supplement well (Nayak *et al.,* 2003). This study is perhaps the first attempt to investigate the utility of the IPFZ forecasts for any fishing vessel in an island condition in general and that of longliners in particular. Since the coastal waters along the islands tend to be optically sensitive, the results may have specific relevance to the tropical island ecosystems (George *et al.*, 2011).

V

CONCLUSIONS AND POLICY IMPLICATIONS

IPFZ forecasts have been proved to be potent tools for harvesting the under-exploited fishery resources of ANI. With increase in effort and overfishing in

mainland waters, intervention is required to divert the fishing to potentially rich and under-exploited waters (Nayak *et al.,* 2003). PFZ advisories reduce the scouting time and thus the usage of fuel and operational costs. Experimental fishing performed in the current study concludes that satellite-based fishing is an excellent source for deriving pecuniary benefits. The lacunae hampering fishing efforts in Andaman sea can be reversed by generating better awareness on the potential use of IPFZ forecasts. However, lack of an established trade channel, out of the islands may limit the market potential and price of the fishes landed in higher quantity. This will be an auto regulation on the amount of fish caught as the domestic market will deprive fishermen the right price if fish is landed in excess. Since the present harvest level is sufficient enough to sustain the demand of the islanders, infrastructure development for a value-added cold chain to harness the potential markets outside the islands should be taken up for ensuring better utilisation of this technology.

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