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Applications of Remote Sensing in the validations of Potential Fishing Zones (PFZ) along the coast of North Tamil Nadu, India

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Fish catch in the Potential Fishing Zones is 3-4 times higher when compared to non-PFZ area. PFZ validations and feedbacks were undertaken through selected group of active fishermen identified at the major selected fish landing centres along the coast of North Tamil Nadu, India from April 2007 to March 2011. With a view to validate the advisories and to qualify the potential benefits of the technology, concurrent validations have been taken up. Results of the PFZ validations and feedbacks data obtained during the present studies are highlighted in this paper.

[Keywords: Remote Sensing, Potential Fishing Zones, Fish Catch, Validation, Sea surface temperature, Chlorophyll concentration, Awareness campaigns.]

Introduction

The coastal marine environment plays a vital role in India's economy by virtue of their resources, productive habitats and wide biodiversity. India has a long coastline of 7517 km including islands with Exclusive Economic Zone (EEZ) of 2.5 million km^2, which is an important area both for exploration and exploitation of natural resources. Marine fisheries sector plays a crucial role in the economy in terms of providing employment to over fourteen million people and foreign exchange earnings through export. The annual marine fisheries production in India is about 2.94 million tons against the harvestable potential of 3.93 million tons[1]. The mechanised sector accounted for 67% of the landings followed by motorized (25%) and artisnal (8%) sectors. India's share in the world fish production has increased from 3.2% to 4.2% during the last decade. The marine fisheries sector is dynamic and has undergone substantial changes over the years and support the livelihood of million people. Major factors having visible impact on marine fisheries are introduction of mechanised trawlers and purse-seiners, motorization of countrycrafts, multiday fishing crafts etc. Modern electronic gadgets for positioning and fish finders have improved the efficiency of crafts. In order to formulate long term plan and chalk-out strategies for development of marine fisheries and to face new challenges, it is essential to have diversified informations on modern fishing applications such as remote sensing in validation of potential fishing zones and other technologies. The fisheries of east and west coast of India are quite different in terms of species composition and quality caught. The major oceanographic features of Bay of Bengal are different from Arabian sea, as the basic circulation pattern of water masses are quite different[2].

The use of satellite derived infrared thermal data; scatterometer windstress measurements and Coastal Zone Colour Scanner (CZSC) in fisheries research have demonstrated that satellite remote sensing is an important tool in fisheries application. At present, the fishing activities are concentrated to a narrow belt of inshore waters upto a depth of about 50 m. Timely forecast of potential fishing grounds can be of help in optimizing the schedule of fishing operations. In the recent past, mapping of chlorophyll concentration (CC) and sea surface temperature (SST) using satellite remote sensing as a tool to study the distribution of fishery resources is gaining momentum[3,4,5]. In the absence of ocean colour scanner, efforts have been largely focused using SST data derived from NOAA AVHRR for different target species. The integration of SST and chlorophyll concentration for PFZ forecast will be more effective and informative, especially in the areas of weak SST gradients.

Fishes are known to respond well with changes in temperature i.e., they are known to congregate in the

temperature boundaries. Surface circulation features like location and evolution of frontal boundaries, upwelling zones, currents, eddies etc., are important in defining marine fish habitats. Sea surface temperature is the most easily observed environmental parameter and it has been frequently used in correlation with fish availability[6]. It serves as a useful indicator of prevailing and changing conditions and variations in temperature indirectly account for distribution of fishery resources. The Indian National Centre for Ocean Information Services (INCOIS) has taken up this activity on a machine mode and brought many improvements in the generation as well as the dissemination of these activities. The marine area of the entire coastline of India consisting of all coastal states and island territories, has been conventionally divided into about 12 sectors viz., Gujarat, Maharashtra, Goa & Karnataka, Kerala, South Tamil Nadu, North Tamil Nadu, South Andra Pradesh, North Andhra Pradesh, Orissa & West Bengal, Lakshadweep, Andaman and Nicobar Islands (Fig. 1). PFZ advisories are brought separately for each of these 12 sectors.

Conventional methods for locating fishing grounds are used by way of (i) fishing in the traditionally known fishing grounds; (ii) locating productive fishing areas through colour breaks and (iii) presence of large number of sea birds over an area. However, medium and large size fishing vessels owned by the government organizations such as Fishery Survey of India (FSI), Central Marine Fisheries Research Institute (CMFRI), National Institute of Oceanography (NIO) and National Institute of Ocean Technology (NIOT) etc., and private agencies are equipped with acoustic, navigational and fishing aids viz., Echosounders, Sonars and Nansen sampler, Rosette sampler, Bathythermograph etc., which are used to locate thermal fronts for identifying Potential Fishing Zones.

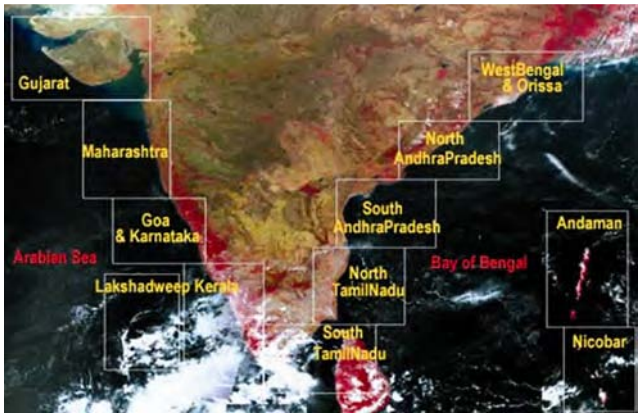

Fig. 1—PFZ advisories in 12 sectors of India

The fishing communities have developed over generations a mental model for arriving at conclusions related to availability/abundance of fish. Scientific community make use of parameters such as SST, chlorophyll, nutrients, dissolved oxygen, salinity, winds and currents to study the feeding and breeding, migratory habits of fish and thus to evolve scientific indicators of Potential Fishing Zones. Information of these parameters is derived from satellites and from in-situ platforms. Potential Fishing Zone advisories are disseminated by INCOIS on Mondays, Wednesdays and Fridays to around 200 nodes covering the entire coastline of India. To maintain fish stocks at sustainable level and conservation of fishery wealth, a uniform ban on marine fishing has been imposed by the Government of India along the east coast from April 15 to May 31 and along the west coast from June 10 to August 15 every year and during the monsoon seasons in view of the cloud coverage, the PFZ advisories have not been issued for the respective sectors during these periods.

The main objective of the study is to discuss the advantages of the application of remote sensing in the validations of potential fishing zone advisories, disseminated to the fishing community along the coast of North Tamil Nadu, India. has been discussed in the present paper.

Materials and Methods

Six major fish landing centres were selected in three coastal districts of Northern Tamil Nadu namely Thiruvallur (a. Ennore Kuppam), Chennai (a. Kasimedu - Royapuram, b. Santhome-Nochikuppam, c. Thiruvanmiyur kuppam) and Kancheepuram (a. Neelangarai kuppam and b. Kovalam kuppam) during April 2007 and March 2011 – Fig. 2) for disseminating PFZ advisories.

Fishery resources along the North Tamil Nadu coast have been traditionally exploited by a number of types of indigenous gears. Indigenous gears are broadly classified under major heads based on their mode of operation such as trawl net, bag net, inshore drag net, encircling net, hook and line and gill net etc,. During the study period, the following major pelagic gillnet gears viz, Kavala valai, Thatta valai, Vala valai, Ara valai, Pannu valai, Thuri valai, Mani valai, Irukka valai, Vauval valai, Vanjiram valai, Retta aruppu valai and Moonu aruppu valai have been

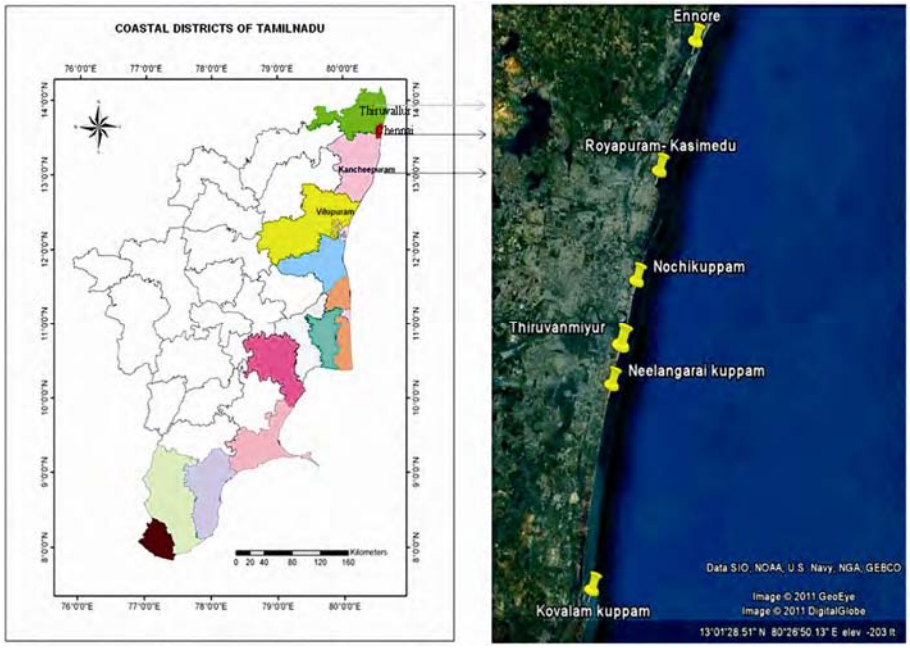

Fig. 2—Major selected fish landing centres of the coastal districts of North Tamil Nadu.

used for fishing. Major fishing crafts used for pelagic fishing were 32 feet length, out board engine fitted fiber boats. Identical fishing vessels were hired and used for experimental fishing in the PFZ areas for concurrent validations. SST images from NOAA-AVHRR satellite data using Multi Channel Sea Surface Temperature (MCSST) approach[7] and Ocean Colour Monitor (OCM) data for chlorophyll computations were generated[8&9] Fig. 3.

Generation of fishery forecast

PFZ information in the form of maps is generated by compositing daily SST images of three or four days to obtain maximum thermal gradient information. These images are filmed to prepare relative thermal gradient image. Name of the landing centres and land marks are also featured and the location of the PFZ area with reference to a particular fish landing centre is drawn (as thick line) by identifying the nearest point of the thermal feature to that of the fishing centre. (Figs 4-5). PFZ map also possesses the direction, distance (km), bathymetry (m), validity period and latitude and longitude (˚). Both the map and the message are useful to the fishermen when they go for fishing.

Dissemination of PFZ advisories

Initially the descriptive information has been disseminated with reference to major fish landing centres. Institute for Ocean Management (IOM),

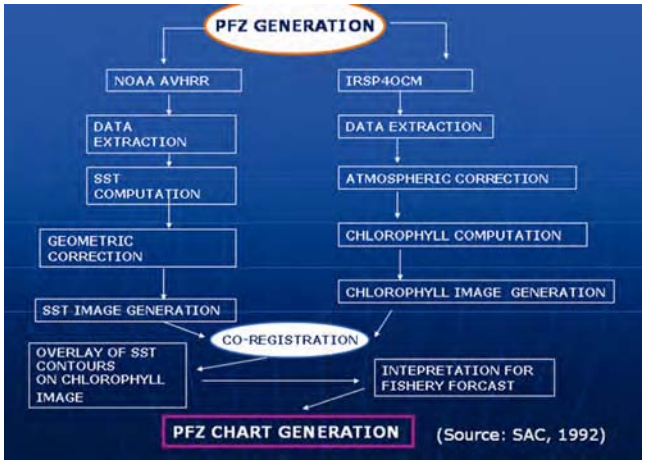

Fig. 3—PFZ generation Methodology

Anna University, Chennai is the nodal agency to implement this forecast for north Tamilnadu Sector. The PFZ advisories were disseminated to the fishing community using a wide range of media such as fax, telephone/cell phone, All India Radio, Doordharshan, other private TV channels, electronic display boards, E-mail, web site as well as print media in north Tamilnadu to enable the fishing community to obtain information and attempt for more fishing in the PFZ areas (Fig. 6). Disseminated PFZ advisories are valid for 3 to 4 days. The user awareness campaigns were conducted in major selected fish landing centres to educate the fishermen and to collect first hand feedbacks. With a view to validate the advisories and

NORTH TAMILNADU வடதமி›நாடு

नार्थ तामिलनाडु

SATELLITE DATA SHOWS LIKELY AVAILABILITY OF FISH STOCK TILL October 20, 2010

செயகைகோதகவ காடுன்வளநிறைதபகுதி

उपग्रह आकडों से October 20, 2010 तक की संभावित मत्स्य भंडार की उपलब्धि।

From the Coast of கடகரையிலிருது समुद्र कि तट से		Direction திசை दिशा मे	Angle in Degrees கோண› कोण (डिग्री मे)	Distance in Km தூர› (கி.மீ) दूरी (किलो मीटर मे)		Depth inBagam ஆழ› (மீ) गहराई (मीटर मे)		Latitude / Longitude रेखांश / अक्षांश
				From லிருது कहाँ से	To வரை कहाँ तक	From லிருது कहाँ से	To வரை कहाँ तक	
Point Calimere	கோடிகரை	NE	17	22	27	10	15	10 29 44.80N 79 55 56.94E
पोईंट कालिमेरे								
Vedaranniyam	வேதாரய	E	90	14	19	10	15	10 29 44.80N 79 55 56.94E
वेदापान्नियाम								
Velanganni	வேளாகணி	SE	111	11	16	15	20	10 39 11.98N 79 57 35.70E
वेल्लान्गान्नि								
Nagapattinam	நாகபடிண	SE	129	14	19	15	20	10 40 05.99N 79 57 53.66E
नागापाटीनाम								
Nagore	நாகூ	NE	56	20	25	40	45	10 55 24.28N 80 01 11.17E
नागोरे								
Karikal	காரைகா	NE	60	18	23	40	45	11 00 03.37N 80 00 53.22E
कारिकाल								
Tranquebar	தாரகபாடி	NE	67	13	18	30	35	11 04 51.46N 79 58 56.50E
त्रान्कुएबार								
Kaverippattinam	காவரிபடி ண	SE	115	14	19	35	40	11 03 57.45N 79 59 23.44E
कावेरिप्पाटिनाम								
Tirumullaivasal	திருலைவா ச	SE	141	25	30	40	45	11 03 12.43N 79 59 14.46E
तिरुमुल्लईवासाल								
Pondicherry	பாடிசேரி	NE	46	23	28	25	30	12 04 07.59N 80 00 17.31E
पोन्दिचेरि								
Malakkanam	மரகான	SE	153	12	17	25	30	12 03 49.58N 80 00 26.28E
मालाक्कानाम								
Cheyur	செயூ	SE	179	26	31	25	30	12 04 34.60N 80 00 35.26E
चेयुर								
Mahabalipuram	மகாபலிபுர	NE	38	32	37	50	55	12 51 05.48N 80 23 01.96E
महाबालिपुराम								
Covelong (Kovalam)	கோவ	NE	51	16	21	50	55	12 53 47.53N 80 23 10.94E
चोवेलोन्ग								
Cathedral (Madras)	சென்னை (கே	SE	137	16	21	45	50	12 54 59.56N 80 23 10.94E
कथेद्राल माद्रास								
Madras	சென்னை	SE	152	20	25	45	50	12 55 53.57N 80 23 19.92E
माद्रास								
Ennur	எணூ	SE	166	23	28	30	35	13 00 59.67N 80 22 44.01E
ऐन्नूर								

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संभाव्य मत्स्य क्षेत्र का परामर्श
इंकोइस INCOIS
Potential Fishing Zone Advisories

निदेशक, भारतीय राष्ट्रिय महासागर सूचना सेवा केंद्र (इंकोईस),
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Fig. 4—Sample chart of Potential Fishing Zones in North Tamil Nadu sector

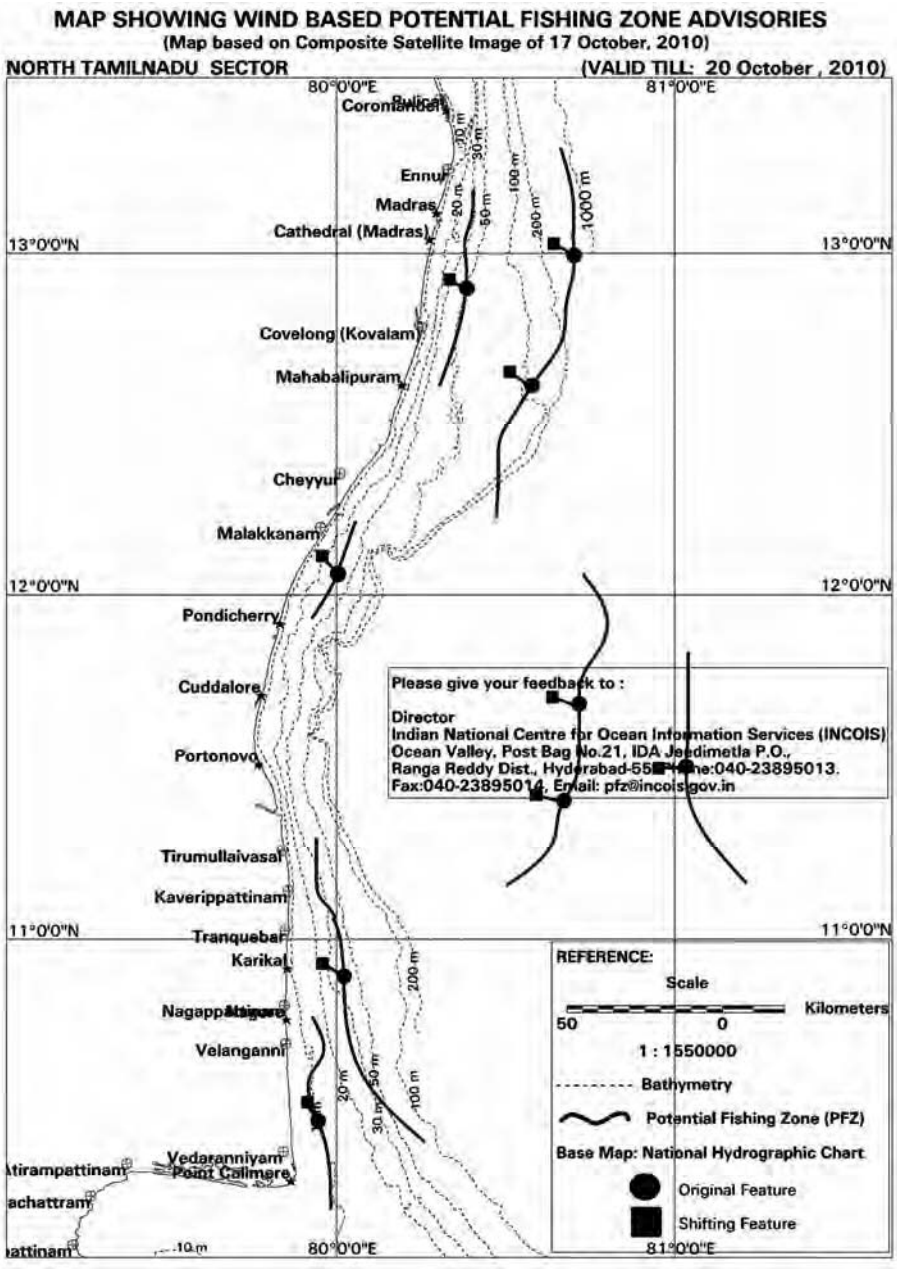

Fig. 5—Sample map showing Potential Fishing Zones (thick lines) in North Tamil Nadu sector

to qualify the potential benefits of the technology, concurrent validation studies have been taken up.

Results and Discussion

PFZ Validations

The total fish catch caught within the PFZ and outside PFZ area which landed in major selected fish landing centres along the coast of North Tamilnadu were compared in the present study. Validations were undertaken through a selected group of active fishermen at the selected fish landing centres mentioned and presented in the (Figs 7-9). It may be revealed that the fish catch obtained from the PFZ area was significantly high in Kancheepuram coastal district when compared to Thiruvallur and Chennai coastal districts in North Tamilnadu (Fig.10). The differential variations in the fish catches may be due to the thermal gradient and chlorophyll content in the sea.

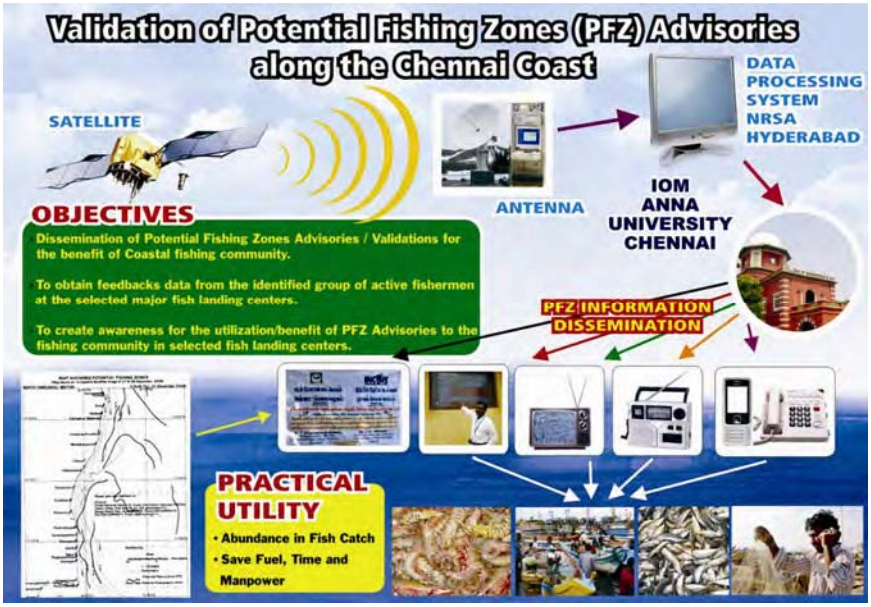

Fig. 6—PFZ dissemination

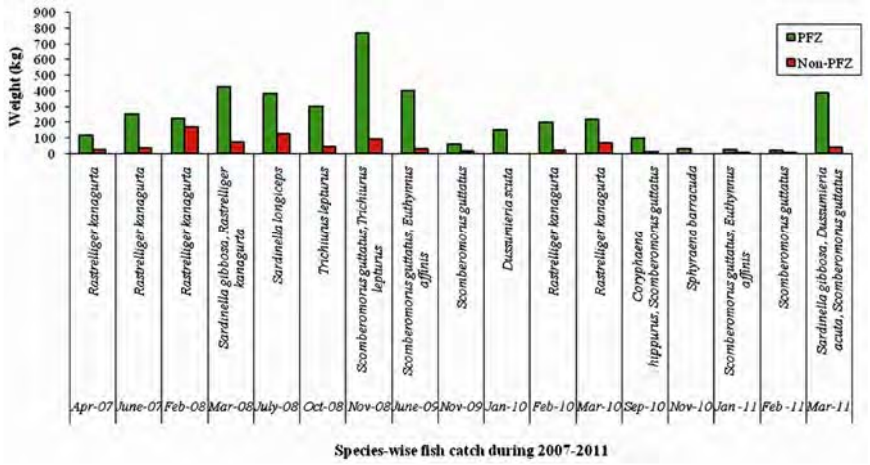

Fig. 7—Fish catch in Thiruvallur District, Tamilnadu

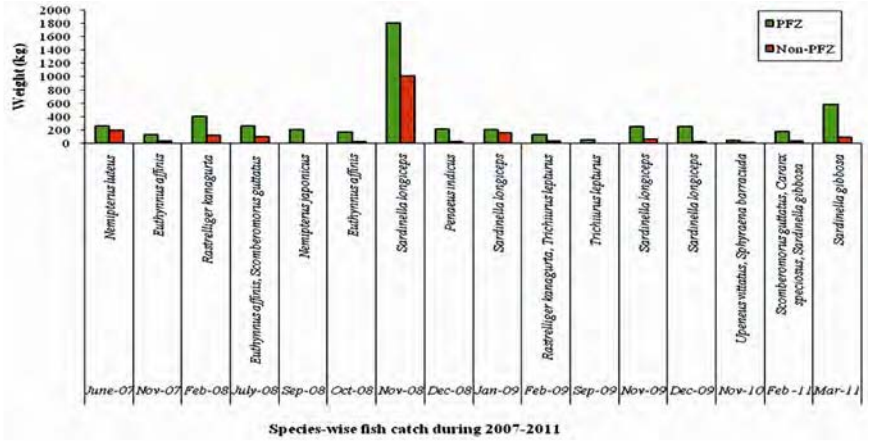

Fig. 8—Fish catch in Chennai District, Tamilnadu

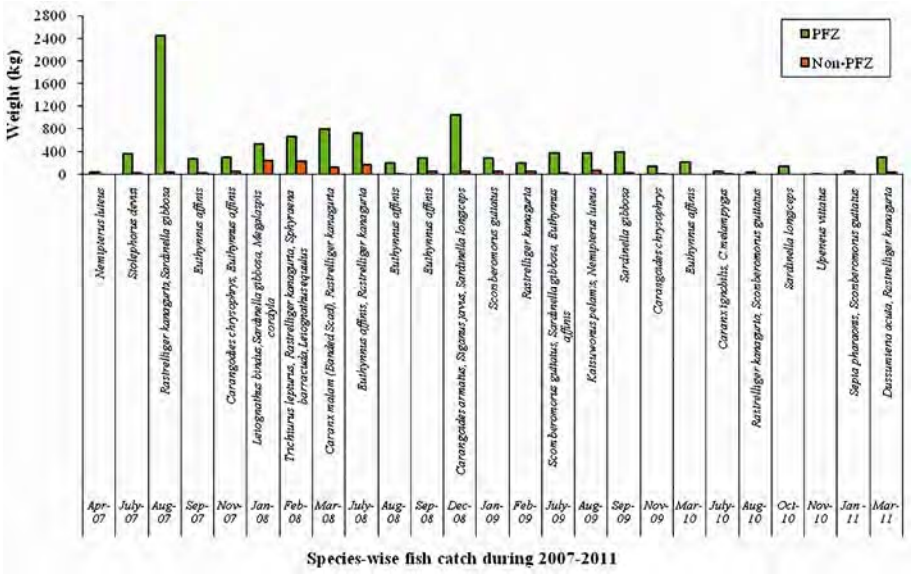

Fig. 9—Fish catch in Kancheepuram District – Tamilnadu

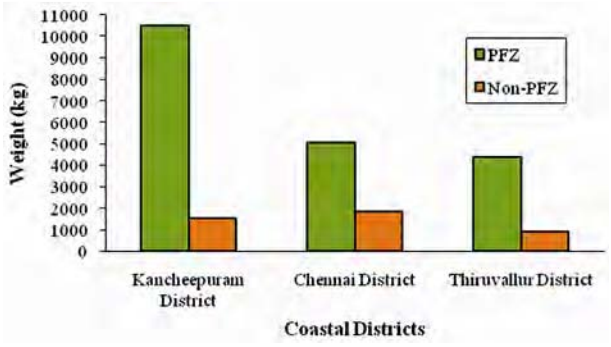

Fig. 10—Total fish catch in three coastal districts of North Tamilnadu

Major fish groups such as Seerfish (*Scomberomorus guttatus*), Little tuna (*Euthynnus affinis*), Ribbonfish (*Trichiurus lepturus*), Sardines (*Sardinella gibbosa, S.longiceps*), Russell's Scad (*Decapterus russelli*) and Indian mackerel (*Rastrelliger kanagurta*) respectively were dominated in the catch from Thiruvallur District (Ennore).

Similarly, the major fish groups such as Sardines (*Sardinella longiceps*), Indian Mackerel (*Rastrelliger kanagurta*), Ribbon fish (*Trichiurus lepturus*), Little tuna (*Euthynnus affinis*), Shrimps (*Penaeus indicus*), and Threadfin bream (*Nemipterus japonicus*) respectively were dominated in the catch in Chennai district (Kasimedu, Nochikuppam and Thiruvanmiyur kuppam).

In the case of fish catch from Kancheepuram district (Neelangarai kuppam and Kovalam kuppam) the dominant groups such as Sardines (*Sardinella gibbosa*), Indian mackerel (*Rastrelliger kanagurta*), Little tuna (*Euthynnus affinis*), Carangids (*Carangoides armatus*), Rabbit fish (*Siganus javus*) and Silverbellies (*Leiognathus bindus*) were respectively contributed the fishery.

In spite of many awareness programmes conducted in Chennai coastal district, the total fish catch was low when compared to Kancheepuram coastal district since the fishermen have other alternative livelihood activities such as tourism, industries and other micro-enterprises.

Experimental fishing for concurrent validations

The experiments conducted in the PFZ area from April 2007-March 2011 along the coast of North Tamilnadu revealed the fish catch composed of Indian mackerel (*Rastrelliger kanagurta*), Seerfish (*Scomberomorus guttatus*), Carangids (*Caranx malam, Carangoides chrysophrys*-Fig.11), Tuna (*Katsuwonus pelamis*), Little tuna (*Euthynnus affinis* – Fig.12) and Rabbit fish (*Siganus javus*). Results of the simultaneous experimental fishing for concurrent validations are shown in the Tables 1-3. Weight of total fish catch within the PFZ areas ranged from 50 to 1210 kg when compared to non-PFZ area (5-140 kg). Total value of fish catch in PFZ was ranged from ₹. 4,500 to 41,000 when compared to non-PFZ areas (₹. 2,00 to 5,000).

The percentage of advantage derived within PFZ area ranged from 81.6% to 96.8% when compared to non-PFZ area (3.2% to 18.4%).

This paper considers remote sensing of the sea in North Tamilnadu coast (Bay of Bengal) on the use of

Fig. 11—Sample of fish catch from PFZ area – Carangids (*Carangoides chrysophrys*)

Fig. 12—Sample of fish catch from PFZ area – Little Tuna (*Euthynnus affinis*)

surface sea water temperature and chlorophyll content through remotely sensed ocean color techniques and their applications in the context of locating potential fishing zones[10]. Validations of sea surface temperature in the Arabian Sea derived from satellite microwave and infrared sensors are reported[11]. Further a knowledge based expert system model working on the basis of a geographical information system (GIS) was applied to predict fishing grounds/ spots in the coastal waters of south and central Sulawesi in Indonesia[12]. Validations of integrated potential fishing zone (IPFZ) forecast using satellite based chlorophyll and sea surface temperature along the east coast of India was made[13]. The fishery survey of India fishing vessel of Visakapatnam base were used to validate the IPFZs based on only four feedbacks (November 2002, March, April and December 2003) in terms of categorized fish catch per unit effort, along with location informations,

Table 1—Results of experiments in PFZ/Non PFZ areas (weight-wise) during April 2007-March 2011

No.	Month/ Year	Major Species	Total catch (kg) PFZ area	Non- PFZ area
1	Feb-08	*Rastrelliger kanagurta*	180	60
		Sphyraena bleekeri	60	--
2	Mar-08	*Caranx malam*	450	75
3	Jul-08	*Euthynnus affinis*	500	100
4	Nov-08	*Scomberomorus guttatus*	320	50
		Siganus javus	300	--
5	Dec-08	*Carangoides chrysophrys*	300	--
		Lethrinus nebulosus.	--	25
6	Jan-09	*Scomberomorus guttatus*	300	60
7	Feb-09	*Rastrelliger kanagurta*	200	--
		Carangoides chrysophrys	--	40
8	Aug-09	*Katsuwonus pelamis*	300	80
		Rastrelliger kanagurta	220	--
9	Mar-10	*Sardinella albella*	--	70
		Euthynnus affinis	220	--
		Sphyraena barracuda	--	15
10	Oct -10	*Sardinella longiceps*	150	5
11	Jan-11	*Sepia pharaonis*	20	8
		Scomberomorus guttatus	30	--
12	Mar-11	*Sardinella gibbosa*	800	140
		Dussumieria acuta	410	--

Table 2—Results of experiments in PFZ/Non PFZ areas (value-wise) during April 2007-March 2011

No.	Month/ Year	Major Species	Total Values (Rs.) PFZ Area	Non PFZ Area
1	Feb-08	*Rastrelliger kanagurta*	15000	3000
		Sphyraena bleekeri		--
2	Mar-08	*Caranx malam*	15000	2600
3	Jul-08	*Euthynnus affinis*	25000	5000
4	Nov-08	*Scomberomorus guttatus*	19200	3000
		Siganus javus		
5	Dec-08	*Carangoides chrysophrys*	41000	--
		Lethrinus nebulosus	--	2000
6	Jan-09	*Scomberomorus guttatus*	21000	4200
		Rastrelliger kanagurta	22000	--
7	Feb-09	*Carangoides chrysophrys*	--	4500
8	Aug-09	*Katsuwonus pelamis*	9000	2400
		Rastrelliger kanagurta	30000	--
9	Mar-10	*Sardinella albella*	--	2100
		Euthynnus affinis	11000	--
		Sphyraena barracuda	--	900
10	Oct -10	*Sardinella longiceps*	4500	200
11	Jan-11	*Sepia pharaonis*	3600	1200
		Scomberomorus guttatus	9600	--
12	Mar-11	*Sardinella gibbosa*	22755	3410
		Dussumieria acuta	7500	--

Table 3—Results of experiments in PFZ/Non PFZ areas (percentage-wise) during April 2007-March 2011

No.	Month/ Year	Major Species	Advantage (%) PFZ Area	Non PFZ Area
1	Feb-08	*Rastrelliger kanagurta* *Sphyraena bleekeri*	84.8	15.2
2	Mar-08	*Caranx malam*	86.4	13.6
3	Jul-08	*Euthynnus affinis*	90.9	9.1
4	Nov-08	*Scomberomorus guttatus* *Siganus javus*	95.7	4.3
5	Dec-08	*Carangoides chrysophrys* *Lethrinus nebulosus*	96.3	3.7
6	Jan-09	*Scomberomorus guttatus*	95.2	4.8
7	Feb-09	*Rastrelliger kanagurta* *Carangoides chrysophrys*	94	6
8	Aug-09	*Katsuwonus pelamis*	81.6	18.4
9	Mar-10	*Rastrelliger kanagurta* *Sardinella albella* *Euthynnus affinis* *Sphyraena barracuda*	83.8	16.2
10	Oct -10	*Sardinella longiceps*	96.8	3.2
11	Jan-11	*Sepia pharaonis* *Scomberomorus guttatus*	86.2	13.8
12	Mar-11	*Sardinella gibbosa* *Dussumieria acuta*	89.6	10.4

whereas the present study conducted during April 2007-March 2011 a total of 63 numbers of feedbacks were collected. Further in order to authenticate the PFZ advisories, 17 numbers of experimental fishing were conducted and correlated. In the present study, the feedback analysis indicates that the fish catch was found to be high in the confluence of SST and Chlorophyll features based on satellite imageries in the PFZ area when compared to Non-PFZ locations.

Awareness campaigns

A total of 43 awareness campaigns on the dissemination and utility of the PFZ advisories were conducted in the major selected fishing villages in Thiruvallur, Chennai and Kancheepuram coastal districts (Figs 13-15). Method of using the PFZ map and Global Positioning System (GPS) were explained to the fishermen in locating the PFZ area in the sea. Expected outcome from these awareness campaigns and the number of beneficiaries in each location were evaluated and presented in (Table 4)

Fig. 13—Awareness program at Ennore kuppam (Thiruvallur district)

Fig. 14—Awareness program at Thiruvanmiyur kuppam (Chennai district)

Fig. 15—Awareness program at Neelangarai kuppam (Kancheepuram district)

Fig. 16—Awareness program at Kovalam kuppam (Kancheepuram district)

Table 4—Number of beneficiaries in the fishing community

Districts	Fishing villages	Respondents (No.)	Respondents (%)
Thiruvallur	Ennore Kuppam	256	20
Chennai	Kasimedu	28	37.3
	Nochikuppam	210	
	Thiruvanmiyur	240	
Kancheepuram	Neelangarai	222	42.7
	Kovalam	325	
Total number of Respondents/Percentage		1281	100

Conclusion

Based on the findings of PFZ and non-PFZ areas, conducted in three coastal districts of North Tamilnadu, the remotely sensed data provided by the INCOIS has proved to be a useful tool in enhancing not only the fish catch, revenue to the fishermen but also reduces the searching time, fuel costs and human efforts.

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