

## Satellite based potential fishing zone (PFZ) advisories - acceptance levels and benefits derived by the user community along the Kerala coast

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### ABSTRACT

Intensive validation studies of potential fishing zone (PFZ) advisories generated using integration of ocean colour monitor (OCM) derived chlorophyll concentration and advanced very high resolution radiometer (AVHRR) derived sea surface temperatures (SST) were undertaken by the Indian National Centre for Ocean Information Services (INCOIS) along Kerala coast during the period 2003-2011. There is a positive relationship between PFZ advisories and occurrence/abundance of commercially important pelagic fishes such as oilsardine, Indian mackerel, anchovies, carangids and coastal tunas. Fishing operations undertaken on or closer to dates on which related SST/chlorophyll images have been received yielded positive results. As the gap increases, the yield within PFZ is likely to come down unless the features remain more or less in the same location as revealed by succeeding satellite imagery. The present paper revealed that the fish catch (CPUE) and net profit earned are higher within PFZ compared to the results of operations outside PFZ. The usefulness of PFZ advisories, the only short term marine fishery forecast available in the country for fisherfolk towards obtaining comparatively higher catch per unit effort for the above mentioned major pelagics is proved beyond doubt from the results of more than 100 controlled experiments conducted within and outside PFZ with identical fishing gear along Kerala coast.

Keywords: Chlorophyll, Pelagic fishes, Potential fishing zone, Shifted feature

### Introduction

Kerala state with a coastline of 590 km situated along the south-west coast of India lands on an average 5 lakh metric t of marine fish against the total landings of 30 lakh metric t for the entire Indian coast including island territories. The export of marine products from the state earns valuable foreign exchange besides affording innumerable job opportunities in the industry. The population depending on fisheries has steadily increased over the years and stood at 6,02,234 in 2005 (CMFRI, 2005).

Marine fish landings along the Kerala coast during the year 2010 was 5,30,078 t (CMFRI, 2011). The pelagic fishery resources contributed 71%, demersal finfish 15%, crustaceans 8% and molluscs 6%. Mechanised sector contributed 62%, motorised 37% and artisanal sector 1%. The major fishing gear contributing to the fishery was ring seine (51.6%). Catch per unit effort (CPUE) of mechanised ring seine was 1207.4 kg compared to 713.4 kg in outboard ring seine and 979.2 kg in mechanised purse seine.

The Indian National Centre for Ocean Information Services (INCOIS) at Hyderabad under the Ministry of Earth Sciences operationally generates and disseminates potential fishing zone (PFZ) advisories for the benefit of fishing community. These multilingual PFZ advisories are generated on every Monday, Wednesday and Friday during

non-ban and non-cloudy days to about 500 fish landing centres/fishing villages covering all coastal states and islands. The advisories are being disseminated through various mechanisms like telephone/fax, e-mail, web, newspapers, radio, Doordarshan, electronic digital display boards, information kiosks, mobile phones *etc.* Currently, about 50,000 users around the country are regularly utilizing these services for their fishing operations. Also to ensure the safety of the fishermen and to decide on whether to venture into the sea or not, INCOIS provides 3-hourly forecast of ocean state that includes ocean wave heights/direction and wind speed /direction for specific locations.

### Marine fishery forecast

It is well known that the adaptation of fish to the surrounding marine environment is controlled by various physico-chemical and biological factors. Fishes are known to react to changes in the surrounding environmental conditions and migrate to areas where favourable environmental conditions in terms of seawater temperature, salinity, dissolved oxygen level *etc.* exist. The availability of food is an important factor that controls their occurrence, abundance and migrations in the sea. Sea surface temperature (SST) is the most easily observed environmental parameter and is quite often correlated with the availability of fish, especially pelagic fish. Changes in

SST can result from changes occurring in the direction/velocity of both horizontal and vertical circulation processes in the sea. Many pelagic species are known to concentrate at current boundaries especially in areas with sharp horizontal temperature gradients. Monitoring the above mentioned parameters in space and time is time consuming and prohibitively expensive and a real time picture of any one of these parameters or a combination of the above becomes almost impossible. Indirect methods of monitoring selected parameters such as SST and phytoplankton pigments (chlorophyll-*a*) at sea surface from satellites is found very ideal as it provides highly repetitive values and large spatial coverage.

The usefulness of PFZ advisories for locating pelagic fish concentrations along Kerala coast was initiated jointly by scientists of Space Application Centre, Ahmedabad, Central Marine Fisheries Research Institute, Kochi and Fishery Survey of India, Mumbai as early as 1981 (Gopalan and Silas, 1985; Dwivedi *et al.*, 1986; Narendranath *et al.*, 2001). Subsequently the usefulness of the technology was established based on validations attempted since 1996 (Pillai *et al.*, 2010; 2011).

Trawl ban is being observed along Kerala coast for a period of 47 days every year from 15<sup>th</sup> June. Pelagic fishing activities such as ring seining, gillnetting, hooks and line fishing *etc.* are continued during the ban period. Vessels fitted with engines of 9.9 hp and below are permitted to operate irrespective of the type of fishing activity undertaken. During the trawl ban period, a large percentage of crew members employed onboard trawlers are deployed onboard ring seiners. When the average requirement of deckhands for a medium sized trawler is only 5, the requirement of crew to handle a medium to large sized ring seiner is 30 to 40 depending on the OAL/ BHP of the vessel and also the length as well as vertical hanging of the fishing gear. Alternate employment provided for crew of bottom trawlers onboard ring seiners during the trawl ban period reduced the friction among the fishermen engaged in different types of fishing operations. Dissemination of PFZ advisories was discontinued by INCOIS during the trawl ban period also.

## Materials and methods

PFZ advisories brought out by INCOIS during the period under report were disseminated and validated through selected number of artisanal/motorised/mechanised sector fishing vessels based at major fishing harbours/landing centres *viz.*, Neendakara, Sakthikulangara, Thottappally, Ambalapuzha, Purakkad, Alappuzha, Andhakaranazhi, Manakkodam, Fort Kochi, Vypeen, Munambam, Azhikkode, Nattika, Ponnani, Beypore, Puthiappa, Koylandi, Badagara, Mahe, Thalassery and

Kannur depending on the location of individual PFZ advisory and proximity to one or more of the above mentioned landing centres. Depending on the location of PFZ, the contents of each advisory were passed on to the particular group of active fishermen and the feedback was recorded when the vessel returned to the shore after conducting the fishing operations. The feedback was also gathered through selected representatives from the fishermen community who were either placed onboard the mother boat as one of the crew members or sent onboard a hired boat for collecting factual information on the spot.

In order to study the effectiveness of wind based PFZ advisories, effort was put in to observe the CPUE of more or less identical fishing vessels on day 1, 2, 3, 4 and 5 along the track followed by the shifting feature. The quality (species-wise identification) as well as quantity (approximate) of fish catch is also reconfirmed by the enumerator on the spot (out at sea) when the enumerator who is invariably drawn from the fishermen community visits the area of fishing activity onboard a hired vessel or at the landing centre.

The consolidation of the data gathered from different landing centres was undertaken every month and average CPUE for different types of operations calculated. The average reduction in searching time for individual PFZ for different species was also calculated. Information on changes observed in the major environmental conditions such as seawater temperature, salinity, dissolved oxygen content, nutrients, primary/secondary productivity of surrounding waters, prey-predator relationships and feeding habits of major varieties of fish landed *etc.* were gathered from simultaneous hydrographic observations undertaken both within and outside notified areas located in and around Kochi onboard a 62' OAL purse seiner and also from relevant literature for possible correlation with occurrence/abundance of major varieties caught within and outside notified areas.

Necessary steps were always taken to ensure that the information contained in individual advisory reaches active fishermen groups at the location within the minimum possible time. The period from June to October (cloudy months) was utilized for educating the fishermen groups on the usefulness of the technology and also for participating in awareness campaigns organised among active fishermen groups at major fishing harbours/landing centres. This period was also utilized for gathering information from available literature to throw light on the relationship between environment and availability/abundance of fishes reflected in their behaviour leading to feeding/breeding migrations and shoaling behavior in space and time. During the period under report, more than 100 controlled experiments were conducted by hiring more or

less identical commercial fishing vessels to obtain concurrent and quantitative feedback on the total fish catch (species-wise) within and outside notified areas (PFZ). A representative drawn from the local fishermen community was also sent onboard the vessel conducting fishing activity within notified area to obtain the right information pertaining to fishing activity.

## Results and discussion

PFZ advisories generated from satellite retrieved SST and chlorophyll data were found to be good indicators of the availability/abundance of pelagic fishes such as sardines, mackerel, anchovies, tunas and carangids. These advisories are found beneficial to artisanal, motorised and small mechanised fishermen engaged in pelagic fishing activities such as ring seining, purse seining, gillnetting *etc.* for locating concentrations of these highly migratory pelagic species, thereby reducing the searching time which in turn resulted in the saving of valuable fuel oil and also human effort. In view of the likely concentration of pelagic shoals in thermal boundaries and areas of phyto/zoo plankton abundance, fishing undertaken in potential fishing zones yielded comparatively higher catch per unit effort.

### *Advantages derived for different types of fishing operations*

Positive relationships between PFZ resulting out of comparatively high gradients of SST/chlorophyll and fishable concentrations of commercially important fishes was found only in respect of pelagic and column fishing activities such as purse seining, ring seining, gillnetting and trolling activities. In the case of bottom trawling activity, the relationship was found to be negligible except in the case of pelagics, which undertake diurnal vertical migration (*eg.* mackerel and horse mackerel).

The study revealed that the reduction in searching time reported for pelagic shoaling fishes is mainly dependent on the following factors:

- a) The time lag between satellite data acquisition and dissemination of PFZ advisory to the end-user and the fishing activity in view of the fact that the characteristics of the thermal front as well as the surface chlorophyll concentration are likely to get dissipated through horizontal/vertical circulation processes active in the area and also consumption at different trophic levels.
- b) The fishing methods adopted, *viz.*, gillnetting, ring seining, purse seining and trolling and the time at which the fishing activity is undertaken.
- c) Type of fish targeted. The top/bottom depth of the thermocline is a major factor controlling the effectiveness of operation of purse seines and ring

seines. Unless the fishing gear has a vertical hanging, which extends beyond the depth of the thermocline, depending on the time of activity, a certain percentage of the fish shoal is likely to escape through the bottom before the gear is pursued.

Catchability and in turn CPUE in purse seining as well as ring seining is comparatively high when fishing operations are conducted during early morning and late evening hours in view of the fact that metabolic activity is comparatively low among pelagics during dawn and dusk. Metabolic activity increases by noon with increasing seawater temperature. Success of gillnetting is found to be comparatively high during night time when the gear is released after sunset and hauled in before sunrise especially during the newmoon phase.

Catchability and in turn CPUE in purse seining as well as ring seining is comparatively low at times when shoals are sighted at subsurface levels during day time due to difficulties in encircling the shoal in view of the comparatively higher metabolic activity exhibited by the fish as well as mistake likely to be committed in assessing the depth at which the shoal is moving because of distortion caused by direct sunlight (*eg.* oilsardine shoals off Kerala during April and May).

### *Advantages derived for different types of targeted species*

Depending on the behaviour of individual species in relation to variations in sunlight intensity, seawater temperature, salinity, dissolved oxygen demands, feeding habits, feeding preferences, and breeding habits, suitable fishing gear will have to be employed for catching different types of fishes *viz.*, oilsardine, mackerel, tuna, anchovies, carangids, seerfish *etc.*, which mostly belong to annual year class and their availability very much depends on the changes in the prevailing environmental conditions which ultimately decide the success of their spawning activity, mortality of eggs and larvae, recruitment to the fishery, availability of suitable feed for further growth, shoreward/seaward/alongshore migrations, diurnal vertical migrations *etc.* Among fishes like mackerel, oilsardine, anchovies, small tunas, carangids and seerfish, maximum advantage in terms of reduction in searching time as well as increase in CPUE are found in respect of ring seining and purse seining. In the case of mackerel, since mature fish is known to undertake vertical migrations, matured mackerel is also caught in bottom trawling gear during day time especially during the summer months when they migrate to subsurface waters to avoid comparatively warmer surface waters. Possibly due to the effect of global warming, of late the tendency is found more or less during all the months except during the rainy season (south-west and north-east monsoon).

Reduction in searching time is found to be maximum (60-70%) for oilsardine shoals in ring seining with 30-50% reduction reported for mackerel, anchovy, tuna and carangid shoals in ring seine operations. It was noted that fishing operations undertaken on or closer to dates on which related SST/ chlorophyll imageries have been received, yielded positive results. When the gap increased, the yield within PFZ is likely to come down unless the features remain more or less at the same location as revealed by the succeeding satellite imagery. This is especially so when the coastal currents (monsoon drifts) takes effect during the period November-March (north-east monsoon drift which is northerly along the west coast). The monsoonal drift during south-west monsoon *i.e.*, June to September does not assume much significance in view of total fishing ban/trawl ban along west coast /Kerala coast and absence of advisories during the south-west monsoon period. This also could be the possible explanation for a certain percentage of success outside PFZ and failures within the declared PFZ.

In order to make profit, individual boats will have to reduce the cost of operation to the barest minimum by way of reducing the fuel consumption since the actual fish catch will depend on many environmental factors which influence the availability and abundance of a particular species of fish in space and time. In the absence of PFZ advisories, these vessels will have to blindly search for fish shoals of suitable dimension in order to catch them. In the absence of PFZ, very often these vessels utilize lot of fuel

for searching and return to the base without coming across a single shoal.

In general, oilsardine shoals are found nearer to the coast between a running distance of 10 to 20 km or even nearer whereas mackerel, coastal tuna and carangid shoals are invariably found away from the coast beyond 20 km. The comparatively higher unit returns for mackerel, tuna and carangids to a certain extent compensate the extra cost on fuel. In the case of multi-day fishing activity lasting for a week or so (as in the case of purse seiners operating along Kerala coast), the economics of operation will improve greatly since the vessel is not returning to the base every day thereby saving fuel. The fish catches can be brought to the shore periodically by carrier boats in case the total catch exceeds the frozen storage capacity of the mother boat.

Based on the results of more than 100 controlled experiments undertaken during the period under report employing more or less identical ring seiners (13-21 m OAL 90-140 HP) within and outside notified areas (PFZ), the total fish catch as well as profit earned by individual ring seiner engaged in daily fishing activity within notified area (PFZ) was found to be considerably higher compared to vessels which operated outside PFZ (Table 1) because of comparatively higher CPUE and through reduction in searching time resulting in the saving of valuable fuel oil and human effort.

Table 1. Average CPUE (kg) for major species caught and average profit earned (Rs.) by ring seiners engaged in daily fishing activity within and outside notified area along Kerala coast (April, 2006 - May, 2011)

Total number of controlled experiments conducted engaging identical ring seiners	Major species caught	Average CPUE (kg)		Average profit earned (Rs.)	
		Within notified area	Outside notified area	Within notified area	Outside notified area
20	Oilsardine ( <i>Sardinella longiceps</i> )	1544	243	41495	5903
29	Indian mackerel ( <i>Rastrelliger kanagurta</i> )	1360	207	94711	15341
25	Carangids ( <i>Decapterus russelli</i> )	1285	241	96571	18265
7	<i>Alepes djedaba</i>	1125	234	64155	12000
2	Trigger fish ( <i>Odonus niger</i> )	1650	337	64670	6612
3	<i>Megalaspis cordyla</i>	1700	312	33192	4533
3	Yellow fin tuna ( <i>Thunnus albacares</i> )	2833	566	72220	13330
6	Coastal tuna ( <i>Auxis rochei</i> )	3300	870	54595	6972
3	Anchovies ( <i>Stolephorus commersoni</i> )	1233	217	25375	1125
2	Penaeid shrimp ( <i>Metapenaeus dobsoni</i> )	2500	450	127350	42610
1	Cuttlefish ( <i>Sepia pharaonis</i> )	1350	700	6442	2866
2	Barracuda ( <i>Sphyraena</i> spp.)	1366	291	76010	12425
1	Seerfish ( <i>Scomberomorus</i> spp.)	1150	110	82350	4170

### Direct and indirect beneficiaries of PFZ advisories along Kerala coast

As on today, the total number of fishermen who are directly benefited by the PFZ advisories along Kerala coast between Kollam and Kannur are 1350 active fisherfolk employed onboard a total of 45 ring seiners (on an average minimum of 30 fishermen on board each vessel), another 150 fisherfolk employed onboard 30 gillnetters/ hooks and line vessels, another 250 active fisherfolk employed onboard a total of 50 bottom trawlers and 30 active fishermen employed onboard three purse seiners. The total number of fisherfolk indirectly benefited by the technology is around 12,150 fishermen employed onboard a total of 405 ring seiners and 1,350 employed onboard 270 gillnetters and 500 fishermen employed onboard 50 purse seiners thereby making a grand total of 15,780 active beneficiaries. (Table 2 and 3).

Since the direction in which the feature is likely to get shifted within the next 2 or 3 days is clearly indicated in the diagram, fishermen could navigate in the same direction of shifting feature and locate a sizeable shoal of these highly migratory pelagics.

The study revealed that PFZ advisories, the only short-term forecast for marine fisheries available in the country which are brought out on the basis of satellite derived SST and chlorophyll imageries is found useful for locating pelagic fish concentrations. The major beneficiaries are the artisanal and small scale mechanised/ motorised sector fishermen. Timely forecasts of PFZ based on SST and or surface chlorophyll concentrations can help in increasing fish catch and minimise the searching time for shoaling fishes which in turn can result in the saving of valuable fuel for the mechanised/motorised vessels there by bringing down the overall cost of fishing operations. Fishing

Table 2. Direct beneficiaries of PFZ advisories along central and north Kerala coast (Kollam to Kannur)

Category of fishing vessels	Total number available in the area under study	No. of vessels which actively participated in the controlled experiments	Total number of fisherfolk working onboard each vessel	Total number of direct beneficiaries
Ring seiners	450	45	30	1350
Gillnetters/ Hooks and line	300	30	5	150
Bottom trawlers	50	50	5	250
Purse seiners	53	3	30	90
Total				1840

Table 3. Total number of active fisherfolk (direct and indirect) benefited by PFZ advisories along central and north Kerala coast (Kollam to Kannur)

Category of fishing vessels	Total no. of direct and indirect beneficiaries
Ring seiners	13500
Gillnetters/ Hooks and line vessels	1500
Bottom trawlers	250
Purse seiners	530
Grand total	15780

\*Direct beneficiaries receive the forecast either through fax/ telephone messages or through electronic digital display boards installed at major fishing harbours/ landing centres.

\*\*Indirect beneficiaries receive the information mainly through mobile phones.

INCOIS initiated action for incorporating the wind component in PFZ advisories where possible area of shifting feature is also indicated in the advisory, since August 2009. Results of validation experiments conducted with more or less identical vessels off Kerala coast had an advantage of providing information related to shifting feature to active fishermen engaged in pelagic fishing activities (Table 4).

operations undertaken on or closer to dates on which related SST/chlorophyll images have been received yielded positive results. When the gap increases, the yield within PFZ is likely to come down unless the features remain more or less in the same location as revealed by the succeeding satellite imagery. The fish catch within PFZ gave higher CPUE and net profit compared to the results of operations outside PFZ. Average income derived by vessels which operated in the PFZ were considerably higher than vessels which operated outside PFZ. Fishing expenses were also comparatively less for vessels which operated within PFZ through reduction in searching time which in turn resulted in saving of valuable fuel and also human effort.

Approximately 71% of the total marine fish catch along Kerala coast is from pelagic species. Oilsardine, mackerel, anchovies, tunas, seerfishes, carangids *etc.* constitute about 65% of the pelagic stock which is about 35% of the total marine fish catch of the country (CMFRI, 2011). The usefulness of PFZ advisories for the marine fishermen engaged in different types of pelagic fishing activities does not need any further emphasis. Among fishes like oilsardine, mackerel, anchovies, small tunas and

Table 4. Usefulness of wind based PFZ advisories indicating the effect of wind in shifting the direction / location of PFZ.

Date/ time of fishing activity	PFZ location (lat./long.)	Actual fishing location (lat./long.)	Major species caught	CPUE (kg) for different fishing techniques adopted and profit earned (Rs.)			Within/ outside notified area (PFZ)
				RS	GN	BTR	
2.09.2010	11°52' N/ 75°20' E	11°52'N/ 75°20' E	Mackerel	1600 (81000)	400 (7000)	800/1300 (33000)	Within PFZ
2.09.2010	11°52'N/ 75°20' E	11°52'N/ 75°30' E		400 (5900)	250 (4250)	110/600 (5300)	Outside PFZ
3.09.2010	11°52' N/ 75°20' E	11°52'N/ 75°20' E	Mackerel	1500 (78000)	310 (5100)	600/1100 (29500)	Within shifted feature
3.09.2010	11°53'N/ 75°24' E	11°53'N/ 75°30' E		300 (4750)	260 (4500)	150/700 (4800)	Outside shifted feature
4.09.2010	11°52' N/ 75°20' E	11°52'N/ 75°20' E	Mackerel	1700 (89000)	325 (5650)	700/1200 (31500)	Within shifted feature
4.09.2010	11°53.5'N/ 75°24'E	11°54'N/ 75°34' E		375 (5350)	200 (3850)	200/700 (9100)	Outside shifted feature
6.09.2010	11°52' N/ 75°20' E	11°52'N/ 75°20' E	Mackerel	1950 (1,07,810)	410 (7250)	1000/1300 (35,000)	Within shifted feature
6.09.2010	11°58'N/ 75°22' E	11°52'N/ 75°20' E		310 (4910)	300 (4950)	170/650 (7000)	Outside shifted feature
RS-Ring seining (0900-1000)	GN-Gill netting (2000-0500)	BTR-Bottom trawling (3 <sup>rd</sup> haul 1230-1530) Major species/Total catch					

carangids, maximum advantage in terms of reduction in searching time as well as increase in CPUE are found in respect of ring seining and purse seining.

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