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Validation of Potential Fishing Zones using IRS-P4 OCM Data

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Recognising ocean features such as water colour, temperature variations over sea surface turbidity, sea state, size and direction of waves, wind patterns, etc can be efficiently used to formulate fishing strategies. Efforts have been made by India to utilize satellite based remote sensing for identification and exploitation of potential fishing grounds. The Central Institute of Fisheries Technology, Cochin and Space Applications Centre, Ahmedabad as collaborating agencies have attempted to correlate the chlorophyll imageries taken by IRS-P4 OCM with the sea truth data. Energy conservation in fishing involve practices such as selection and promotion of low energy fishing techniques wherever possible, adoption of energy conservation practices and devices in energy intensive fishing systems by way of adopting advanced technologies such as remote sensing. The analysis for validating the IRS-P4 OCM chlorophyll imageries with the actual sea truth data by CIFT and SAC was carried out in two phases. In the first phase the data collected from boats operating off Munambam, Kerala from February to May 2000 was analyzed, along with the data collected by departmental vessel "Sagarkripa". For the second phase the data analyzed was collected from the mechanized boats engaged in demersal trawling operating from Veraval Port, Gujarat. Rsults has shown that areas of greater catch rates generally coincided with high chlorophyll gradients detected by remote sensing. Further studies with supporting data on oceanographic parameters correlated with the ground truth data and the satellite imageries will make the interpretations more meaningful.

Key words : Potential Fishing Zone, IRS P4 OCM, Ocean Colour

Satellite based remote sensing is beginning to play a very important role in India for fishery forecasting, research and management by providing synoptic measurements of ocean parameters. The data can be used for evaluating environmental effects, which ultimately affects the abundance and availability of fish populations. Indian seas have low intensity multi species fish composition, and information on variations in ocean conditions is necessary to understand the influence they cause on fish stocks and their distribution. This knowledge will immensely help in formulating the best fishery management strategies and developing efficient harvesting methods for fishery resources.

The physical features in the ocean such as changes in temperature, wind speed, upwelling, eddy etc. directly affect the productivity of the ocean. Due to these changes particular areas in the ocean is richer in nutrients and phytoplankton. Sequential aggregation of fishes at all levels in food chain is usually observed in areas of high productivity. The data pertaining to ocean variability and productivity can be obtained by collecting sea truth data with the help of vessels, by placing equipments attached to buoys etc, but data thus collected is on smaller scales, discontinuous and restricted to the time

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when ships can cover the area of interest. Remote sensing is one of the most effective means for acquiring data as a vast area of ocean can be covered in a single day. It is possible to have a synoptic look at the ocean processes at the shortest possible time. In India majority of the fishing fleet is dominated by small and medium class of vessels. The effort put by these vessels is restricted to the shelf waters. The potential yield of fishery resources in Indian EEZ has been estimated to be 3.92 million tonnes. Presently 2.8 million tonnes are exploited while most of the oceanic and deeper water resources remain under exploited. Scope of further increased production from inshore waters is limited due to the existing excess capacity in traditional grounds. The improvements made so far on the craft and gear technologies with an objective to increase fish production are becoming counter productive. Inappropriate exploitation patterns such as concentration of 80% of the total fishing effort in the inshore waters and over dependence on trawling are showing detrimental effects on the fisheries (Devaraj & Vivekananadan, 1999).

A lot of time is expended by fishermen in the search of productive fishing grounds. Due to sharp increase in the cost of fuel, commercial fishing in deeper waters is becoming economically risky business. To ensure profit by reducing the scouting time for productive areas and good catches, it has become necessary to utilize available scientific tools like remote sensing. Hameed (2004) suggested that recent advances in the detection of PFZ based on remote sensing and wider availability of GPS improved efficiency of harvesting operations.

During the last four decades, the remote sensing technology has provided data on different aspects of coastal and marine environments. Data provided by various sensors were used to generate information on various oceanic parameters like waves, surface winds, sea surface temperature, ocean colour, currents, sea ice, coastal landforms, wet lands, land use, erosion etc. and were used for many operational applications (Nayak *et. al.*, 2000). Thermal signature generated from NOAA-AVHRR data are being operationally utilized for locating the potential fishing grounds in various countries including India (Laurs *et. al.*, 1984, Maul *et. al.*,1984, Solanki *et al* 1992a; 1998 b). The constraint in Indian waters is narrow temperature ranges and there was a need for identifying another parameter that could be linked to temperature gradient. Ocean color information effectively filled this lacuna, as ocean color indicates the surface productivity of the ocean. Presently synchronous IRS-P4 OCM and NOAA-AVHRR SST data is used for the identification of PFZ. Arnone (1987) used CZCS and NOAA data to understand the relationship between parameters to classify different types of water. The data is used to define productive areas where fishery resources could aggregate, using satellite data, which are collected contemporaneously with fishery/biological data and sea truth measurements gathered by research and fishing vessels.

Recognising ocean features such as water colour, temperature variations over sea surface turbidity, sea state, size and direction of waves, wind patterns, etc can be efficiently used to formulate fishing strategies, efforts have been made by India to utilize the satellite based remote sensing for identification and exploitation of potential fishing grounds. The Central Institute of Fisheries Technology (CIFT), Cochin and Space Applications Centre (SAC), Ahmedabad has been involved in a collaborative project for validating IRS P4 OCM integrated chlorophyll imageries with the actual sea truth data.

Material and Methods

The near synchronous IRS P4 Ocean Colour Monitor (OCM) derived chlorophyll and NOAA AVHRR derived SST are used for exploring fishery resources. OCM data were atmospherically corrected using long wave length approach and Ocean Chlorophyll -2 (OC2) bio-optical algorithm was applied to corrected radiance to calculate chlorophyll concentration (Solanki *et. al.*, 2001). The method described by Soalnki *et. al.*, (2000) was used to generate chlorophyll and SST composite and to develop geocoded images. The composite images were interpreted for generating the experimental forecast. The flow of information regarding the potential fishing zones were gathered from the feed back from the fishermen of Munambam –a fishing village at the southwest coast of India which is located 30 km from Cochin (Lat 08°40′ and Long 76°02′). About 710 small and medium trawlers operate from Munambam. Over 70% of the mechansied vessels falling in the size group of 43-60′ are installed with Global Positioning System (GPS) and Echosounder. Most of them use mobile phones for communication between the vessels, while at sea. A fishermen's organization based at Munambam was equipped with a fax machine funded by SAC, Ahmedabad which helped them in easy reception and dissemination of all fishery prospect charts in real time. The catch data were collected primarily from them and also from other boats doing commercial operations from Munambam. Similar data were collected from commercial boats operating from Veraval Port, Gujarat also. The satellite pictures were developed and correlated with fish catch data during the period 2000-01.

Detailed information and data on the area of fishing operation, depth and the catches landed by the bottom trawlers were collected from the boats operating off Munambam during the period February-March 2000. For further study, data collected by departmental vessel "Sagarkripa" during 12 voyages from September to December 2000 were also used. The collected data were analysed at the space Applications Centre. The grading of the caches for the analysis was done on the basis of the number of stations covered on a particular day. The chlorophyll image was generated from the raw satellite data, processed and geometrically corrected using the IMAGINE image processing software.

Results and Discussion

A total number of 24 satellite imageries covering February to may 2000 were analysed and the images suitable for further analysis were selected based on the image quality and cloud cover in the area of interest. A total of 10 imageries were finally used for correlation studies. The fishing stations were plotted geographically on an annotation layer, data wise with the fishing data available. For every image, annotation layers of the same day were superimposed and observations made.

It was observed that in all the images where no chlorophyll gradient was seen, catches have been either average or poor. The image on 21st March showed a chlorophyll gradient at lat 11° 25′N long 75° 19′E. The annotation layer of 17th March when superimposed on 21st image, one of the stations fell in the gradient area (Fig. 1). A gradient was observed on 8th April image. When superimposed with the annotation layer of 10th April, two stations fell in the gradient and the individual catch details for these stations were not available. On an average good catch of prawns were recorded on that day. A strong gradient seen on 9th March remained until 23rd March in and around lat 9°28′N long 77°44′E (Fig. 2), but none of the fishing stations fell within the gradient range.

While analyzing the data collected from "Sagarkripa" pertaining to 12 voyages during September to December 2000, it was observed that in almost all images where no chlorophyll gradients were seen, catches were either average or poor. All the images of North Kerala covering the period from September to December 2000 were analysed and special emphasis was given to the dates of good catches and very poor catches. The stations of 9th September when plotted on 8th September images have shown a good gradient very close to the fishing stations. A good CPUE of one haul recording 1000 kg fishes was recorded and no specific gradients were seen in the areas where poor catches were recorded. The problem with the satellite pictures

Fig. 1. Chlorophyll (IRS-P4 OCM) on 17th March, 2000

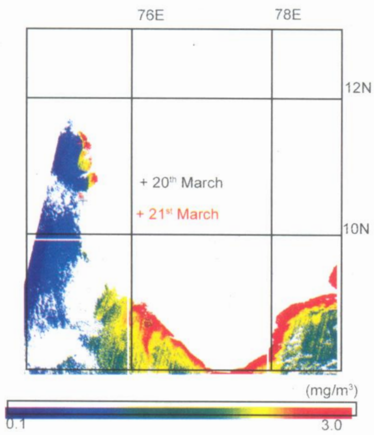


Fig. 2. Chlorophyll (IRS-P4 OCM) on 10th April, 2000

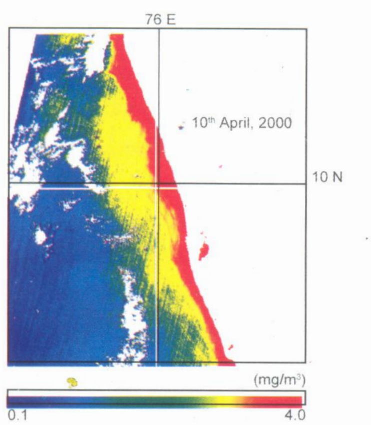


Fig. 3. Chlorophyll (IRS-P4 OCM) on 9th September 2000

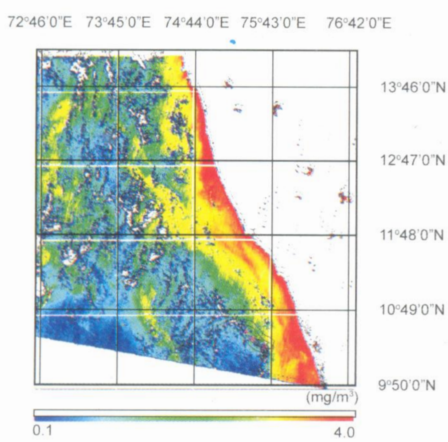
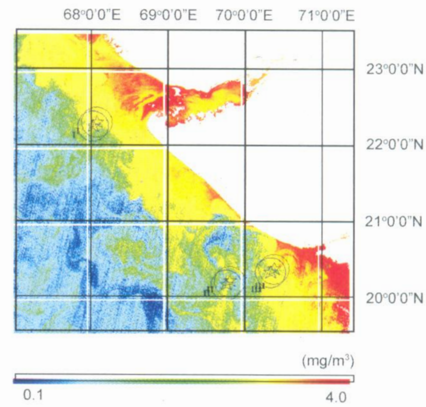
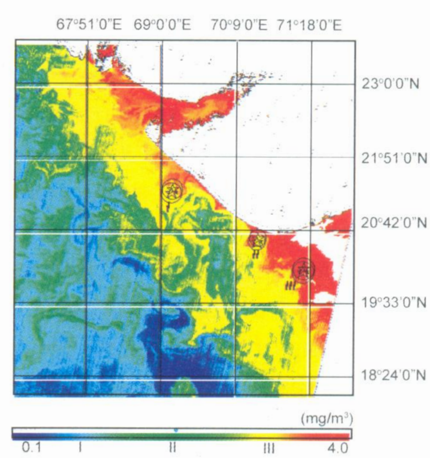


Fig. 4. Chlorophyll (IRS-P4 OCM) on 9th December 2000



Area Lat/Long	22° 18′N 68° 05′E	20° 12′N 69° 48′E	20° 22′N 70° 23′E
Average Catch / boat/day (kg)	1250	1000	1250
Depth of operation (m)	70	80	70
No. of vessels operated	150	100	150
Period	31/11/2000 07/12/2000	31/11/2000 07/12/2000	31/11/2000 07/12/2000

Fig. 5. Chlorophyll (IRS-P4 OCM) on 7th December 2000



Area Lat/Long	21° 20′N 69° 10′E	20° 34′N 78° 29′E	20° 05′N 71° 12′E
Average Catch / boat/day (kg)	1005	1000	1010
Depth of operation (m)	70	60	10
No. of vessels operated	20	400	10
Period	05/12/2000 13/12/2000	06/12/2000 14/12/2000	06/12/2000 13/12/2000

Area Lat/Long	21° 22′N 69° 20′E	20° 22′N 70° 12′E	20° 34′N 70° 29′E
Average Catch / boat/day (kg)	785	642	790
Depth of operation (m)	55	65	70
No. of vessels operated	200	350	350
Period	13/03/2001 18/03/2001	15/03/2001 19/03/2001	12/03/2001 18/03/2001

Fig. 6. Chlorophyll (IRS-P4 OCM) on 7th January 2001

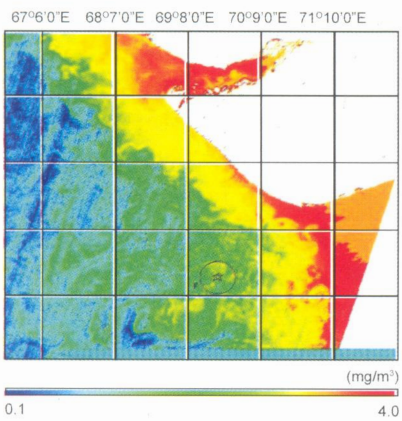


Fig. 7. Chlorophyll (IRS-P4 OCM) on 17th March 2001

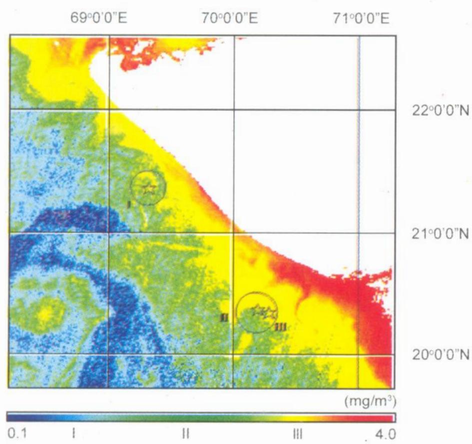
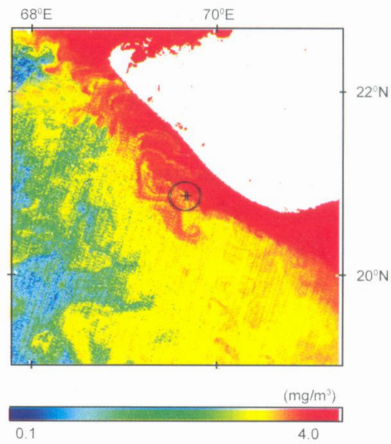


Fig. 8. Chlorophyll (IRS-P4 OCM) on 8th December 2001



Area Lat/Long	20° 55.22′N 69° 48.25′E
Average Catch /boat/day (kg)	1100
Depth of operation (m)	55
No. of vessels operated	100
Prominent catch	Cuttlefishes / Squids

was in most of the images analysed, had cloud cover in the areas of interest (Fig. 3).

The satellite pictures developed for Gujarat area could be used successfully as there was no cloud cover during the period of study. The validation clearly showed the stations with bumper catches always fell on the edges of strong chlorophyll gradients. All the images of Gujarat and Maharashtra coast for the period November 2000 – December 2001 were analysed. During 6th – 14th December 2000 more vessels had operated at two areas off Porbandar and Madhwad of Saurashtra and some at Bombay High at the same period. At all stations where strong chlorophyll gradients were observed (Fig. 4) good catches were reported.

During 3rd December to 7th December about 100 vessels from Veraval port had operated in three areas along the Saurashtra coast (off Dwaraka, Suthrapada & Kodinar). In all the three areas strong chlorophyll gradients were seen (Fig. 5) and on an average each vessel brought 1 tonne of fishes a day mainly dominated by Ribbon fishes (*Trichuirus lepturus*) and Kalava (*Epinephelus diacanthus*).

During 12th -16th January 2001 many vessels of Veraval Port had operated in the deeper waters off Bombay High and had recorded very good catches of ribbon fishes (*Trichuirus lepturus*) and squids (*Loligo duvaucelli*). When analysed with satellite data, on the 14th January image, a strong gradient was seen in this area for almost a week (Fig. 6). Good catches were reported from Saurashtra coast between 13th – 18th March 2001. Three stations (off Porbandar Mangrol and Madhwad,) when imposed on 17th March image, strong gradients were observed (Fig. 7) and around 200 vessels operated here landing more than 700 kg/day.

More than 100 mechanised trawlers from Veraval harbour had landed very good catch of squids (*Loligo duvaucelli*) and cuttlefishes (*Sepia pharaonis*) by operating off bottom trawls in shallow waters off Mangrol during December 4th to 11th 2001. On correlating with December 8th image (Fig. 8) it is observed that the stations fall in the areas with strong chlorophyll gradients.

The technique adopted for forecasting potential fishing zone is primarily based on the concept that fishes have the tendency to accumulate in the areas of high productivity and the areas of high productivity are the areas of high plankton and high nutrients. Sugimoto & Tameishi (1992) have observed that targeting of fishing ground depends on oceanographic features or processes such as upwelling, eddies, meanders fronts with varying shape and size, the temperature gradient, intrusion of warm waters into cold water masses, pockets of warm and cold water masses etc are known to be favourable sites of enhanced primary production because of nutrient availability. Nakata (2000) observed that the upwelling of nutrient rich water to the surface in the vicinity of eddy enhances primary production and subsequent copepod production thus providing potentially favourable conditions for feeding and growth of anchovy larvae in the Enshu-Nada Sea off the Central Pacific coast of Japan. Laevastu & Rosa (1963) observed that if a fishing ground is crossed by current boundary, there is an abrupt increase in fish abundance.

Higher catches are found in the vicinity of thermal fronts, eddies and meanders, and hence such areas could be generally designated as better fishing grounds. Identification of such oceanographic features persistent over seasons in particular areas and satellite data inputs in the form of chlorophyll-SST composite can help in better identification of fishing grounds. Passive remote sensing gives information of the state of the ocean. The satellite infrared thermal data is being used very effectively for fisheries research in many countries since 1984. Ocean colour sensor provides synoptic chlorophyll concentration, and thermal infrared sensor is used to derive the SST information. The oceanic features can thus be detected in near real time in terms of plankton aggregation and thermal fronts. Laurs et al (1984) used NOAA-AVHRR and Nimbus-7 CZCS data to understand the distribution of Tuna resources. Vladimir & Vladimir (2000) observed that many pelagic fishes accumulation were detected directly during airborne remote sensing measurements and visual observations, which is useful in making fishery forecasts.

In the present study, it is seen from the results that the locations of higher catch coincided with chlorophyll gradients detected through remote sensing. Most of the conventional fish stocks are reportedly in a state of full exploitation or over exploitation. Hence there is need to locate new and unconventional fishery resources in order to fill the supply-demand gap for fish protein. As the coastal waters are being over exploited the satellite information will be of immense importance to guide the fishermen to exploit the deep water resources.

Nayak *et. al.*, (2003) have made a cost-benefit analysis to understand the impact of potential fishing zone forecasts on the fishing industry and shown that the benefit cost ratio increased from 1.27 to 2.12 for trawling and 1.3 to 2.14 for gill netting. Solanki *et. al.*, (2001) reported about 2-3 fold increase in the catch in potential fishing zones by gill netters. He found that the frontal positions in chlorophyll image coincide with temperature boundaries which indicate that physical and bio-chemical processes are closely coupled at these locations.

For using of PFZ for benthic trawling, the time lag for aggregation of benthic resources needs to be understood based on the depth of the ground or the gradient. To examine how various substances and optical processes influence the color of coastal waters and to identify the requirements like review algorithms for remote sensing of coastal waters, effects of environmental parameters on the fishery resources need to be studied and correlated with fish aggregation. Traditional oceanography research is necessary for meaningful validation and calibration of remote sensing data and this has to be further pursued.

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