

Exploration of demersal fishery resources through satellite derived thermal signature

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An approach for exploration of demersal fishery resources using remote sensing technique has been developed and demonstrated. This involved study of aggregation pattern of demersal fish in response to the thermal fronts observed in the sea surface temperature (SST) image generated using NOAA-AVHRR data. Demersal fish catch data obtained from the Gujarat Fishery Development Corporation of India were used for the correlation study. Over 30 AVHRR scenes spread over different seasons were analyzed for SST. Fish catch data for the corresponding dates were located in the SST images of corresponding dates. A definite pattern of preference of demersal fish in the waters of overlying thermal fronts was observed. Subsequently, a joint CIFNET-SAC experiment was planned for validation of the approach. This involved generation of SST charts on real time basis at and communication of information on potential areas of occurrence of demersal fish at SAC. Follow up action was taken by CIFNET by carrying out experimental fishing in the suggested areas within 24 hours. This paper emphasizes validation exercise carried out to locate demersal fish from satellite data. It was found that high catches of demersal resources including prawns were associated with sediment fronts in the Sand heads area (Bay of Bengal), long persistent fronts and coastal fronts with large temperature gradients.

Meso scale oceanic features detected from remotely sensed sea surface temperature (SST) images represent the areas where fishes tend to accumulate. Detection of the features like thermal fronts, eddies, upwellings, meandering currents, etc. is possible because of thermal anomalies associated with them which can be seen in a classified satellite image. These serve as feeding grounds for the living marine resources since they form areas of high phytoplankton concentration. Decayed phytoplankton and sediments from land drainage form the food source for shrimps and other benthic resource as they gradually sink to the bottom.

The Bay of Bengal is characterized by reversal of monsoon winds. Circulations are governed by northeast and southwest monsoon trade winds and also fresh water discharge from various rivers. During premonsoon period (March-May), large scale, clockwise gyre-like circulations are observed and during postmonsoon period (October-November) large scale anti-clockwise circulations are dominant. Besides this, seasonal

western boundary current is observed in the Bay of Bengal. North equatorial current is deflected northward from Sri Lanka and under the influence of wind stress prevailing during February-March flows parallel to east coast of India as western boundary current¹.

Advanced Very High Resolution Radiometer (AVHRR) data from NOAA satellite were used for this study to generate sea surface temperature (SST) images in the waters of northeast coast of India, for the period September-March, 1988-1993. A detailed study involving correlation of georeferenced shrimp catch data normalized to unit effort, with the oceanic features was conducted. Contrast enhanced SST images revealed occurrence of the oceanic features like thermal fronts, eddies, upwelling etc. in the form of thermal anomaly. A definite pattern of preference of shrimps emerged from the thermal front-shrimps correspondence study. Subsequently an experiment was planned to validate an approach for exploration of the demersal fisheries resources

in collaboration with Central Institute of Fisheries & Nautical Engineering Training (CIFNET). This joint experiment involved generation of the information on potential fishery areas at Space Application Centre. CIFNET was responsible for the follow up action within 24 hours of the satellite overpass. The fishing vessel Skipper III was identified on dedicated basis to carry out experimental fishing in the suggested sites. Though the execution which began in March 1994, had to be curtailed due to influence of clouds from March end, some useful results could still be obtained and are described here in this paper. Besides this, georeferenced shrimp catch data were obtained from Gujarat Fisheries Development Corporation (GFDC) for January-February 1994 period collected by three of their vessels in the Sand heads area of the Bay of Bengal (21-22°N, 87-88.5°E). It appears from the results that SST which is a surface expression of oceanic circulations² should serve as a relevant parameter not only for pelagic but also for the demersal resources.

Methodology

Real time NOAA - AVHRR data were available at AES (Ahmedabad Earth Station) of SAC. Channel 4 and 5 data of AVHRR were corrected for geometric distortions as a part of preprocessing. Computer softwares developed at SAC account for scene related as well as sensor related distortions³. Geometric fidelity of the data was further improved by registering current image with another master image from overhead pass which was earlier resampled on a Mercator grid. SST was estimated using split window technique⁴ and enhanced SST images were generated. A grid was overlaid to this image before colour printing. A next step involved selection of oceanic features based on the aggregation pattern of the demersal fishery resources studied earlier. In particular, cyclonic/anti-cyclonic eddies and high rate of change of SST were considered for the forecast provided to CIFNET, keeping in mind the area of operation in 19-20°N belt. This is the area where a pair of cyclonic-anticyclonic eddy formation occurs during February-March period. Description of the fishing site was made with more precise definition of the parallel fishing tracks to be

followed along the front and on either side. In case of circular ring like feature centre point was defined with specific radius. This information was telexed to CIFNET for immediate action in the form of experimental fishing through bottom trawling on the suggested tracks. Besides GFDC provided shrimp catch data from the Sand heads area which were plotted on the corresponding dates SST images. Only unusually high shrimp catches were marked on SST images with time lag not more than 24 hours study.

Results and Discussion

Figures 1-5 represent colour coded SST images generated from AVHRR data, density sliced at 0.5°C interval. Location of the suggested fishing tracks and the actual tracks of fishing operation are shown in the figures with reference to the numeric/alpha numeric numbers. Corresponding details and catch per unit effort (CPUE) are presented in Table 1. Figure 1A shows location of one of the suggested tracks provided as part of forecast. As described earlier, the track was identified because of rapidly changing SST ($\approx 1^\circ\text{C}/\text{km}$). Also with the reference of 7-3-1994 image it was observed that the front was persistent. The same front can be seen in 9-3-1994, image also (Fig. 1B) with weaker temperature gradient and changed orientation of meander. Fishing operation was performed along tracks 1A, 2A and 3A (Fig. 1B). Location of track 1A closely matches with that of suggested track 1, whereas tracks 2A and 3A are across a similar front parallel to the one selected from Fig. 1A. The corresponding CPUE are 129, 81 and 61 kg / h. The first and second values are high compared to the average catch (calculated on the basis of total catch for the period 9-16 March, 1994) whereas the third value is comparable to the average. Tracks 4, 5 and 6 (Fig. 1B) were made on 10-3-1994 with no reference to forecast. CPUE are less in all the cases. This may be because of the increased time delay (≈ 72 hours of forecast) which could have further weakened the temperature gradients.

Fishing operations along tracks 7, 8, 9 (Fig. 2A) were also carried out without the forecast. Track 7 is seen just across the strong temperature gradient. CPUE in this case is comparable to the average value whereas tracks 8 and 9 which are away from

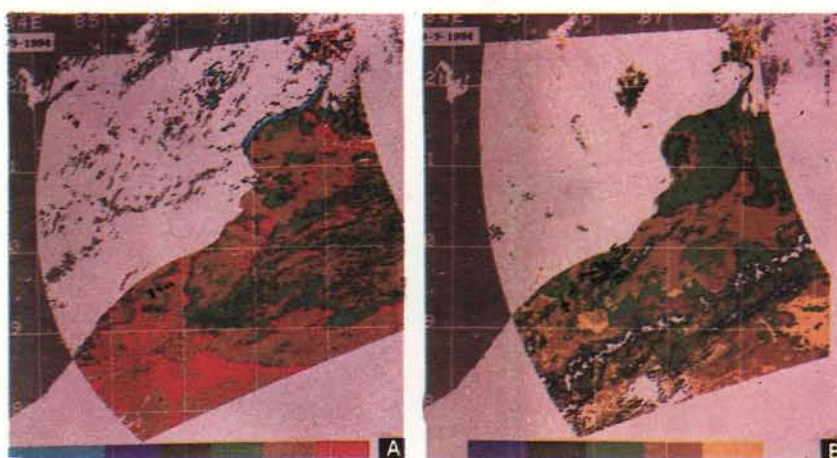


Fig. 1—NOAA-AVHRR derived sea surface temperature (north east coast of India) for A) 7-3-1994 and B) 9-3-1994

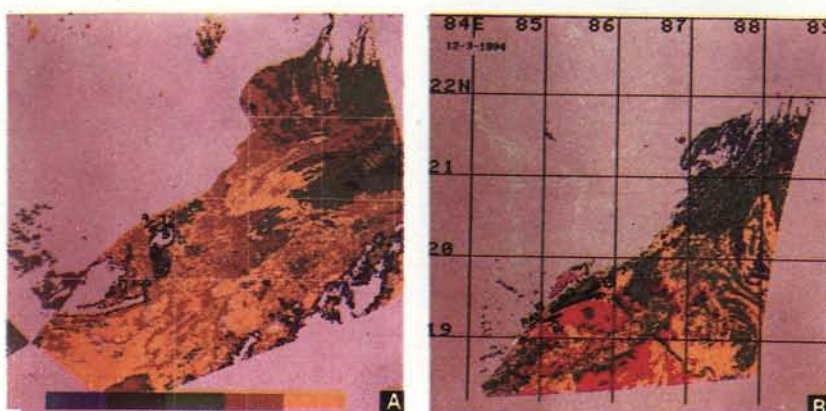


Fig. 2—NOAA-AVHRR derived sea surface temperature (north east coast of India) for A) 11-3-1994 and B) 12-3-1994

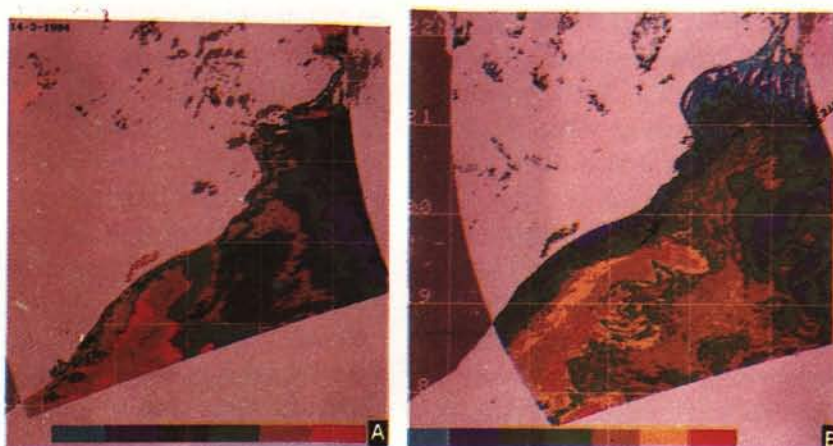


Fig. 3—NOAA-AVHRR derived sea surface temperature (north east coast of India) for A) 14-3-1994 and B) 27-1-1994

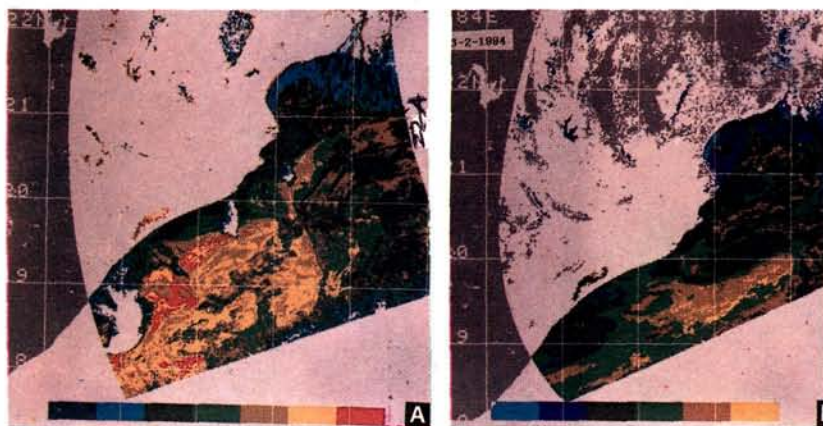


Fig. 4—NOAA-AVHRR derived sea surface temperature (north east coast of India) for A) 28-1-1994 and B) 3-2-1994

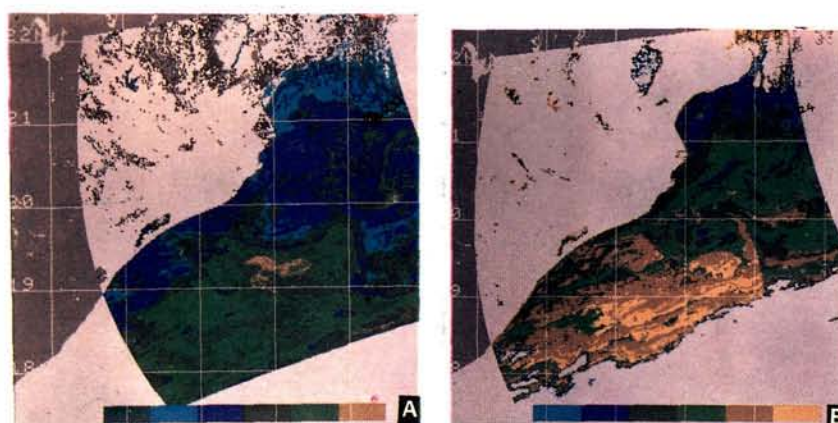


Fig. 5—NOAA-AVHRR derived sea surface temperature (north east coast of India) for A) 4-2-1994 and B) 7-2-1994

this small scale circular feature on either side yielded poorer catches. Track 10 (Fig. 2B) with horizontal temperature gradient $\approx 1.5^\circ\text{C}$ in 8 kms was suggested as part of forecast of 12-3-1994 data. Track 10 A (Fig. 2B) is about 3 to 4 km away (cooler side) from the forecasted track 10. The corresponding CPUE is 69.2 kg/h which is marginally higher than the average value. Track 12 A lies close to similar front which also yielded high catch. CPUE from track 11 A is much lower than the average value, location of this track can be seen in uniform waters.

High CPUE from tracks 13 and 14 which fall in uniform waters cannot be explained from Fig. 2B. Same date SST image would provide better explanation.

Track 15 (Fig. 3A) was selected for the forecast. This feature appears like a weak upwelling event forming layers of gradually increasing temperature from core to periphery with a temperature gradient

$\approx 2^\circ\text{C}$. Actual fishing tracks followed (15A to 19A) are shown in Fig. 3A. These are on the periphery of the possible upwelling event on the extreme other side of the ellipse, still all the catches are unusually high and significantly greater than localized mean. Table 2 presents some unusually high catches obtained by GFDC vessels during January-February 1994. Fishing track 20 as shown in Fig. 3B can be seen close to eastward deviating streamer which ultimately resulted in formation of warm core eddy (3-2-1994 and 4-2-1994 images of Fig. 4B and 5A). Shrimp catch from these waters is very high.

Area 21A (Fig. 4A) is on cooler side of the plume front of large temperature gradient. Corresponding shrimp catch value is high in this case. Area 21 (Fig. 4A) is close to thermal front with high temperature change per unit distance on sea surface ($\approx 1.5^\circ\text{C} / 11 \text{ km}$). Shrimp catch from this area is also significantly higher than average

Table 1—Demersal fish catch data obtained by Skipper III, CIFNET vessel from suggested fishing grounds / other areas off north east coast of India (localized mean = 66 kg / h)

Sr. no.	Image date	Fishing date	Forecast area	Fishing area	CPUE, kg/h	P/NP/S/NS/CS*
1	7-3-94	9-3-94	1	1A	129	P/S
2	7-3-94	9-3-94	1	2A	81	P/NS
3	7-3-94	9-3-94	1	3A	61	NP
4	9-3-94	10-3-94	1	4	29	NP
5	9-3-94	10-3-94	1	5	21.3	NP
6	9-3-94	10-3-94	1	6	19.1	NP
7	11-3-94	11-3-94	1	7	65	P/NS
8	11-3-94	11-3-94	1	8	37.8	NP
9	11-3-94	11-3-94	1	9	38.5	NP
10	12-3-94	12-3-94	10	10A	69.2	P/CS
11	12-3-94	12-3-94	10	11A	41.3	NP
12	12-3-94	12-3-94	10	12A	69.2	P/CS
13	12-3-94	13-3-94	10	13	80.9	P/CS
14	12-3-94	13-3-94	10	14	61.8	P/CS
15	14-3-94	14-3-94	15	15A	86.2	P/NS
16	14-3-94	14-3-94	15	16A	100	P/NS
17	14-3-94	14-3-94	15	17A	72.8	P/NS
18	14-3-94	15-3-94	15	18A	107.7	P/NS
19	14-3-94	15-3-94	15	19A	82.2	P/NS

* P = Potential area for fishing as per criteria of correlation study

NP = Non-potential area

S = Suggested area from the forecast

NS = Not suggested

CS = Fishing operation close to the suggested area

Table 2—Normalized Shrimp catch data obtained by GFDC vessels from the Sand heads area

Sr. no.	Image date	Fishing date	Track no.	CPUE (KG/h)	
				Shrimp	Others
1	27-1-94	27-1-94	20	4.5	3.75
2	27-1-94	27-1-94	21A	4.08	—
3	27-1-94	28-1-94	21	4.1	6.4
4	28-1-94	28-1-94	22A	3.66	—
5	28-1-94	29-1-94	22	4.0	8.0
6	3-2-94	3-2-94	23	2.07	7.7
7	4-2-94	4-2-94	23A	1.33	1.38
8	7-2-94	7-2-94	24	2.15	12.1
9	7-2-94	8-2-94	24	1.66	21.4

value of catches obtained from these waters during the season. Area 22 and 22a are close to river plume front which forms a strong temperature gradient ($\approx 2^{\circ}\text{C}$ and 1°C respectively). Shrimp catches are high in both the cases. Area 23 (Fig. 4B of 3-2-1994 image) is significantly away from prominent sediment front in uniform waters. Catches in this case are lower than average values. Area 23A (Fig. 5A of 4-2-94 image) is in the same area. However a strong plume front with high rate

of temperature changes can be seen developed on 4-2-1994 and it resulted in high demersal fish catch. However, shrimp catches are poor in both the cases (area 23 and 23A). Area 24 (Fig. 5B of 7-2-1994 image) also lies close to sediment front with rapidly changing temperature, on cooler side. Corresponding demersal fish catches are high.

The present experimental results were found in compliance with the inferences drawn from earlier study of distribution of shrimps in space and time

using SST charts⁵. Relevance of cyclonic/anti-cyclonic eddies for the demersal fish exploration could not be studied because of non-availability of the surface truth data against occurrence of the event. However, it was confirmed that the fronts with large temperature gradient and high rate of change of temperature often yield better catches and the same can be exploited. Also, the observed upwelling event on 14-3-1994 southwest of Chilka lake, near the coast between 18-20°N latitude, possibly induced by winds yielded better catches. Study of collocation of normalized shrimp catches and thermal anomalies detected from AVHRR data in the Sand heads area reveals that the waters close to plume front on either side are profitable areas for shrimps. These are the locations where run off from the rivers from north cause assemblage of high concentration of sediments. It was noticed that time lag of 48 hours is a safe period for profitable fishing when temperature gradients are of the order of 1°C. It is felt that an update of satellite based information on fish availability every alternate day would lead to more effective results. Remote sensing data provided useful clues for locating area of demersal fish/shrimps assemblages during February-March 1994 which forms a

part of lean fishing season for the study area (February-June, total lean period). Though the preliminary observations made from limited field tests indicate utility of thermometric remote sensing technique for demersal fish exploration, there is a need to authenticate the approach through extensive fishing trials in future.

Acknowledgement

Shrimp catch data provided by GFDC for the present study and in the past were useful inputs. Their support is gratefully acknowledged.

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