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The statistical analysis of Catch per Unit Effort (CPUE) in Kg of fish catch by using potential fishing zone advisories along the coast of Ratnagiri District, Maharashtra, India.

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ABSTRACT

A reliable and timely forecast on the Potential Fishing Zone using satellite derived sea surface temperature and chlorophyll has become an important aspect for the fishermen. The potential fishing zone (PFZ) advisories received from Indian National Centre for Ocean Information Services (INCOIS), Hyderabad during April, 2007 to March, 2012 were validated along Maharashtra coast. Available information was disseminated to the fishermen community via electronic digital display boards, internet media, fax and telephonic messages at the 3 major fish landing centers (Harnai, Mirkarwada and Sakhri-Natye) of Ratnagiri district coast of Maharashtra. Feedback was collected for both the PFZ and Non-PFZ locations in the prescribed format developed by INCOIS office Hyderabad. This contains name of vessel or boat, date of fishing, time of hauling, latitude and longitude, type of net used, depth of catch, distance from the coast, direction, catch in kg, major catch in kg and major variety. In the present study an attempt has been made to compare fish catch per unit efforts (CPUE) in the areas predicted by Satellite imagery (potential fishing zones PFZ) and with those of non predicted areas (outside potential fishing zones). The direct validations were done within and outside PFZ area, which shows positive relationship between PFZ and abundance in pelagic fisheries. It means comparing the catch using fishing vessels simultaneously from the potential fishing zones (notified region) with that of catch from outside potential fishing zones (non notified region). Then the Catch per Unit Efforts (CPUE) was computed by dividing total fish catch (Kg) by number of fishing hours. The comparison was made of catch data from PFZ with outside PFZ areas from notified vessels from 3 fish landing centres, in which Mirkarwada fish landing centre showed higher fish catch than Harnai and Sakhri-Natye. Also the CPUE was significantly higher

during the year 2011-12 than in 2007-08 and followed by 2008-09, 2009-10 and 2010-11. About 70% increases was reported in total fish catch CPUE in potential fishing zones PFZ than outside potential fishing zones PFZ in 30-100 m depth zones. 50% advisory was used by fisher folk of Ratnagiri district which is higher than the fisher folk of Maharashtra State which was used only 40% PFZ forecast to extent their fishing activity. An analysis of fish catch data from fishing vessels (within and outside PFZ) revealed that CPUE was higher in notified areas compared to non-notified areas in trawl as well as purse-seine net operations during 2007-2012. Therefore the accuracy of timely forecasts of PFZ validation is important source of economic gain in fisheries.

Keywords: Standardized CPUE, PFZ Forecast, Validation, Ratnagiri coast and fish catch

INTRODUCTION

The Ratnagiri district coast is a nutritional region for the fishes and an availability of food is an important factor which controls fish occurrence, abundance and migration in the sea. The classification of water mass appears to be associated with different biological and physical processes. Sea surface temperature (SST) is one of the important parameters which drive the tropical atmosphere-ocean interaction (Pandey *et al.*, 2008). Several remote sensing techniques has been provide information regarding surface circulation features that effect of define fish habitat (Solanki et al, 2008). Potential fishing zone is a technique of identifying the fish shoals depends upon certain oceanic features of chlorophyll and sea surface temperature (Solanki *et al.*, 2001a & b; Solanki et al, 2003; Pillai, 2005).

During the 1980-90 it has been started to use potential fishing zones (PFZ) by using NOAA AVHRR derived SST in India (Solanki et al, 1998, and according to Nath et al., (1991) have used SST image to estimate for fish catch in the Arabian Sea of west coast of India. After this successful efforts, Satellite based Sea Surface Temperature (SST) images are being used as an input for locating potential fishing zones productivity and fish availability for commercial fishing operations (Pillai, 2005, Dwivedi, et al, 2005). A reliable and timely fore cast on the potential fishing zones of fish aggregation have become beneficial to fishing community by reducing search time and efforts involved in catching grounds (Nayak, 2007; CCMB, 2012). The validation experiments of potential fishing zones (PFZ) forecast were carried out by using integration of chlorophyll concentration and SST image; through direct fishing efforts jointly by our laboratory with INCOIS, Hyderabad and about 70% increase catch was reported from suggested areas (Radhakrishna, 2004; Bhaware et al, 2013)

There are many methods have been developed and applied for standardization, catch per unit of effort (CPUE) is an important variable in fisheries sciences, as it provides means to monitor population size trends; relative abundance of species in different habitats and sites; as well as to compare efficiency of different fishing gear (Sahu et al, 2012). Standardizing CPUE including environmental variables is one of the most commonly applied methods being used as an input data (Song & Wu, 2011). It is also often

used as a relative abundance index; assumed to be proportional to stock abundance, in monitoring and assessment of fish stock (FAO, 1998; Sighan et al, 2009). According to Lima *et al.*, (2000) CPUE is especially useful if the relationship between catch and effort is linear through the origin (strict proportionality). It seems a convenient approach, and one that can easily be performed whenever the assumption of similar fishing conditions is fulfilled. A based on our approach can serve as an effective abundance index for stock of fishes. The objective of this study is to develop a standardised CPUE for the fish catches of within and outside of potential fishing zones from Harnai, Mirkarwada and Sakhri-Natye fish landing centres of west coast of Ratnagiri Maharashtra.

MATERIALS AND METHODS

The validation experiments of Potential Fishing Zones (PFZ) forecast were carried out by using the PFZ information received from Indian National Centre for Ocean Information Services (INCOIS), Hyderabad (during April 2007 to March 2012 except June to October and cloudy weather) thrice in a week (Monday, Wednesday and Friday). Immediately after receiving these PFZ advisory were distributed to fishermen by personal contacts, fax or telephone messages and on Digital Display Boards (which were installed at major landing centres along Ratnagiri district coasts) in real time data. Also the information could transfer to the specific vessels, which were selected for to conduct validation exercise in order to obtain concurrent and quantitative feedback on the total catch (species-wise) within and outside PFZ areas. The data on feedback from fishermen consists of type of craft and gear, fish catch, fishing lat. and long., distance from coast, direction and depth of catch, major catch, fish quantity and variety. According to the locality, Fish catch data pertaining to the potential fishing zones (PFZ) advisories were collected from both the boats operated within and outside PFZ in prescribed format developed by INCOIS for carrying out further quantitative analysis immediately upon fishing with experimental validations. The quality, as well as quantity and species-wise identification of fish catch were reconfirmed by personal visit on the landing centres which were drawn earlier by enumerator of the fishermen community. Monthly data of different landing centre were analysed for average CPUE and further calculations were done.

The CPUE were calculated by

$$\text{CPUE (kg/hr)} = \frac{\text{Total weight of fish catch (in kg)}}{\text{Fishing Effort (in hrs)}}$$

Catch and effort data are typically analyzed in the form of catch-per-unit effort (CPUE), which express the quantity of fish caught (in weight) by a given amount of fishing effort. For validations experiments of within and outside potential fishing zones (PFZ) three landing centres were selected, Harnai, Sakhri-Natye (for trawl operating boats) and Mirkarwada (for both trawl and purse-seine operating boats) respectively.

RESULTS

Ratnagiri district is situated on west coast of Maharashtra, India, in which having 3 major fish landing centers (i.e. Harnai, Sakhri-Natye and Mirkarwada). Over 80 Fishermen Co-Operative Societies and one District Fisheries Federation are engaged in fishing activity. The fishing fleet consists of 2,464 mechanized and 1,563 non-mechanized fishing boats and over 67,615 fishers are serving for these fishing industries (Anon, 2007 and Bhaware, 2019).

Quantification of advantages derived from the usage of Potential Fishing Zone (PFZ) advisories:

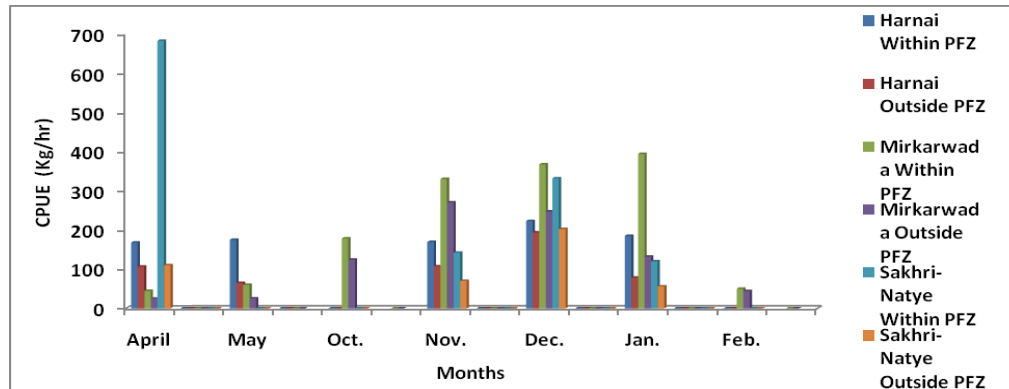
Total 53 PFZ forecast advisories were received during the year 2007-2008 for fishing and all were used, and 53 results were advantaged. In 2008-2009, 75 PFZ forecast advisories were received, in which 66 were used and 59 were advantaged. While in 2009-2010 73 PFZ forecast advisories were received, 62 used and 52 were advantaged. In the year 2010-2011, 87 PFZ forecast advisories were received, in which 59 used and 36 were advantaged. While 2011-2012, 64 PFZ forecast advisories were received, 45 used and 27 resulted in advantages. Therefore on the basis of usage of PFZ forecast advisories and overall success in fishing was 87.36 %.

The standardized CPUE has been compared in between each of the two major fishing zones, such as within and outside potential fishing zones (PFZ and outside PFZ) particularly for trawl and purse-seine fishing operations. The catch per unit efforts CPUE shows highest and most favourable oceanographic conditions for fishery resources accumulation and for fishing operations within in potential fishing zones PFZ. And result indicated that, the catch has been increased within potential fishing zone areas (PFZ) than outside potential fishing zone areas (outside PFZ) during the study period.

Standardized CPUE at Harnai, Mirkarwada and Sakhri-Natye fish landing centres, Trawl net catch during the year 2007-2008:

The validation experiments of potential fishing zones (PFZ) were conducted at Harnai fish landing centre (Fig. 1) during the months of April, May, November, December and January and feedback advisory data were collected from the users. Standardized CPUE of fish catch at Harnai was the higher (222.33) in the month of December and lower in April (167.70) within PFZ areas and standardized CPUE of fish catch was lower in the month of December (193.70) followed by May (65) from outside the PFZ areas. Standardized CPUE of fish catch from Mirkarwada fish landing centre was higher in the month of January (393.77) and lower in April (44.66) within potential fishing zones PFZ areas, while in outside of potential fishing zone PFZ area showed in November (270) followed by in April (25) and May (25.33). Standardized CPUE of fish catch from Sakhri-Natye fish landing centre was recorded highest in April (682) and lowest in January (120) within potential fishing zones PFZ areas. While standardized CPUE of fish catch from outside potential fishing zones PFZ was higher in December (202.33) and was lowest in January (56.02).

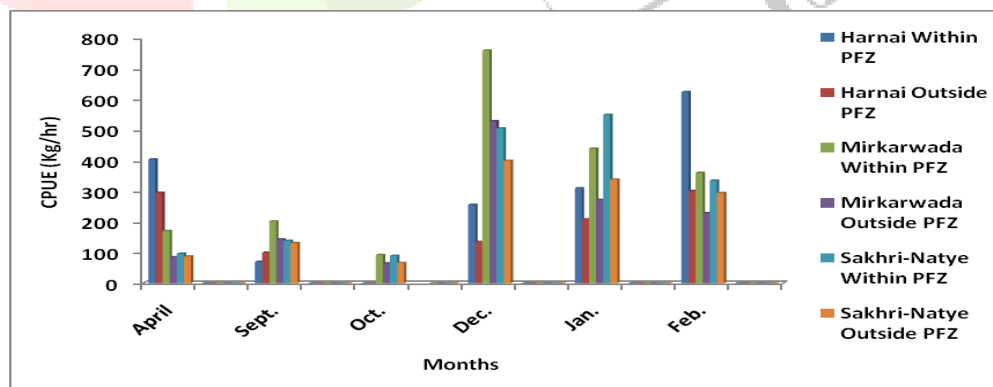
Fig. 1. Standardized CPUE (kg/hr) at Harnai, Mirkarwada, and Sakhri-Natye (FLC), Trawl net catch during 2007-08.



Standardized CPUE at Harnai, Mirkarwada and Sakhri-Natye fish landing centres of Trawl net catch during the year 2008-2009:

Fig. 2 shows that, in Harnai trawl CPUE was more on 625.33 in within PFZ and low 70 in September within PFZ, while outside PFZ CPUE was more 302 in February and low 100 in September. In Mirkarwada trawl operation CPUE was more 440.33 in January and low 92.22 in October from within PFZ then in outside PFZ; CPUE was more 529.70 and very low 65. In Sakhri-Natye trawl net FLC the CPUE was high 550 in January and low 89.70 in October within PFZ while, outside PFZ high 400 in December within PFZ and low 66.33 in October from outside PFZ. In Mirkarwada fish landing centre, during trawl net operation, CPUE showed that the CPUE was high than outside PFZ. In this study period May, November and March CPUE was not compared due to the absence of PFZ forecast for offshore region.

Fig. 2. Standardized CPUE (kg/hr) at Harnai, Mirkarwada, and Sakhri-Natye (FLC), Trawl net catch during 2008-09.

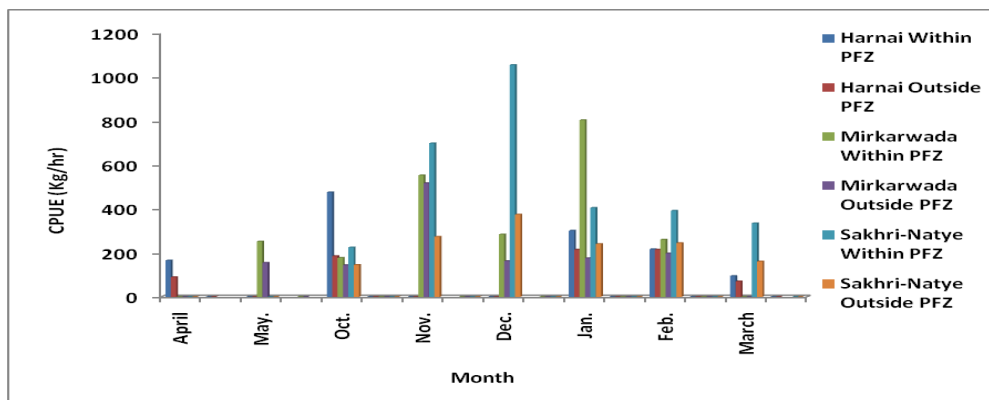


Standardized CPUE from Harnai, Mirkarwada and Sakhri-Natye fish landing centres of Trawl net catch during the year 2009-2010:

The CPUE from Harnai FLC more was found to be 475.70 in October and in March within PFZ, while it was 214.70 during both months January and February outside PFZ. In Mirkarwada FLC trawl net operation CPUE was found to be high 803.70 in January and low 177.33 in October within PFZ, while in outside PFZ it was found 517.33 in November and 144.33 in October. In Sakhri-Natye FLC the CPUE

was found in the range of 225 to 1055 within PFZ, within PFZ, while in outside PFZ it was 145 to 374.33 during study period. (Fig.3). It clearly shows that Catch per Unit Effort (CPUE) is higher within PFZ than outside PFZ during the study period 2009-2010.

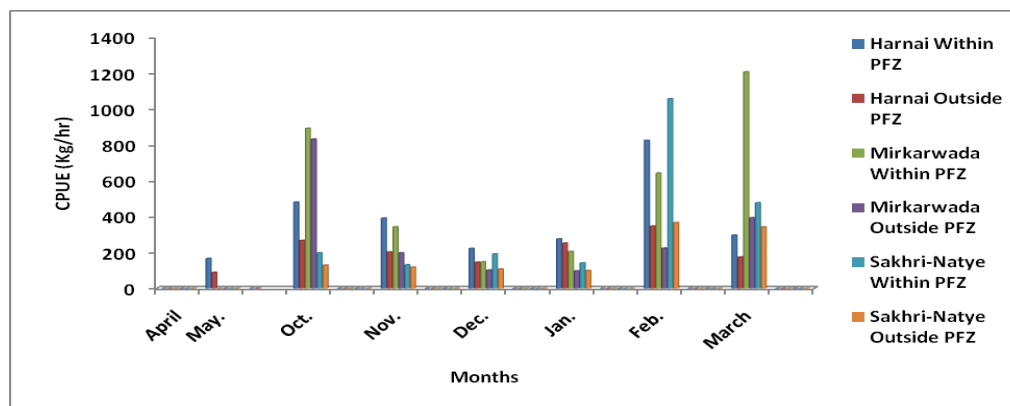
Fig. 3. Standardized CPUE (kg/hr) at Harnai, Mirkarwada, and Sakhri-Natye (FLC), Trawl net catch during 2009-10.



Standardized CPUE at Harnai, Mirkarwada and Sakhri-Natye fish landing centres of Trawl net catch during the year 2010-2011:

The CPUE at Harnai FLC (Fig. 4) shows high value 824, in February and low (166) in April within PFZ, whereas in outside PFZ CPUE was high (346) in February and low 88.12 in May. In Mirkarwada FLC, the CPUE was higher (1205.70) in March and lower (147) in December. Therefore, the inferred PFZ advisories are more beneficial to the real time user fisher as the CPUE is definitely high within PFZ. In Sakhri-Natye FLC the CPUE high 1056.33 in February and low (131) in November within PFZ, while in outside PFZ higher CPUE (366) in February and 99 lower in January. It indicates that the CPUE was higher and beneficial to the real time used PFZ advisories. Therefore in February Harnai, March Mirkarwada and March Sakhri-Natye FLC higher CPUE was recorded from the PFZ than outside PFZ.

Fig. 4. Standardized CPUE (kg/hr) at Harnai, Mirkarwada, and Sakhri-Natye (FLC), Trawl net catch during 2010-11.

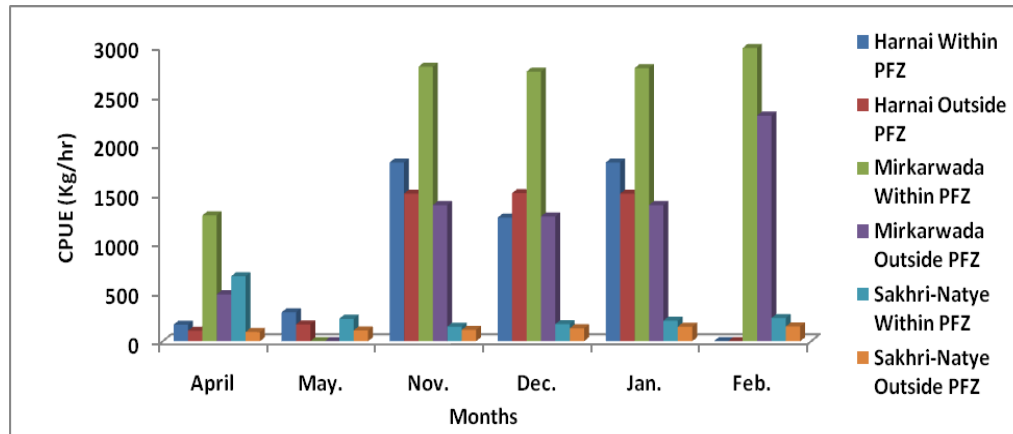


Standardized CPUE at Harnai, Mirkarwada and Sakhri-Natye fish landing centres of Trawl net catch during the year during 2011-2012:

The CPUE was found in Harnai FLC to be high (1823 & 1823) in both November & January and low 169 in April within PFZ, whereas in outside PFZ CPUE was higher (1510) in December, lowered by

both November & January (1505) and low (107) from outside PFZ (Fig. 5). From Mirkarwada-Ratnagiri FLC CPUE was higher 2,990 February, 2,785 January and 2,749 December and lower 1,283 in within PFZ while in outside PFZ 2,300 in February higher and

Fig. 5. Standardized CPUE (kg/hr) at Harnai, Mirkarwada, and Sakhri-Natye (FLC), Trawl net catch during 2011-12.

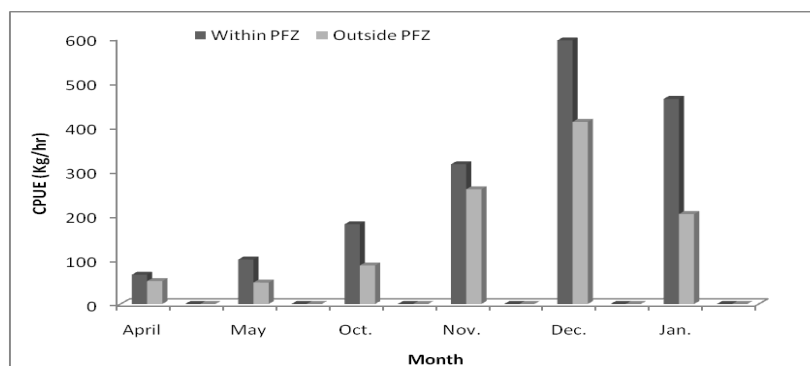


lower 479 in April outside PFZ. In Sakhri-Natye FLC the CPUE was found to be 663 in April and low 149 in November within PFZ, while in outside PFZ 150 in February and 148 in January was recorded followed by 94 in April in trawl net operation. Therefore, it indicates that the CPUE that the more beneficial to the in real time PFZ advisory users.

Standardized CPUE at Mirkarwada fish landing centre of Purse-seine net catch during the year 2007-2008:

In Mirkarwada fish landing centre, study period pertains to April, May, October, November, December, January and February. (Fig. 6) shows Purse-seine landing at Mirkarwada, within and outside PFZ fish catch data collected from the users for CPUE. The CPUE was higher 595 in December and lower 66.10 in April within PFZ, while outside PFZ CPUE was 411 higher in December and lower 48.33 in May. Thus it is indicated that the CPUE was more within PFZ than outside PFZ.

Fig. 6. Standardized CPUE (kg/hr) at Mirkarwada (FLC), Purse-seine catch during 2007-08.

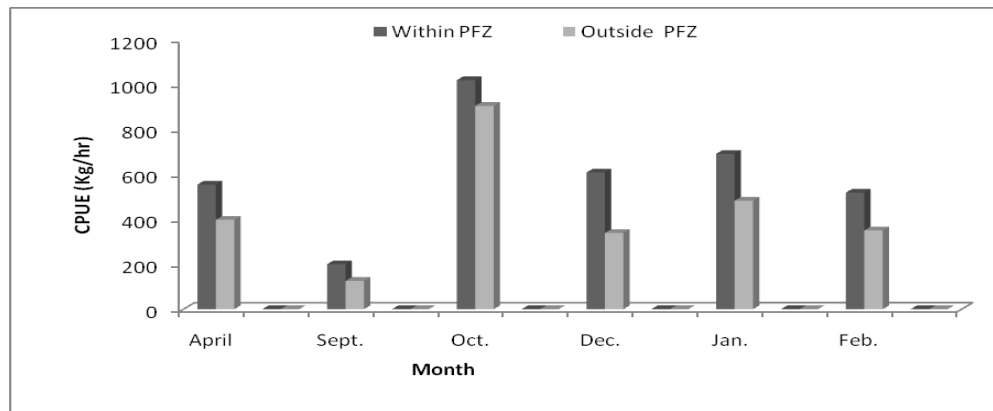


Standardized CPUE at Mirkarwada fish landing centre of Purse-seine net catch during the year 2008-2009:

In Mirkarwada purse-seine FLC, CPUE was high on (1020) in October and low (200) in September within PFZ (Fig. 7) as the CPUE was in the range of 126 to 905 it was high October and low

in September respectively in outside PFZ. In May, November and March PFZ data not available because of the PFZ dissemination was offshore region due to which fisherman could not go to the fishing.

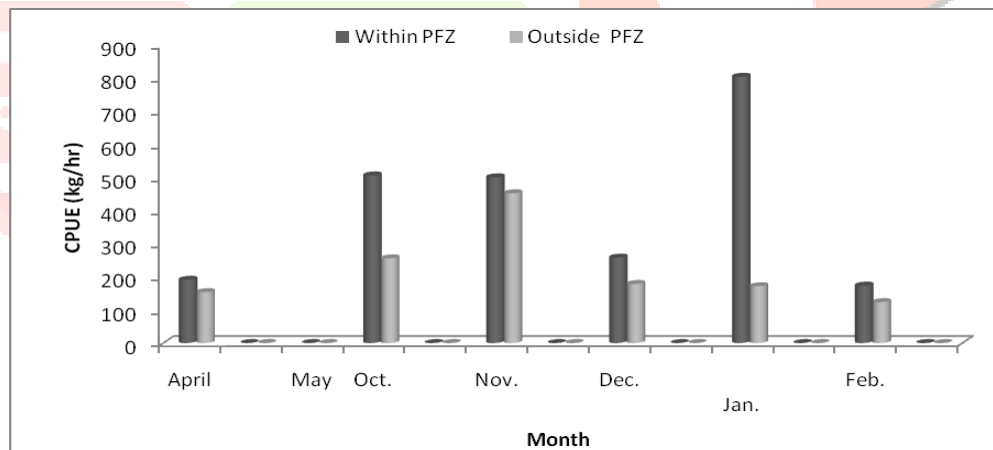
Fig. 7. Standardized CPUE (kg/hr) at Mirkarwada (FLC), Purse-seine catch during 2008-09.



Standardized CPUE from Mirkarwada fish landing centre of Purse-seine catch during the year 2009-2010:

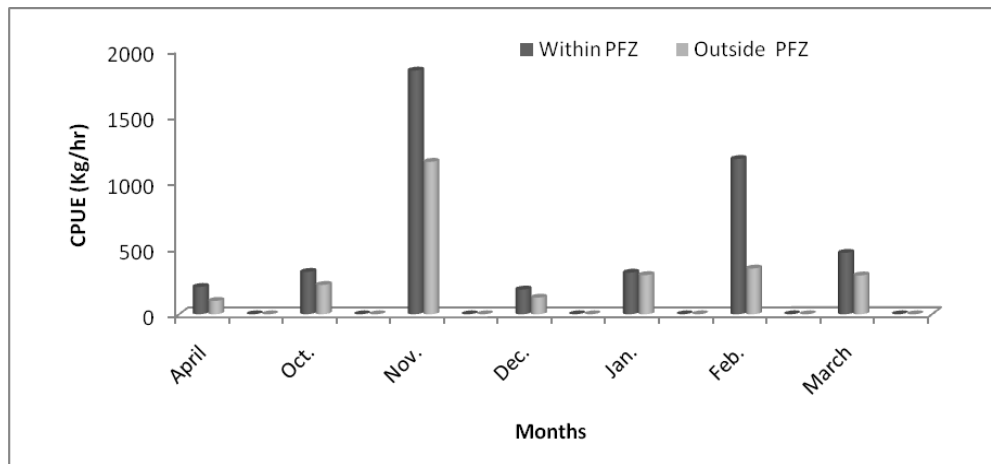
The CPUE of purse-seine net operation of Mirkarwada was found to be high in January 805 and low 173.70 in February within PFZ, while in outside PFZ CPUE was found to be high in November 453 and low 123.70 in February from outside PFZ. In the month of May and March PFZ advisories were in offshore region as fishermen do not conduct fishing. (Fig.8)

Fig. 8. Standardized CPUE (kg/hr) at Mirkarwada (FLC), Purse-seine catch during 2009-10.



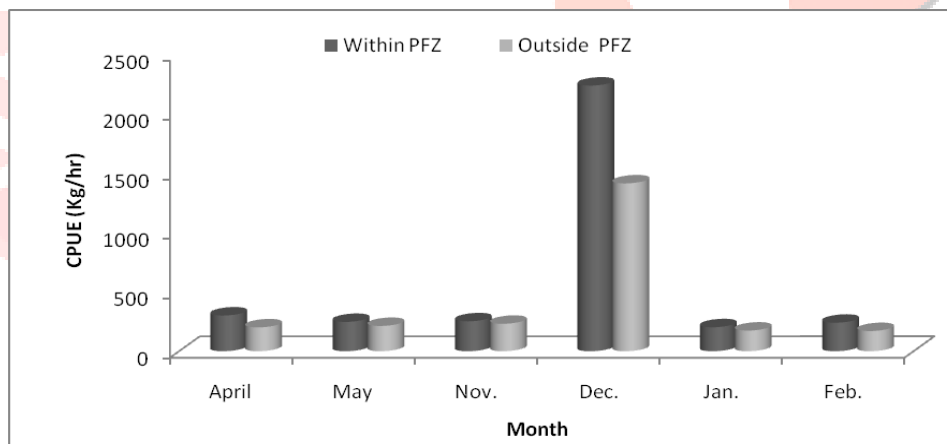
Standardized CPUE at Mirkarwada fish landing centre of Purse-seine catch during the year 2010-2011:

In the Mirkarwada FLC purse-seine net operation CPUE was to be found high 1846.33 in November and low 187 in December from within PFZ, while in outside PFZ CPUE was high 1155 in November and low 101 in outside PFZ. The results showed that the CPUE is high in PFZ than outside PFZ during purse-seine net operation. During the study period of April 2010 to March 2011 the month of May and September the PFZ forecast was offshore region due to the fishermen did not go to that region for fishing. (Fig. 9)

Fig. 9. Standardized CPUE (kg/hr) at Mirkarwada (FLC), Purse-seine catch during 2010-11.

Standardized CPUE at Mirkarwada fish landing centre of Purse-seine catch during the year 2011-2012

In the Mirkarwada FLC purse-seine net operation (Fig. 10.) shows that the CPUE was found to be high (2,238) and low (202) in January within PFZ, while in outside PFZ CPUE was high (1,414) in December and low (170) in February and (174) in January. During the study period of April 2011 to February 2012 the month of December was more beneficial due to the real time uses of the PFZ advisories.

Fig. 10. Standardized CPUE (kg/hr) at Mirkarwada (FLC), Purse-seine catch during 2011-12.

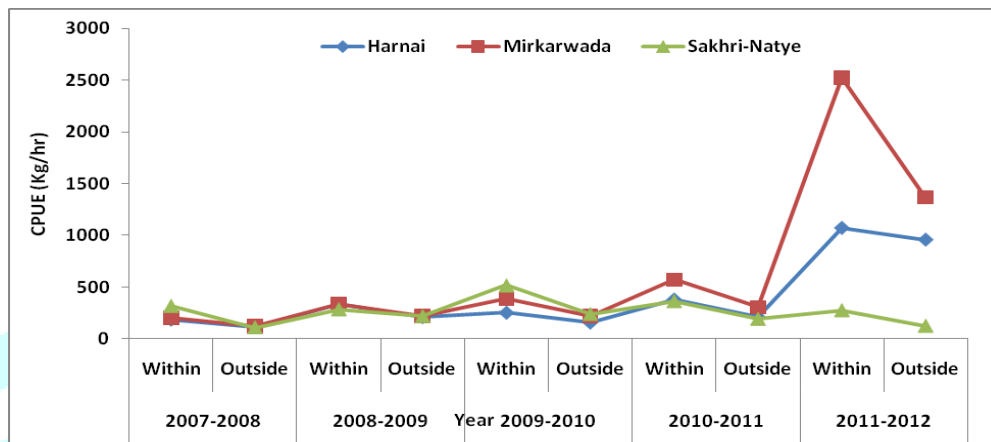
It is usually assumed that CPUE is directly proportional to abundance of fish in the area and is commonly used because it is a fishery-dependent indicator. Solanki *et al.* (2003) reported about 70% observations were positive in depth zone 30-50m whereas 90% observations were positive in 50-100 m depth zone. On an average 100% and 70% increase in catch at 30-50 m and 50-100 m respectively. The per cent increase in total catch was calculated from CPUE in PFZs as compared with mean CPUE of the month.

Average CPUE from Trawl in Ratnagiri District from 2007 to 2012:

The average CPUE in trawl net (Fig. 11) was found higher 318.91 kg within PFZ and 109.58 kg outside PFZ in Sakhri-Natye during 2007-2008, in 2008-2009 CPUE was high 337.93 within PFZ and

220.89 outside PFZ in Mirkarwada FLC. In Sakhri-Natye FLC CPUE was found high 518.4 within PFZ and low 239.78 outside PFZ during 2009-2010. The CPUE was found to be high within PFZ (572.17) and low (307.13) outside PFZ in Mirkarwada FLC during 2010-2011. In Mirkarwada FLC CPUE was as high as 2521.2 within PFZ while in outside PFZ 1365.4 during 2011-2012. The overall results shows that the CPUE high in Mirkarwada FLC and low in Harnai and Sakhri-Natye.

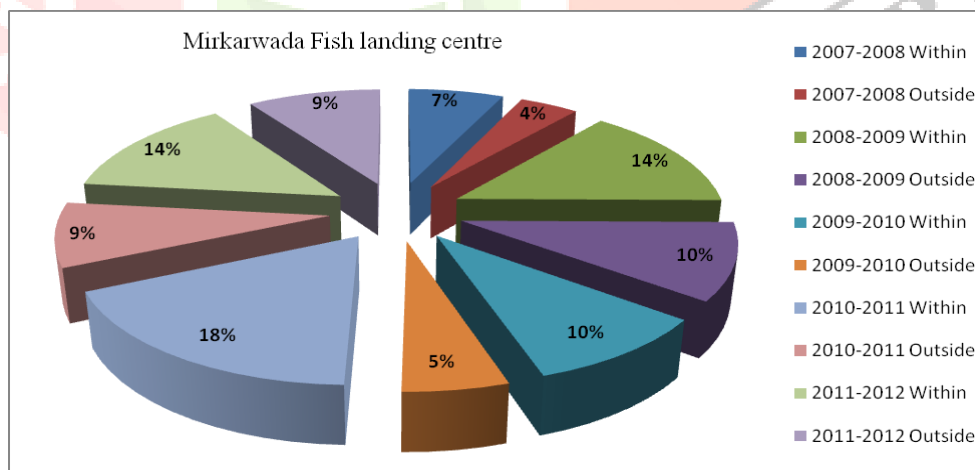
Fig. 8. Average standardized CPUE (kg/hr) at Harnai, Mirkarwada & Sakhri-Natye (FLC) of Trawl net catch during 2007 to 2012.



Average CPUE from Purse-Seine in Mirkarwada-Ratnagiri from the year 2007 to 2012:

The CPUE in Purse-seine operation was found to be high in 2010-2011 within PFZ and low in 2007-2008, while in outside PFZ CPUE was more in 2008-2009 and low in 2007-2008 (Fig. 12).

Fig. 9. Average standardized CPUE (kg/hr) at Mirkarwada (FLC), Purse-seine net catch during 2007-2012



DISCUSSION

The development of fisheries depends upon availability of natural resources, climate, physical resources, adequate finance, suitable and new technology, growth of fishing units, extension of fishing areas, Government policies, the modern technology, growth of fishing units, extension of fishing areas and flow of the technical information to grass-root level (Nayak *et al.*, 2003). With increase in fishing fleets, there is a tremendous pressure on the traditionally known fishing grounds, which may lead to

decline in CPUE. Hence, there is a need to divert some fishing efforts in other suitable potential fishing areas, which can be explored using remote sensing techniques.

With the launch of Indian Remote sensing Satellite (IRS P4) on May 26, 1999 ocean colour monitor (OCM) data provided information on the basis of chlorophyll concentration and validation of Potential Fishing Zones (PFZ) forecasts are carried out by using integration of chlorophyll concentration and SST image. These advisories are being generated by using the satellite data sets from NOAA AVHRR, IRS-P4 OCM and MODIS AQUA. The SST and chlorophyll-a are derived from the NOAA AVHRR and IRS P4 OCM/MODIS AQUA respectively (Solanki et al., 1998; Solanki et al, 2003). Data distribution is pertaining to the coastal states directly through the fishing efforts jointly by INCOIS, Hyderabad and different institutions on regular basis. This PFZ information is distributed through the fax, telephone, prints and electronic digital display board (EDDB) to the coastal fishermen community immediately after receiving from the INCOIS. The EDDB plays a vital role in providing information in local languages. A reliable and timely forecast of PFZ advisories of fish aggregation are benefitted to the fishermen to reduce their search time for locating fish and saved fuel and effort spent in searching the fishing ground too. It has been proved and validated that, the search time for fish has been reduced by 70 % due to usage of this advisories (Radhakrishna, 2004). The PFZ advisories are more beneficial within the PFZ zones than outside the PFZ zones in pelagic region in Arabian Sea near to the coast of Ratnagiri (Bhaware et al, 2012). Exploitation of fishing resources through the integration of ocean colour with sea surface temperature are becomes a more important fishing ground for fishermen community (Dwivedi, et al, 2005).

The comparisons of CPUE were made between the 3 fish landing centres (Harnai, Mirkarwada and Sakhri-Natye) and Mirkarwada fish landing centre showed higher fish catch than Harnai and Sakhri-Natye. Also the standardized catch per unit efforts CPUE was higher during the year 2011-12 than in 2007-08 followed by 2008-09, 2009-10 and 2010-11. So it is very correlate with the work of Chih-Shin Chen-Tai Sheng Chiu, (2009) the catch per unit efforts (CPUE) of a commercially exploited population which can serve as an effective index of its abundance, as long as different sources of the catch-efforts data are comparable.

It is also observed that, the CPUE of the fishing depth (30-50 m) zone along the Ratnagiri coast were 100% followed by 80% in 50-100 m depth zone were observed in purse-seine and trawl net operation (CCMB, 2012). At present increase in total catch CPUE in potential fishing zones PFZ were calculated and compared with mean CPUE of outside potential fishing zones PFZs and about 70% increase was reported from suggested area in 30-100 m depth zones previously reported by Solanki et al, (2003). Also it is important that the fisher folk of Ratnagiri have used 50% advisory and operated their purse-seine and trawl net in potential fishing zones area while total fisher folk of Maharashtra State fishers used only 40% PFZ forecast to extent fishing activity (CCMB, 2012). Thus, majority of active

fishermen are using forecast for locating potential fishing grounds and getting substantial and benefits to fishery in the PFZ advisories areas.

To conclude from present study the standardized catch per unit efforts CPUE in purse seine and trawl net calculated and revealed that, i) the CPUE at three landing centres within PFZ is higher than outside PFZ for both the trawls and purse-seine. This indicated that, use of timely forecast PFZ advisories are beneficial for fisher folk to save time and effort and get higher fish catch. ii) And the purse-seine net fishing percentage are more benefitted than trawl net fishing in potential fishing zones PFZ areas in pelagic fishery.

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