Indian Journal of Geo Marine Sciences
Vol. 48 (02), February 2019, pp. 228-232

Seasonal occurrence of potential fishing zones along northern Andhra Pradesh coast

Loveson L. Edward*, Hanumantha Rao M.V., Uma Mahesh V., Muktha Menon, & Shubhadeep Ghosh

ICAR-Central Marine Fisheries Research Institute, Regional Centre, Oceanview Layout, Pandurangapuram, Visakhapatnam, Andhra Pradesh, India

*[E-mail: loveson_edward@yahoo.co.in]

Received 02 August 2017; revised 04 October 2018

Data on potential fishing zones (PFZ), obtained from the Indian National Centre for Ocean Information Services (INCOIS), Hyderabad, and advisories for North Andhra coast were segregated season wise and analyzed to understand the trends and the frequency of occurrences of PFZ in North Andhra coast. Plotting of data revealed location of PFZ near coastal regions during summer months. These zones moved towards deeper waters during pre-monsoon, expanding to a larger area as the monsoon progressed and moved north during post-monsoon season. Plotting also revealed that Kakinada waters have frequent PFZ hits especially nearer to the Kakinada bay. Visakhapatnam waters were observed to get high intensity of PFZ hits during Monsoon followed by those during post-monsoon and summer seasons. However in Kalingapatnam waters, high intensity of PFZ occurred during post-monsoon followed by monsoon and summer seasons.

[Keywords: Potential fishing zone, north Andhra]

Introduction

Remote sensing techniques are used in quickly gathering information about large area and finds application in different disciplines, saving time and manpower. Remote sensing is used in ocean sciences for coastal zone management, ocean features and ocean colour analysis [1] by collecting data on sea surface temperature, transparency and depth of penetration of sunlight, phytoplankton, chlorophyll, and biological productivity of the ocean[2,3]. Based on these oceanic parameters and considering their increased biological productivity, such areas can be demarked as zones where increased fish catch can be obtained[4]. Internationally remote sensing and satellite

fish catch termed as Potential Fishing Zones (PFZ). Presently in India, validated PFZ forecasts are disseminated by Indian National Centre for Ocean Information Services (INCOIS), Hyderabad[5], which also provides latitude and longitude positions, distances, directions and depth of operations from the nearest fishing harbours. This helps fishermen in finding fish shoals and thereby reducing the cost of commercial fishing operation. Hence the present study was conducted to determine the trends of PFZ along north Andhra coast by segregating the PFZ advisories season-wise and analyzing it for the frequency of its occurrences season-wise and region-wise, so as to help the fishermen in identifying the fishing zones in different seasons.

Materials and Methods

The PFZ advisories for north Andhra coast were obtained from INCOIS, Hyderabad, for two years (2012 and 2013) and were analyzed for frequency of their occurrences. The 1x1 degree grids of the study area from 16° 30' to 19° N latitudes and 82° 15' to 86 ° E longitudes were divided into 16 smaller grids. All 1x1 degree grids having connection with fishing area were named as zones starting from A to K from top to bottom and smaller grids were numbered starting from top to bottom (Fig. 1). The raw data was segregated season-wise viz., March to May as summer, June to August as pre-monsoon, September to November as monsoon and December to February as post-monsoon seasons, based on the climate of this area for further analysis. A base map of INCOIS advisories with zones and smaller grids were kept over the PFZ advisory chart and the PFZ lines coinciding with the grids were recorded. Each occurrence of PFZ lines in a grid were taken as a PFZ hit[6]. The data on number of PFZ hits on each grid was added season-wise and the average value for two years (2012 and 2013) was taken for further plotting

(Table 1). The data on PFZ hits season-wise and region-wise (Table 2), with area demarcation as per administrative boundaries were statistically analyzed using SPSS software (Version 16.0) for Chi-Square test for independence of attributes for its frequency of occurrences (Table 3). Season-wise colour based hit chart was prepared based on the number of hits in each grid (Very high>15, High 11-15, Medium 6-10, low 1-5), using open source software QGIS (version 2.4.0).

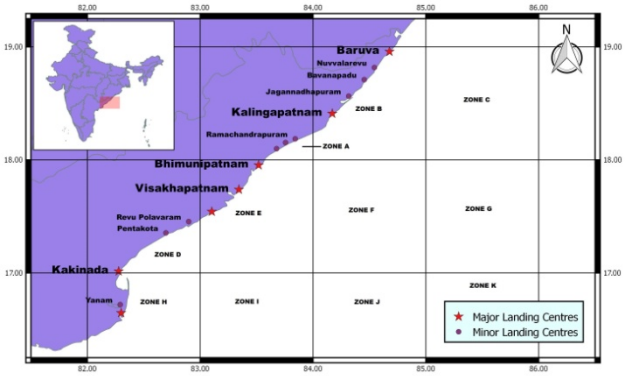

Fig. 1 — A base map of northern Andhra coast with different zones and smaller grids

Results and Discussion

The zone-wise PFZ hit data for different seasons were depicted in Table 1 with the corresponding number of smaller grids. As per Table 1, the zone with maximum number of hits was Zone B, followed by Zones E, F and C when comparing all the seasons. During summer and post-monsoon, Zone B had the highest number of PFZ hits, whereas Zone E had it during pre-monsoon and monsoon. This shows the existence of a cyclic pattern among zones. The data was further classified region-wise, viz., Kalingapatnam waters, Visakhapatnam waters and Kakinada waters with corresponding number of smaller grids for analyzing region-wise frequency of its occurrences (Table 2).

The plotting of PFZ advisories and its lines revealed that the total number of hits was more during monsoon season followed by post-monsoon and summer seasons and the least was during pre-monsoon season. During summer season (Table 3), from the months of March to May, even though the numbers of PFZ hits were less when compared with monsoon and post-monsoon seasons, they are mostly found near the coastal waters (Fig. 2). The number of

Table 1 — Details of different zones and smaller grids with the corresponding frequency of PFZ hits season wise

Position	Zone	No of Grids	No of Hits Season wise				Total Hits	Grids with High and Very High Frequency
			SU	PR	MO	PO		
18° to 18° 15' N 83° 35' to 84° E	**A**	2	13	1	6	17	37	1
18° to 19° N 84° to 85° E	**B**	13	102	68	155	229	554	10
18° to 19° N 85° to 86° E	**C**	16	60	71	114	141	386	7
17° to17° 30' N 82° 20' to 83° E	**D**	5	41	21	34	46	142	3
17° to 18° N 83° to 84° E	**E**	15	66	115	180	114	475	10
17° to 18° N 84° to 85° E	**F**	16	98	66	169	59	392	9
17° to 18° N 85° to 86° E	**G**	16	32	16	19	23	90	0
16° 30' to 17° N 82° 15' to 83° E	**H**	6	53	30	46	46	175	3
16° 30' to 17° N 83° to 84° E	**I**	8	9	14	22	27	72	1
16° 30' to 17° N 84° to 85° E	**J**	8	20	2	8	20	50	0
16° 30' to 17° N 85° to 86° E	**K**	8	9	0	2	13	24	0
Total		113	503	404	755	735	2397	44

Abbreviation: SU-Summer, PR-Pre Monsoon, MO-Monsoon, PO-Post Monsoon

Table 2 — Details of regions and zones covered with corresponding fish landing centres

Region	Position	Zone covered	No of Grids	Fish landing centres
Kalingapatnam Waters	Lat 18° to 19° N Long 83° 35' to 86° E	A, B, C	31	Konada, Chintapalli, Ramachandrapuram, Srikurmam, Kalingapatnam, Jaganadhapuram, Bavanapadu, Nuvvalarevu, Baruva
Visakhapatnam Waters	Lat 17° 15’ to 18° N Long 82° 32’ to 86° E	D, E, F, G	37	Bhimunipatnam,Visakhapatnam, Pudimadaka, Pentakota, Revupolavaram
Kakinada Waters	Lat 16° 30' to 17° 15’ N Long 82° 15’ to 86° E	D, E, F, G, H, I, J, K	45	Kakinada, Karakutippa, Yanam, Bhairavapalem

Table 3 — Details of number of PFZ hits season wise and region wise

Season	Total no of hits*				Grids with High and Very high frequency			
	SU	PR	MO	PO	SU	PR	MO	PO
Kalingapatnam Waters	175	140	275	387	7	4	12	14
Visakhapatnam Waters	166	162	292	173	2	6	14	5
Kakinada Waters	162	102	188	175	5	4	7	5
Total	503	404	755	735	14	14	33	24

*Chi-square test for independence of attributes – significant – P<0.01
Abbreviation: SU-Summer, PR-Pre Monsoon, MO-Monsoon, PO-Post Monsoon

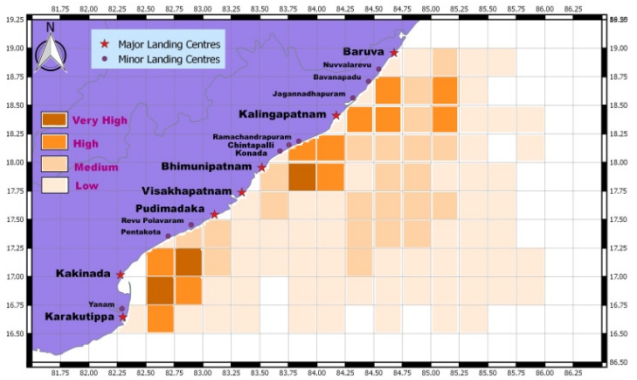

Fig. 2 — Colour-based hit chart during summer months for north Andhra coast

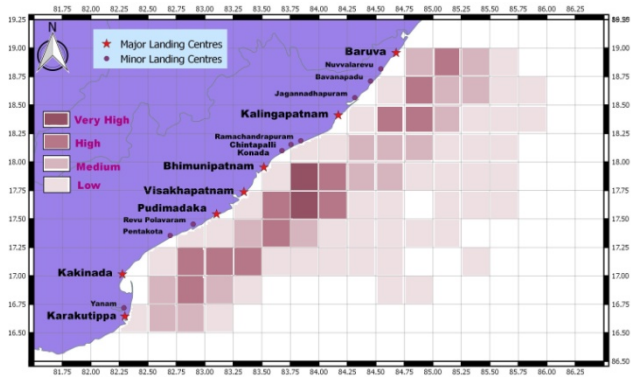

Fig. 3 — Colour-based hit chart during pre-monsoon months for north Andhra Coast

grids with low level of hits was more and spread mostly in deeper waters. However, few grids with high and very high frequency were found near the coast. The fishing area near Kalingapatnam waters got the maximum number of PFZ hits followed by Visakhapatnam and Kakinada waters; this can be further supported by the zone-wise classification of data in Table 1.

Pre-monsoon (Fig. 3) is found to be the lean season with less number of hits. But during this season, Visakhapatnam waters got the maximum PFZ hits followed by Kalingapatnam and Kakinada waters. The trend of grids with high and very high frequency hits shows that they move towards deeper waters away from the coast as compared with the summer season. The total numbers of hits are comparatively less than all the other three seasons, but the grids with hits 11 and above were found to be same as that of summer months.

During monsoon months, the PFZ was found to expand to a larger area (Fig. 4) with more number of high and very high frequency hits and maintains to stay over the deeper waters. Here too, maximum aggregation is near Visakhapatnam waters followed by Kalingapatnam and Kakinada waters. The trend of these color-based charts shows an apparent northerly movement of PFZ advisories. Comparatively, this season is found to possess the highest number of PFZ hits throughout the northern Andhra coast.

Post-monsoon is found to be the second most productive season (Fig. 5) with the second highest number of PFZ hits. During this season, the advisories were found to be available near the northern latitudes with a definite trend of high and very high frequency grids moving back to the coastal near shore areas.

Since the shift is towards the northern latitudes, the maximum number of hits was in

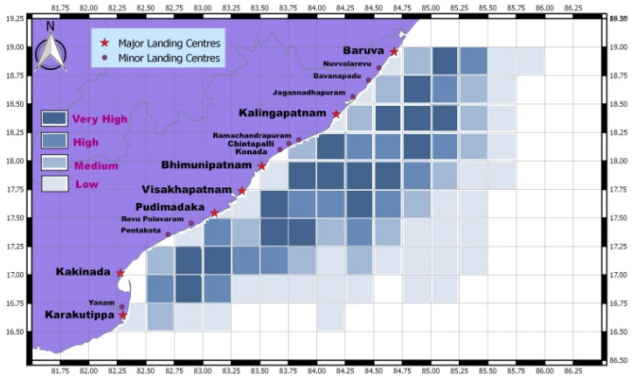

Fig. 4 — Colour-based hit chart during monsoon months for north Andhra Coast

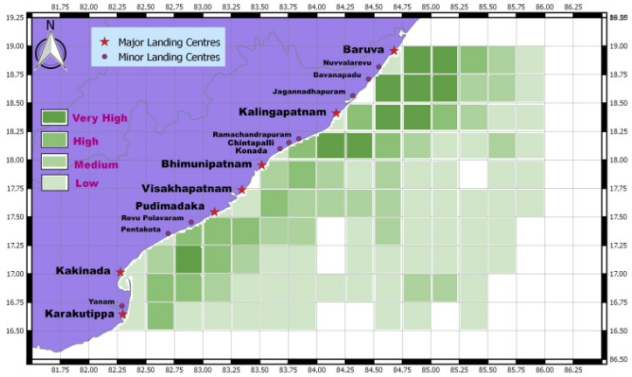

Fig. 5 — Colour-based hit chart during post-monsoon months for north Andhra Coast

Kalingapatnam waters followed by Kakinada and Visakhapatnam waters.

Earlier, an oceanographic study[7] in this region found influence of salinity in the formation of high productive zone in depths less than 50 m. A study[6] along Kerala coast opined that salinity variations are mainly due to rainfall, and river runoff plays a critical role in developing PFZs. Longhurst and Pauly[8] also observed a positive correlation between mean annual river discharge and fish catch rate. The low production in coastal waters of north Andhra may be due to the absence of major rivers in the study area. The present study area gets huge amount of freshwater influx only during the north-east monsoon whereas south-west monsoon river discharge remains in northern Bay of Bengal[9]. However presence of high saline waters between Gopalpur and Kakinada has also been confirmed[10]. The trends in the high and very high hit zones changes of this area may be due to different regions experiencing upwelling and downwelling in different seasons along the coast, which has been reported by several researchers[11,12,13]. Coastal water circulations of this region are also

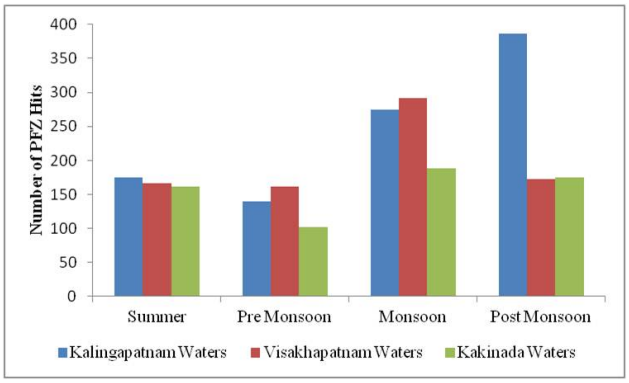

Fig. 6 — Season-wise PFZ hits for different waters

influenced by seasonal reversing monsoon winds when there is no significant freshwater flow [10,14,15].

Kalingapatnam waters recorded low frequency hits during pre-monsoon and then the frequency increases during monsoon and attains a peak during post-monsoon and then again drops back during summer season. Thus it forms a cyclical pattern with more number of hits in the coastal areas during post-monsoon and summer and in the deeper areas during pre-monsoon and monsoon seasons.

Monsoon gives Visakhapatnam its peak in the number of PFZ hits, after which it gets less during post-monsoon due to the movement of PFZ to higher latitudes and still reduces during summer and registers the lowest during pre-monsoon season. The same cyclical trend is followed when looking at the high and very high frequency hit grids pattern.

Even though the number of grids in the Kakinada region is more, except in post-monsoon, when Kakinada registers the lowest number of PFZ hits (Fig. 6). Monsoon is the most productive for Kakinada followed by post-monsoon, summer, and pre-monsoon. However, Kakinada waters follows its own cyclical pattern of rotation of PFZ hits near the Kakinada bay without being disturbed much when Visakhapatnam and Kalingapatnam waters are following a cyclic pattern between them. Here in Kakinada, the rotational pattern is within their waters, not much into deeper waters making it independent of the other two regions. Chi square test for independence of attributes of depth-wise and region-wise data (Table 3) also concludes that there is an association between region and depth of occurrences of PFZ hits ($P<0.01$).

The existence of cyclical pattern in the occurrence of PFZ during different seasons and the movement of high and very high frequency PFZ hit zones from coastal to deeper waters (Figs 2 to 5) may be due to

freshwater influx. The presence of high saline waters and strong offshore currents (0.5 to 0.6 m s^{-1}) pushes the cascading low saline waters[16] from the north which runs parallel due to the straight orientation of the east coast[10]. Due to this, the low saline waters are pushed to deeper waters forming low saline pools. A study[17] along the east coast of India also confirms the occurrence of freshwater plume, located at a distance of 100 km away from the coast.

In general, the PFZ in the north Andhra region follows a cyclic pattern, with the PFZ occurring more near coastal waters in summer and moving towards deeper waters during pre-monsoon and expands its territory in monsoon with trends of moving towards north and spreading itself in post-monsoon in the northern latitudes with a definite trend of moving back to coastal areas down south. This cyclical pattern is similar to that occurring in the waters of Visakhapatnam and Kalingapatnam, whereas in the Kakinada waters, the pattern is different. These seasonal trends can only be attributed to the heavy influx of north bound freshwater, presence of high saline waters along near coastal regions, and coastal water circulation influenced by seasonal reversing monsoon winds.

Acknowledgements

The authors are very much grateful to the Director, ICAR - Central Marine Fisheries Research Institute (CMFRI), Kochi and the Head, FEM Division for their constant encouragement, support and facilities rendered during the course of this study. Authors are equally grateful to Dr. J. Jayasankar, Principal Scientist, CMFRI, for suggesting statistical analysis.

References

1 Ali, M.M., Rao, K.H., Rao, M.V. & Sridhar P.N., Oceans, In: *Remote sensing applications, 2nd edition*, edited by Roy, P.S., Dwivedi, R.S. & Vijayan, D., (NRSC, Hyderabad), 2010, pp. 217-250

2 Vinayachandran, P.N., Chauhan, P., Mohan, M. & Nayak, S.R., Biological response of the sea around Sri Lanka to summer monsoon, *Geophys. Res. Lett,* **31(1)** (2004), L01302. doi:10.1029/2003GL018533

3 Shetye, S.R., Shenoi, S.S.C., Gouveia, A.D., Michael, G.S., Sunder, D. & Nampoorthiri, G., Wind driven coastal upwelling along the western boundary of the Bay of Bengal during the southwest monsoon. *Cont. Shelf Res,* **11** (1991), 1397-1408

4 Solanki, H.U., Dwivedi, R.M. & Nayak, R., Generation of composite image using OCM chlorophyll and NOAA AVHRR SST for locating potential fishing grounds. In: *Proceedings PORSEC 2000, Vol. II.* (National Institute of Oceanography, Goa), 2000, pp. 669-672

5 Nayak, S., Solanki, H.U. & Dwivedi, R.M., Utilisation of IRS P4 ocean colour data for potential fishing zone - A cost benefit analysis, *Indian J. Geo-Mar. Sci,* **32(3)** (2003), 244-248

6 Kripa, V., Mohamed, K.S., Prema, D., Mohan, A. & Abhilash, K.S., On the persistent occurrence of potential fishing zones in the southeastern Arabian Sea. *Indian J. Geo-Mar. Sci,* **43(5)** (2014), 737-745

7 Kumar, S.P., Narvekar, J., Nuncio, M., Gauns, M. & Sardesai, S., What Drives the Biological Productivity of the Northern Indian Ocean?, *Geophys. Monogr. Ser,* **185** (2009), 33-56

8 Longhurst, A.R. & Pauly, D., *Ecology of Tropical Oceans*, (Academic Press, London, United Kingdom), 1987, pp 407

9 Shetye, S.R., Gouveia, A.D., Shankar, D., Shenoi, S.S.C., Vinayachandran, P.N., Sundar, D., Michael, G.S. & Nampoothiri, G., Hydrography and circulation in the western Bay of Bengal during the northeast monsoon, *J. Geophys. Res,* **101** (1996), 14011-14025

10 Mahapatra, D.K. & Rao, A.D., Redistribution of low-salinity pools off east coast of India during southwest monsoon season, *Estuar. Coast. Shelf Sci,* **184** (2017), 21-29. doi:10.1016/j.ecss.2016.10.037

11 Murty, C.S. & Varadachari, V.V.R., Upwelling along the east coast of India, *Bull. Natl. Inst. Sci. India,* **36** (1968), 80-86

12 Rao, T.V.N., Rao, B.P. & Raju, V.S.R., Upwelling and sinking along the Visakhapatnam coast, *Indian J. Mar. Sci,* **15** (1986), 84-87

13 Johns, B., Rao, A.D. & Rao, G.S., On the occurrence of upwelling along the east coast of India, *Estuar. Coast. Shelf Sci,* **35** (1992), 75-90

14 Cutler, A.N. & Swallow, J.C., *Surface Currents of the Indian Ocean (to 25_S, 100_E). Compiled from Historical Data Archived by the Meteorological Office, Bracknel, UK. Report 187*, (Institute of Oceanographic Sciences, Wormley, UK), 1984, pp 8 and 36 charts

15 Hastenrath, S. & Greischar, L.L., *Climatic Atlas of the Indian Ocean. Part III: Upper-Ocean Structure*, (University of Wisconsin Press, Wisconsin, USA), 1989, Charts 247

16 Lucas, A.J., Nash, J.D., Pinkel, R., MacKinnon, J.A., Tandon, A., Mahadevan, A., Omand, M.M., Freilich, M., Sengupta, D., Ravichandran, M. & Le Boyer, A., Adrift upon a salinity-stratified sea: a view of upper-ocean processes in the Bay of Bengal during the southwest monsoon, *Oceanography,* **29(2)** (2016), 134-145. doi:10.5670/oceanog.2016.46

17 Vinayachandran, P.N. & Kurian, J., Hydrographic observations and model simulation of the Bay of Bengal freshwater plume, *Deep-Sea Res I,* **54** (2007), 471-486.