Research Communications

Enhancing the quality and utility of India's Marine Fish Landing Data Collection and Processing System using spatial information

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Abstract

The ICAR-Central Marine Fisheries Research Institute is mandated with the monitoring and assessment of marine fishery resources of India. The methodologies adopted for the collection and processing of fish landings data have undergone due changes in tune with developments in the relevant scientific fields. This paper discusses how the addition of spatial domain information explicitly to the present fish landings data collection process would be beneficial in analysing, visualizing and extracting additional information from the fish landings datasets.

Keywords: *Spatial analysis, marine fish landing data, interactive map*

Introduction

In the universe, every phenomenon that occurs has a spatial dimension and any analysis of these, without a spatial dimension, is incomplete. Spatial information should form an integral part of the studies leading to the management of living natural resources. The inherent data linkages become more clear when spatial dimension is added. In the past, integration of spatial data to analytical process was not that easy as the required expertise and skill and software options necessary for the analysis was limited and costly. In the last decade, there has been an explosion in the spatial data realm in terms of software tools, data collection procedure and analysis, human expertise available for handling spatial data and how spatial information is used in the day to day life. Spatial information has been extensively used in almost all the fields of study, be it natural sciences, social sciences, archaeology, surveying, marketing and particularly in fish resource mapping elsewhere in the world (Previero *et al.*, 2018; Le´opold *et al.*, 2014; Richards-Rissetto and Landau, 2014; Giacomo, 2019; Kaymaz et al., 2017; Llobera, 2011; Carocci *et al.*, 2009).

Monitoring and assessment of marine fishery resources of India is one of the most important mandates of the ICAR-Central Marine Fisheries Research Institute (CMFRI) which the Institute has been doing since its inception in 1947. Towards this, the sampling design, data collection and processing system has been modified and upgraded from time to time (Srinath *et al.*, 2005). As of now, spatial information such as depth of actual fishing area, distance from the landing centre in addition to the latitude and longitude of the landing centres are being collected. However, these spatial information are not fully utilized in the analysis, and thereby valuable information that could help in better management of the marine fish resources is being lost. Considering this, an attempt to passively georeference the fishing grounds using available spatial information and giving a spatial dimension to the data was made. For this, an App consisting of an interactive map was developed using ArcGIS, QGIS and Leaflet. This pilot study was a part of the LENFEST funded international collaborative project on 'Benchmarks for Ecosystem Assessment: Indicators and Guidelines for Practical Ecosystem Based Fishery Management' led by CSIRO, Australia.

Features of the tool

Geolocating of the Fishing Grounds

In 2018, CMFRI shifted from a paper and pencil method of fish catch data recording to an electronic tablet mode (Mini *et al*., 2020). For this, an App with an interactive map was designed and installed in the tablets used by the field staff for collection of the marine fish landings data for passively geolocating the fishing grounds, based on information collected through an enquiry from the fishers. The Chellanam (9.798805˚N and 76.275287˚E) fish landing centre in Ernakulam district, Kerala where only single day fishing crafts are being operated was selected for testing the App. The coastal waters up to a distance of 50 km from the Kerala coast was divided into 0.1° x 0.1° grids (which is approximately 11 km x 11 km grids) and this forms the basic mapping unit (smallest grid indicating a fishing area) of fishing grounds. The information on the average depth of each of the 0.1° x 0.1° grids was extracted and added to the grid layer. The attribute of the grid layer contains information like, grid identification code (GID), the central latitude of the grid, central longitude of the grid and the mean depth of the grid in meters and fathom. Upon clicking the grid cells, these information will be displayed in the tab. By the GID, one can identify the grid to know its coordinates and also the depth information which are the major spatial characteristics of the fishing grounds. The App also contains the locations of the landing centres and the administrative boundaries of Kerala. When clicked on the landing centres icon, a popup window provides details such as name, zone code, state and the serial number of the landing centre. Likewise, the users also get information about administrative boundaries. The depth contours of 5, 10, 20 and 30 m are also provided in the map to get an easy visual reference of the depth of the area. Panning and zoom control buttons are provided in the top left corner of the map for easy navigation through the map. A measurement tool provided on the top left corner of the map can measure the distance between two points and also estimate the area by joining the points to make a polygon. On the top right of the map window, the map layer list is provided and one can switch on and off any layer using the checkboxes provided. In the layer list window, there is a direction diagram for easy reference of the direction from the landing centres (Fig 1 and 2).

Data collection procedure

The FRAD (Fishery Resource Assessment Division) field observer can enquire with the fishers about the distance

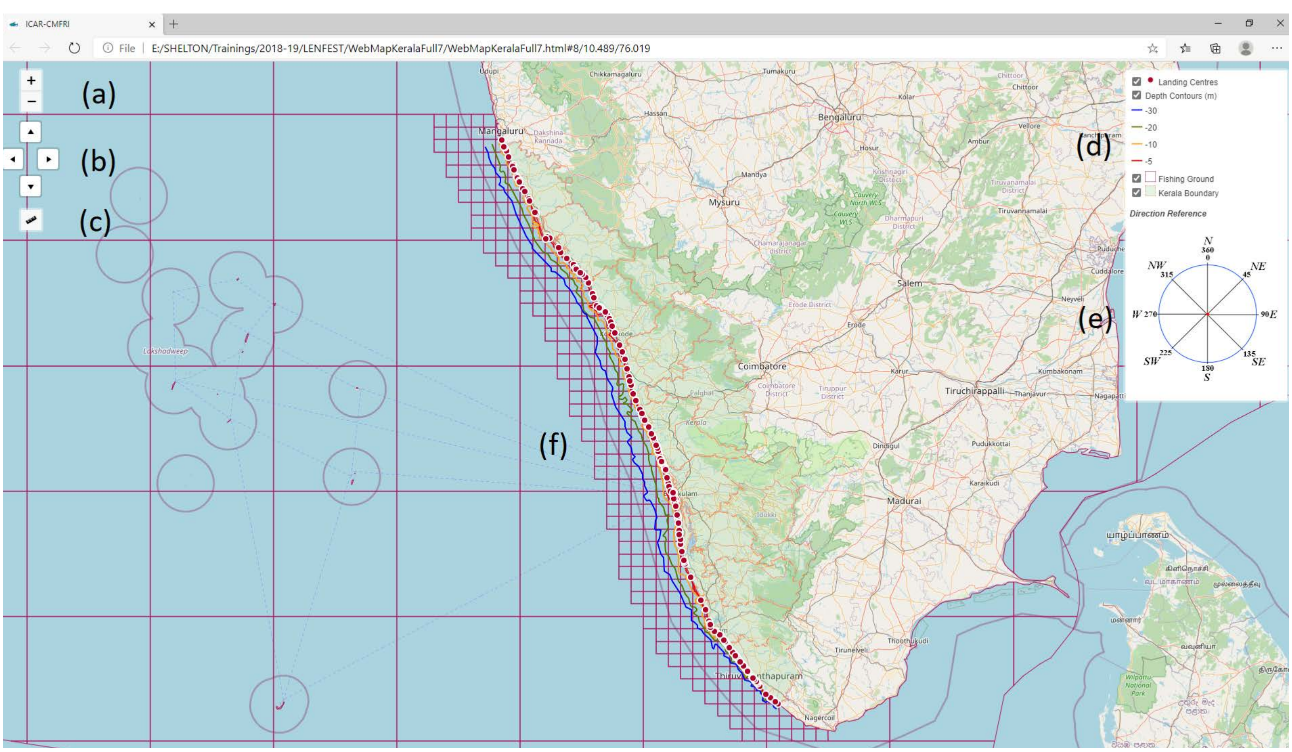

Fig. 1. Homepage of the interactive map showing zoom control buttons (a), panning buttons (b), measurement button (c), map layer list (d), direction diagram (e) and the fishing ground area (f).

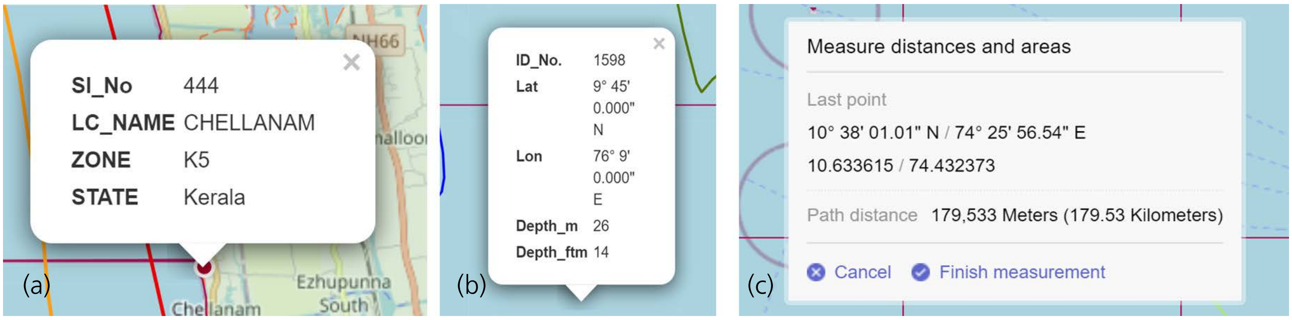

Fig. 2. Popup windows showing the landing centre information (a); fishing ground information (b) and the measurement tool window showing the distance information (c).

and direction of their fishing operation from the landing centre and also about the depth of the location at which the fishing activity was carried out. Using the measurement tool, direction reference and the depth information, he can identify the polygon in which the fishing activity was carried out (Fig 1 and 2). By clicking on the polygon, one can get the grid identification code (GID) of the polygon which he needs to enter in the datasheet along with the other information about fishery he collects usually from the landing centre. Using this GID, during the data processing phase, one can carry out a bunch of spatial data analysis which can throw better light on the fishery resources of the area. For this pilot study, the fish landing data collected were from the Chellanam fish landing centre on 16, 17 and 18 October, 2019.

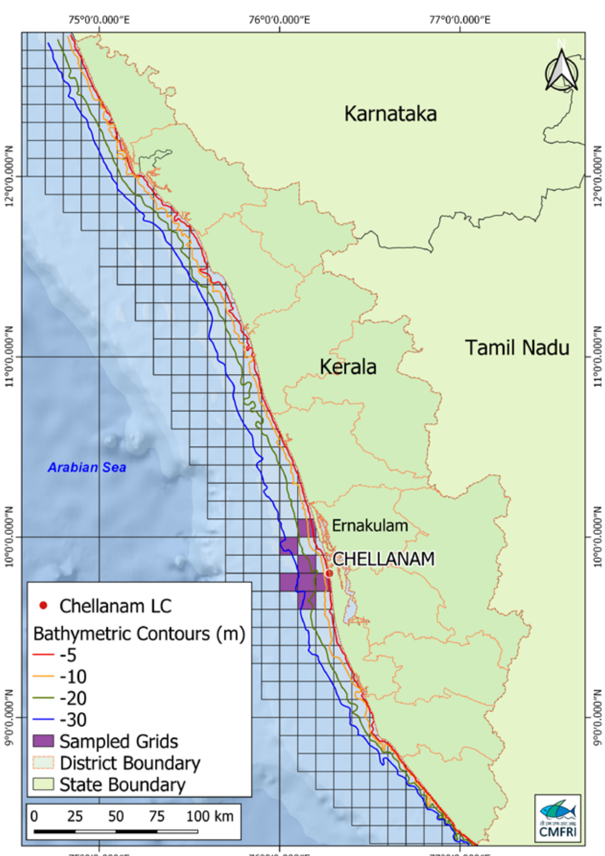

Fig. 3. Fishing grounds exploited by the crafts from Chellanam landing centre

Data analysis

On plotting the data in GIS platform, it was seen that the observed fishing crafts operated in 7 fishing ground polygons near the Chellanam landing centre. The farthest fishing ground was approximately 40 km north-west and the maximum depth of operation was 30 m (Fig. 3). The grid identification codes (GID) in which fishing operations were carried out were 50, 60, 72, 82, 83, 84 and 94. Out of the seven fishing ground polygons, five fishing crafts carried out fishing in two polygons (GID 83 and 84) and only one fishing craft each was found fishing in all the other fishing ground polygons. This indicates that the fishing grounds with the GIDs 83 and 84 has the maximum fish aggregation/fish production areas (Fig. 4).

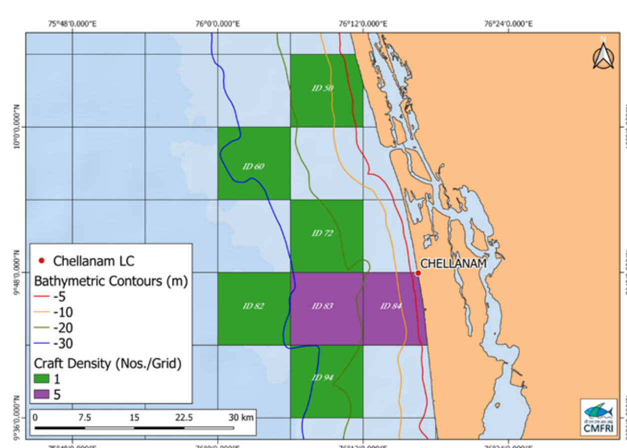

Fig. 4. Combined craft density map for the study period

The types of fishing fleets operated in the sampled area were outboard gillnets (OBGN), outboard hand trawlnets (OBHTN) and outboard ringseines (OBRS). Fishing ground polygons with GID numbers 50 and 82 were operated upon by OBRS only, while in the fishing grounds with GID 60, 72 and 94, only OBGN were used for the fishing activity. Both fishing gears *viz.* OBGN and OBRS were used in GID 83. Similarly, in GID 84, two types of gears namely OBRS and OBHTN were used (Fig 5). In terms of fish availability, the grids with GID 83 and 84 had the maximum number of species (Fig 6). Out of the nine species caught in the study area, four species were available in GID 83 and 84. The species caught from polygon 83 were *Sardinella gibbosa, Opisthopterus tardoore, Thryssa* spp. and *Rastrelliger kanagurta,* while the species caught from polygon 84 for were *Rastrelliger kanagurta, Cynoglossus* spp., *Parapenaeopsis stylifera* and *Penaeus indicus.* The polygons with GID 50 and

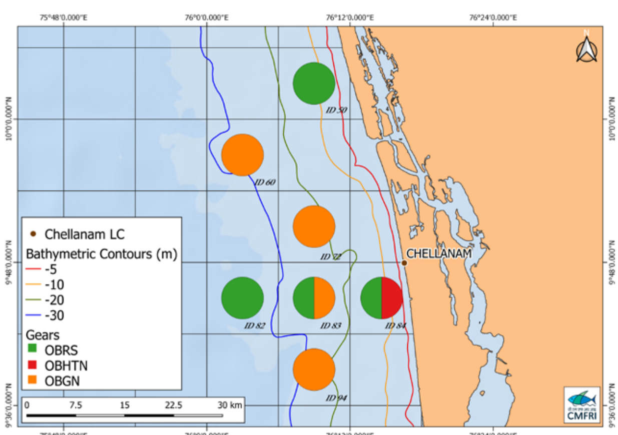

Fig. 5. Bubble map of gear distribution. (Size of bubble indicate the number of gears and the colour indicate the type of gears operated in the grid)

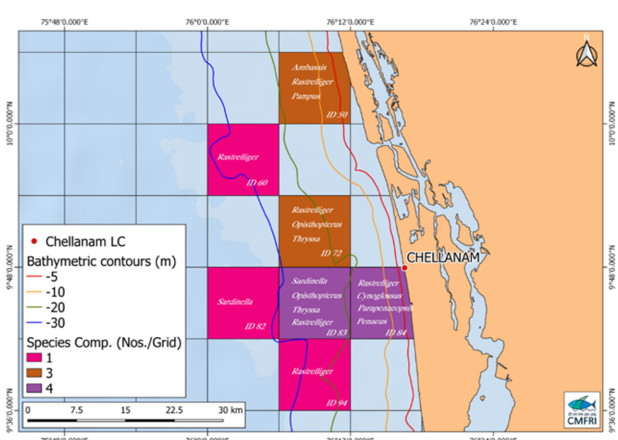

Fig. 6. Fish species caught from the fishing grounds

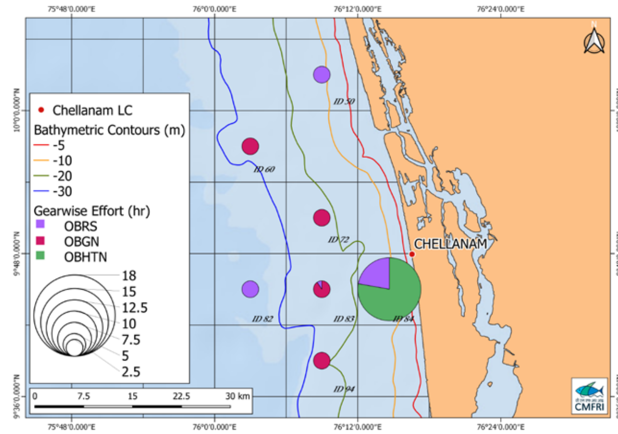

Fig. 7. Bubble map of gear-wise efforts (hr) off Chellanam on the observation days. Size of bubble indicate the magnitude of time (hr) expended by the gears in each grid and the colour indicate the type of gears operated.

72 yielded three species each (GID 50-*Ambassis* spp., *Rastrelliger kanagurta and Pampus argenteus;* GID 72-*Rastrelliger kanagurta, Opisthopterus tardoore and Thryssa* spp.The polygons with GID 60, 82 and 94 yielded one species each only (GID 60-*Rastrelliger kanagurta;* GID 82-*Sardinella gibbosa;* GID 94-*Rastrelliger kanagurta)*. The polygon with GID 82 reported the highest catch rate followed by GID 83. Gridwise details of species caught, number of fishing crafts operated, catch per unit effort (CPUE), catch per hour (CPH) and catch per grid (CPG) was recorded (Table 1).

Concerning the gear-wise effort in the fishing grounds, polygon with GID 84 reported a total effort of 18 fishing hours (OBHTN - 14 and OBRS - 4), while the GID 83 reported a total effort of 10.5 hrs (OBGN - 9.5 and OBRS - 1). All the other polygons were operated upon by single gears, either OBRS or OBGN and the fishing activity was carried out to a maximum of 2 hours of fishing (Fig 7). The polygon with GID 84 reported the highest total catch of 901 kg out of which 750 kg was caught by OBRS and 151 kg was caught by OBHTN. The next highest catch was from polygon 83 which reported a total catch of 625 kg out of which 360 kg was caught by OBRS and 265 kg was caught by OBGN. In polygon 82, the reported catch was 475 kg by OBRS (Fig 8). Rest of the polygon gear combinations gave < 100 kg catch.

The total fishing hours was more in polygon 84 (18 hours) followed by polygon 83 (10.5 hours) (Fig. 9) indicating that these two polygons were consistently

Table 1. Gridwise details of fishing effort and catch indices

GID	Species caught	Date of operation	Units Operated	CPUE (kg/effort)	CPH (kg/hr)	CPG	Total Catch (kg)
						Species-wise catch (kg)	
50	*Ambassis spp.*	16-10-19	1	24	24	24	32
	Rastrelliger kanagurta	16-10-19	1	2	2	2	
	Pampus argenteus	16-10-19	1	6	6	6	
60	*Rastrelliger kanagurta*	17-10-19	1	53	35.33	53	53
72	*Opisthopterus tardoore*	17-10-19	1	2	1	2	21
	Thryssa sp.	17-10-19	1	1	0.5	1	
	Rastrelliger kanagurta	17-10-19	1	18	9	18	
82	*Sardinella gibbosa*	17-10-19	1	475	475	475	475
83	*Opisthopterus tardoore*	17-10-19	2	2.5	1.5	5	625
	Sardinella gibbosa	17-10-19	1	360	360	360	
	Thryssa sp.	17-10-19	2	1.5	0.75	3	
	Rastrelliger kanagurta	17-10-19	5	51.4	27.1	257	
84	*Cynoglossus spp.*	16-10-19	3	7.33	1.53	22	901
	Parapenaeopsis stylifera	16-10-19	3	42.67	9.3	128	
	Penaeus indicus	16-10-19	1	1	0.25	1	
	Rastrelliger kanagurta	18-10-19	2	375	187.5	750	
94	*Rastrelliger kanagurta*	17-10-19	1	95	47.5	95	95

visited by the fish schools and so the fishermen. But, a look at the gear-wise catch per hour indicated polygon 82 fared the best with catch per hr of 475 kg/hr using OBRS (Fig 10).

A comparison of the present and proposed method of fish landings data collection was also done which indicated the advantages of the proposed method of data collection over the existing method (Table 2).

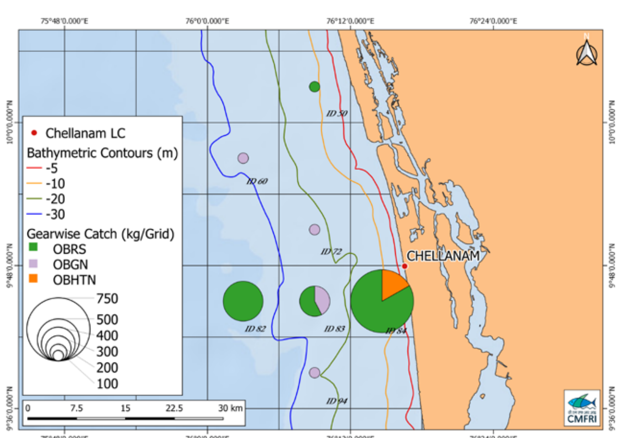

Fig. 8. Bubble map of gear-wise catch (kg/Grid). Size of bubble indicate the magnitude of the catch in kg obtained from each grid and the colour indicate the type of gears operated.

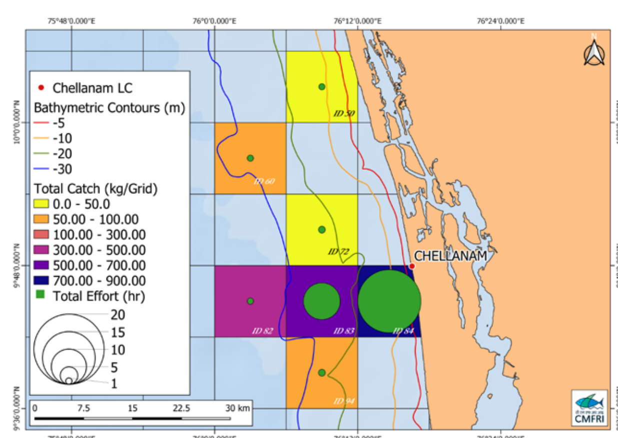

Fig. 9. Total catch and effort in the study area. Yellow to blue shading of the grid indicate the total catch in kg obtained from each grid and the size of the green bubble indicate the total time in hours expended by different gears in the grid.

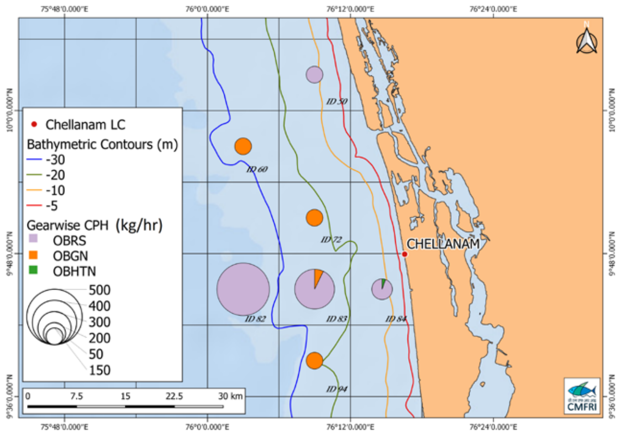

Fig. 10. Bubble map of gear-wise catch per hour.

Size of bubble indicate the magnitude of catch obtained per hour by the gears in each grid and the colour indicate the type of gears operated.

Conclusion

Adding spatial dimension to the fish landings data collection and processing can reveal a lot of additional information for the better management of fishery resources. In the new method proposed, the only additional information required is the polygon identification code (GID) that the field enumerator can collect from the fishers through enquiry and using the App. If the fishing craft is fitted with a GPS, the geographical coordinates collected by the device could be used for spatial querying to identify the GIDs. These operations can happen at the data processing and analysis stage. Adding spatial realm in the marine fish landing data can bring a sea change in the way we analyse, visualize and understand the marine fish landing data and making this change will be beneficial in the long run.

Table 2. Comparative evaluation of the current and proposed new method of fish landings data collection

Parameter considered	Current method of data collection and analysis	Proposed method of data collection and analysis
Fishing ground information	In terms of distance from landing centre, direction and depth	In terms of grid ids
Area-wise information on different catch parameters	Limited information can be derived after converting the direction and distance information to fishing ground locations	The information is available based on the grid ids
Amenability for spatial planning	Limited amenability after pre-processing	Readily amenable
Chance of error in locating the fishing ground	More	Less
Effort in collecting the data	-	No additional effort required after installing the App

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