Development of Capture Fisheries Plan Instrument in Bone Bay Based on Fish Resource Ecological Aspects

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Abstract: ***Previous research has made an important contribution in providing information on fishing and capture fisheries. This research was conducted as an improvisation of previous research and aimed to develope a system in identifying potential areas of capture fishery in an integrated manner by considering the distribution of potential resources based on biological behavior aspect approach of fish targets influenced by hydro-oceanography parameter (Chlorophyll-a, SST, bathymetry and thermal fronts, as well as currents and waves) through the application of Geographic Information System (GIS), resulting in a new improvisation in the field of fishing planning instruments with more comprehensive data references. The research employed secondary data collection method (satellite image data) and field survey method to validate the analysis result. Field validation surveys were conducted during the transitional season from December 2016 to February 2017. An analysis was conducted to assess the suitability of potential fishing areas using GIS-OVERLAY and GIS-POINT DENSITY processes on chlorophyll-a, SST, bathymetric and thermal front parameters.***

Keywords: capture fisheries, fishing ground, hydro-oceanography, Geographic Information System, Bone bay

1. Introduction

Bone Bay has long been used for fishing business. Fishing business is still in traditional scale and in sufficient quantities. One of the fishery resources exploited in Bone Bay is pelagic fish, such as tuna and skipjack. The potential of pelagic fish in Bone Bay is influenced by the spatial and temporal pattern of environmental biophysical distribution. The biophysical environment near the entrance of the bay (Flores Sea) is certainly different from the biophysical environment away from the entrance of the bay (Palopo waters).

The pattern of environmental biophysical distribution in accordance with the characteristics of fish resources can be used to predict the distribution area and the abundance of fish in the waters area through the mapping of potential fishing areas. Prediction of distribution area and fish abundance in waters area is important in formulating fishing planning instrument in the direction of fishing location and this is important for the management and development of capture fisheries activities in Bone Bay waters area.

Research on estimation of fishing area carried out by previous researchers, Muchlisin (2004), had observed the fishing ground location in waters of Makassar strait and its surroundings by analyzing the combination of sea surface temperature (SST) data derived from NOAA satellite with chlorophyll- a data derived from MODIS satellites. The results of the observation indicate that the fishing ground location in the waters moved according to changes in the distribution of the SST and the concentrations of chlorophyll-a.

Furthermore, Mallawa, *et.al*, (2010), conducted a study on the prediction of skipjack fish in Bone Bay waters by using oceanographic condition data for sea surface temperature estimation (SST) and chlorophyll-a density obtained from NASA database ie AQUA satellite data and MODIS (Moderate Resolution Imaging Spectro Radiometer) sensors with spatial resolution of 4 km and monthly average resolution. The result shows that the best skipjack fishing zone (*Katsuwonus pelamis*) was found in the waters of the northern Bone Bay in Luwu, Palopo, and extending to the southeastregion along the coast of Kolaka. The productivity level of the catching area was decreasing towards the southern part of the bay, and the lowest catchment area of its productivity was in the southern part of Bulukumba extending eastward to the waters of Buton. In addition to the waters of Palopo, Luwu and Kolaka, Bone waters are also potential areas for skipjack fishing activities.

As stated above, studies conducted by previous researchers in estimating fishing areas are based on dynamic oceanographic factors, where SST and chlorophyll-a are important oceanographic parameters and are often used to predict potential fishing areas by using remote sensing and GIS (Lanz Et al, 2009; Mustapha et al., 2010; Solanki et al., 2005; Zainuddin 2013; Zainuddin and Jamal 2009).

Previous studies have made important contributions in the provision of information on fishing and capture fisheries management. The recent research was conducted as an improvisation of the previous research, aimed to develop a system to identify the potential region of capture fishery in an integrated manner by considering the distribution of the potential resources based on the approach of biological behavior aspect of fish targets influenced by oceanographic parameters (Chlorophyll-a, SST, bathymetry, and thermal fronts, as well as currents and waves). Hence, will result in a new improvisation in the field of estimating the potential distribution of fish resources with more comprehensive data references. The result of identification of potential fishing area is used as a fishing planning instrument in Bone bay.

2. Methods

2.1 Research Area

The scope of the research area was Bone Bay, this area was selected because the Bone Bay is a marine territorial area that has been designated for general utilization activities (economic exploitation activities) and is a national marine flagship area directed to the needs of human food as well as encourage local economic growth (Government Regulation Number 26/2008, Presidential Regulation No. 88/2011). The area of the waters is approximately 38,421.21 km^2, covering the waters of the northern bay to the southern part of the bay is limited to the coordinates of 50 40'05"South Latitude. The area was divided into 92 grids ie grid A1 - O5 with a grid area of 12 x 12 nm (Figure 1).

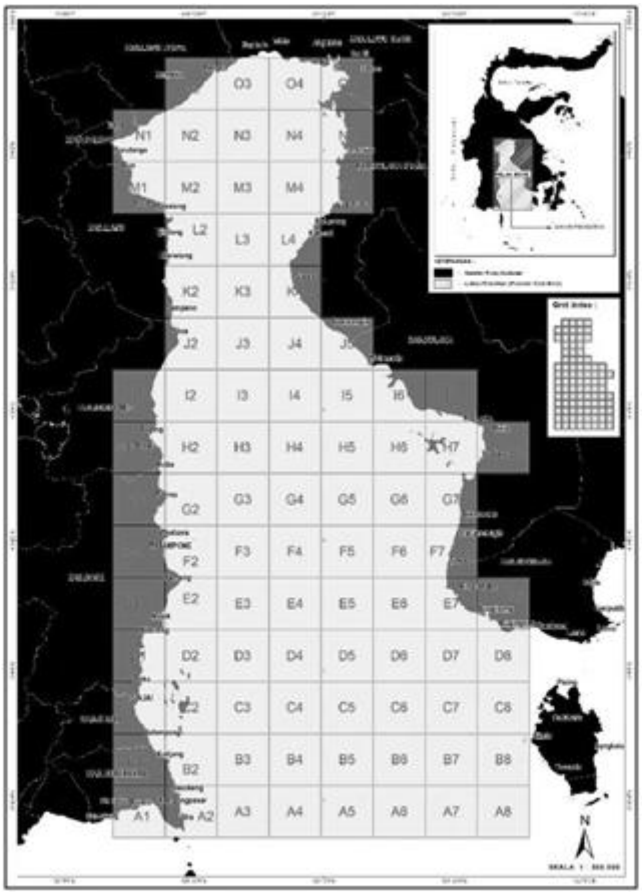


Figure 1: Research Location

2.2 Methods

In order to produce planning instrument for capture fishing in the form of fishing location direction based on approach of fish resources ecological aspect, this research used secondary data collection method (satellite image data) and field survey method to validate the result of analysis. Field validation surveys were conducted throughout the transitional season from December 2016 to February 2017.

The strategy conducted was to collect the ecological data of fish resources from satellite imagery (Chlorophyll-a, SST, Bathimetry and Thermal Front, and current and waves) temporally during the last 5 (five) years and conduct fishing ground suitability analysis based on ecological data of fish resources, such as: Chlorophyll-a, SST, Bathimetry, and Thermal Front, and Flow and Wave (Table 1).

The method of estimating the fishing ground potential area in this study (Figure 2), was based on the consideration of marine productivity and other symptoms of fish resources, therefore the data used in this study were Chlorophyll-a, SST, Bathimetry and Thermal Front, and currents and Waves. Chlorophyll-a and Sea Surface Themperatur (SST) data were used to predict potential fish areas based on the suitability of the marine environment that is more suitable for feeding, Bathimetry data (depth) was used to predict potential fish areas based on suitable habitat suitable for fish, and Thermal Front is used to predict fish potential areas based on marine productivity. Meanwhile, ocean and wave current data are used to predict fish movement and determination of fish migration patterns (Palacios et al, 2006; Lanz et al., 2009; Mustapha et al., 2010; Solanki et al., 2005; Zainuddin 2011; Zainuddin and Jamal 2009).
The results of the analysis of the hydro-oceanography data, resulted in the estimation of potential areas for fishing, which subsequently validated by measuring some parameters of the hydro-oceanography.

Table 1: Types, sources and completeness of oceanography in predicting the potential of fishing ground based on fish resources ecological aspects approach.

NO	*Data*	*Data Source*	*Completeness of Data Atribute*
1.	Sea Surface Temperature (°C)	Interpretation of Aqua MODIS 3 level satellite imagery in HDF (Hierarchical Data Format) format recording year 2012 - 2016 every month for five years to obtain time series data	Perimeter (isotherm contour), Interval class 0.5°0C, Data distribution and temperature value at each class temperature interval.
2.	Depth (m)	BlueChart Pacific VAE009R data and bathymetric countour data on Sea Map by Dishidros TNI AL.	Perimeter (depth contour), Depth Point Coordinate, Depth Value, Scale, Data Source, Area of Each Depth Class
3.	Current speed (cm/dtk)	Satellite images and Las Aviso	Flow Point Coordinates, Flow Rate Values, Flow Rate Values, Scale, Data Source, Area of Each Direction Class and Current Speed
4.	Internal wave (meter), tidal (meter)	Satellite images, Las Aviso and BlueChart Pacific GARMIN data	Perimeter (wave height contour), Wave Coordinate Point, Wave height score, Scale, Data Source, Width Each Class wave height.
5.	Chlorophyll (mg/m³)	Interpretation of Aqua MODIS 3 level satellite imagery in HDF (Hierarchical Data Format) format recording year 2012 - 2016 every month for five years to obtain time series data.	Perimeter (chlorophyll-a), Coordinates, Chlorophyll-a Point, Chlorophyll-a, Scale, Data Source, Total Area of each chlorophyll-a

Paper ID: ART20175738 DOI: 10.21275/ART20175738

NO	*Data*	*Data Source*	*Completeness of Data Atribute*
6.	Thermal front	Interpretation of Aqua MODIS 3 level satellite imagery in HDF (Hierarchical Data Format) format recording year 2012 - 2016 every month for five years to obtain time series data.	Coordinate point of thermal front.

Source : Modification of BPPT, 2010.

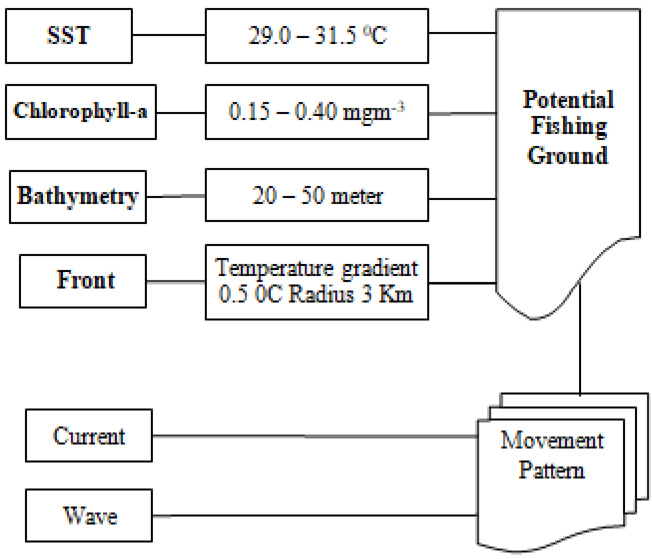


Figure 2: Prediction Method of the potential fishing ground in yhe Bone bay

The steps carried out to produce fishing planning instruments in the form of fishing location based on the approach of ecological aspects of fish resources were:

1) Collected the ecological data of fish resources temporarily and composite satellite image data within recording year 2011 - 2015 every month for 5 (five) years to obtain time series data. Ecological data of fish resources, including:
   a) Sea Spatial Temperature (SST): SST time series data were obtained from the interpretation of Aqua MODIS 3 level satellite imagery in HDF (Hierarchical Data Format) format of the records in 2012 - 2016 every month for five years to produce time series data for the last 5 (five) years . The data can be downloaded at http://www.oceancolor.nasa.gov.
   b) Chlorophyll-a: Chlorophyll-a time series data were obtained from the interpretation of the Aqua MODIS 3 level satellite imagery in HDF (Hierarchical Data Format) format of the records in 2012 - 2016 every month for five years to produce time series data for the last 5 (five) years. The data can be downloaded at http://www.oceancolor.nasa.gov.
   c) Depth (Bathimetry): Depth data were obtained from data extraction of Pacific-BlueE Chart satellite image VAE009R and contour bathymetry data on Navy Dishidros marine map.
   d) Thermal Front: Front is a meeting area of two different water masses having a different characteristic, the Front Event in time series were obtained from the sea surface temperature gradient (SST) data, where the temperature gradient was densely compared to its surroundings with a temperature range of 0.5 ^{0}C within a radius of 3 km as a fishing ground area. The Marine Surface Temperature (SST) data can be downloaded at http://www.oceancolor.nasa.gov.
   e) Current: Current time series data were obtained from satellite image data extraction aviso recording year of 2012 - 2016 every month for ten years to get time series data.
   f) Wave: The time series data of the waves was obtained from the extraction of aviso las satellite image data from 2012 to 2016 every month for ten years to obtain time series data.
2) Validation of the ecological data interpretation results resulted from the analysis of current, temperature, chlorophyll-a, depth, salinity data obtained from satellite image interpretation by measuring in the field, resulting in estimation of potential validated fishing ground areas.
3) Classification of fishing ground suitability parameters based on ecological data of fish resources (Chlorophyll-a, SST, Bathimetry, and Thermal Front, and current and wave), with the following classification:

Table 2: Fishing ground suitability parameters based on fish resources ecological data (Chlorophyll-a, SST, Bathymetry, and Thermal Front,currents and waves)

Fish resources ecological parameters	Suitability Classification	
	Suitable	Not Suitable
St : temperature	29 – 31,5 ^{0}C	< 29 ^{0}C or> 31,5 ^{0}C
Sa :chlorophyll-a	0,15 – 0,40 mgm^{-3}	< 0,15 mgm^{-3}or> 0,40 mgm^{-3}
Sb :bathymetry	20 – 50 masl	< 20 maslor> 50 masl
Sf :thermal front	Temperature Gradient of 0.5 ^{0}C, in the radius of 3 Km	no

Source: BPPT (2010); Hanintyo (2015).

4) Conducting the suitability analysis with GIS-OVERLAY and GIS-POINT DENSITY processes on ecological parameters of fish resources (Chlorophyll-a, SST, Bathimetry and Thermal Front) based on modification to BPPT-based SIKBES-IKAN onthology (2010) resulted in suitability class of fishing ground that has been classified. The mathematical formulation used to overlay the suitability level of capture fisheries based on the suitability values on each parameters of Chlorophyll-a, SST, Bathimetry and Thermal Front, to obtain Fishing Ground based on ecological aspect approach (se), are:

$$S_{Fe} = S_t + S_a + S_b + S_f$$

where:

S_{Fe}: Fishing ground suitability based on ecological aspects.
S_t: Suitability of temperature parameter.
S_a: Suitability of Chlorophyll-a parameter.
S_b: Bathymetric condition.
S_f: Thermal front incident.

5) Conducting an interpretation of the results of fishing ground suitability analysis that has been classified to produce fishing planning instrument in the form of fishing location that is prepared based on the approach of ecological aspects of fish resources (Se).

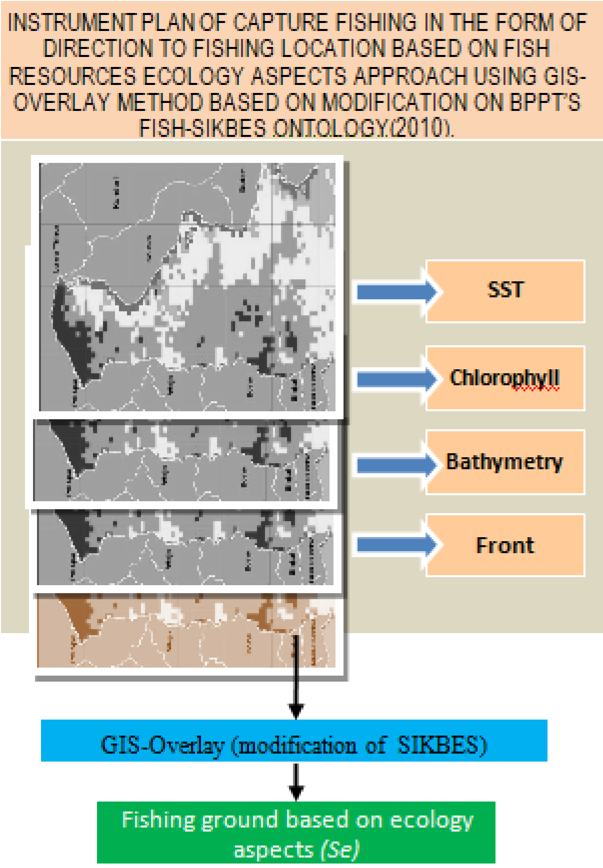


Figure 3: Analysis of fishing ground suitability using GIS-OVERLAY and GIS-POINT DENSITY processes

3. Result and Discussion

3.1. Characteristics of Ecological Data in Bone bay Waters

Sea Surface Temperature (SST)

During the observation period, the sea surface temperature (SST) obtained from the SST time series data resulting from the interpretation of the Aqua MODIS 3 level satellite imagery in HDF (Hierarchical Data Format) format on the records of the year 2012 to 2016 every month for five years, indicates that the SST ranges was between 28.099 – 34.398 °C with an average temperature per month of 30.728 °C, where the lowest average SST occurred in July (29.435 °C) and the highest average of the SST occurred in January (31.339 °C). The fluctuations of monthly average SST in bone bay waters over the past five years are shown in Figure 3.

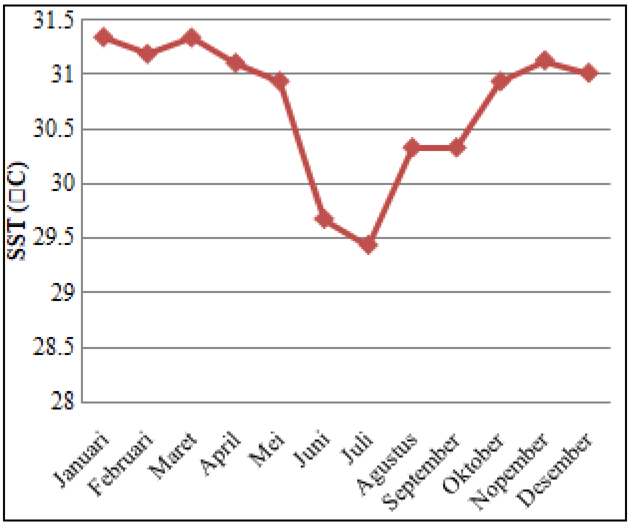


Figure 3: Fluctuation of monthly average of SSTin the Bone bay waters during 2012 - 2016.

Chlorophyll-a.

Chlorophyll-a is the most important and often used oceanographic parameter to predict potential fishing areas by using remote sensing and GIS (Lanz et al, 2009; Mustapha et al, 2010; Solanki et al, 2005; Zainuddin 2011; Zainuddin and Jamal 2009). In the plankton energy cycle, both phytoplankton and zooplankton have an important role in marine ecosystems because plankton is food for many other marine species. Phytoplankton located in the fotic layer contains chlorophyll-a that useful for photosynthesis. Chlorophyll-a is capable of absorbing blue and green light, so the presence of phytoplankton can be detected based on the ability of chlorophyll-a.

During the observation period, chlorophyll-a obtained from the time series data of chlorophyll-a resulted from the interpretation of the Aqua MODIS 3 level satellite imagery in HDF (Hierarchical Data Format) format of records in the year 2012 - 2016 every month for five years, indicates that the chlorophyll-a ranged from 0.104 to 8.846 $mg.m^{-3}$, with an average chlorophyll-a content of 0.365 $mg.m^{-3}$. The highest average of chlorophyll-a content was found in April (0.471 $mg.m^{-3}$, whereas the lowest was In December (0.289 $mg.m^{-3}$) .The average fluctuation of chlorophyll-a content in theBone bay waters over the past five years is shown in Figure 4.

Paper ID: ART20175738 DOI: 10.21275/ART20175738

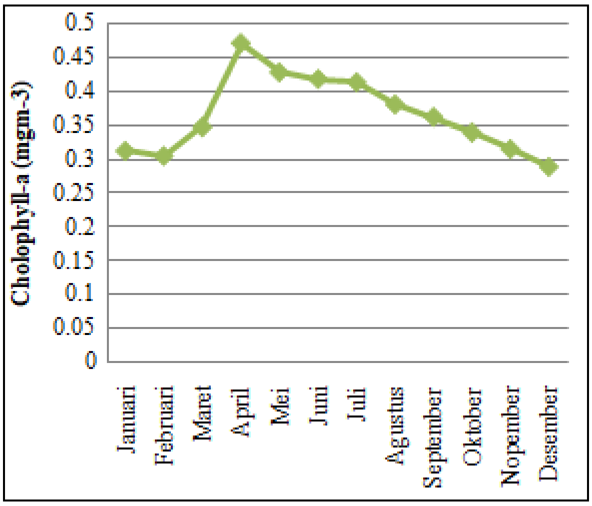


Figure 4: Fluctuation of monthly average of Chlorophyll-a in the Bone bay water during 2012 - 2016.

3.2. Estimation on the potensial fishing ground based on ecological aspects in the Bone bay waters.

Potensial season for pelagic capture fishing in the Bone bay waters.

The results show that the potential of fishing ground for pelagic capture fishery was fluctuatedwith location changed every month. This condition is due to seasonal influences that impact on ecological parameters, such as; temperature, chlorophyll-a content, currents and waves. The best catching season was within October - January, and the fishing season was quite good within March - June, while July - August and February were the less than optimal months for pelagic fishing operations in Bone Bay (Figure 5).

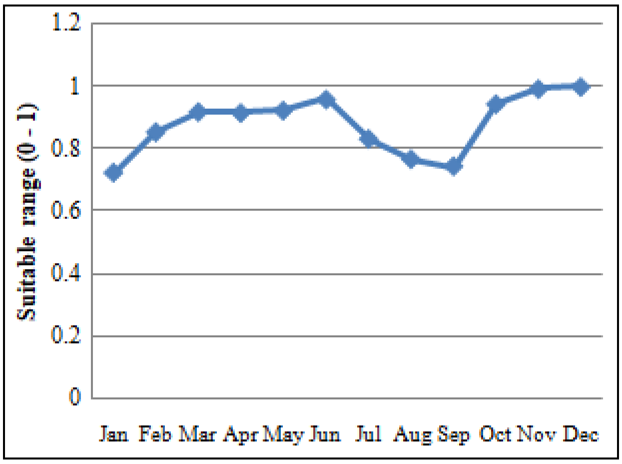


Figure 5: Prediction of potensial pelagic fishing areas season in Bone bay waters.

Distribution of potensial location for pelagic fishing in the Bone bay waters

In January the distribution of high potential fishing areas was found in the waters of Palopo, Sinjai and some in the waters of Sengkang and Kolaka. While location with medium potential wasfound along the west coast of Bone bay. In February, the distribution of high potential fishing areas was found in the waters of Bone and Sinjai, while the medium potential was present in the waters of Palopo, Kolaka and Sengkang. In March, the distribution of high potential fishing areas was found in the southern Bone waters, Sembilang Island waters in Sinjai and some in Palopo and Kolaka waters, while are with medium potential was in the waters of Sengkang, North Kolaka and some in the northern part of Bone bay. In April, the distribution of high potential fishing areas was found in the waters of Bone and Sinjai, the waters of Kolaka and North Kolaka, while medium potential location was present in the Sengkang waters and the west coast of Bone bay (Figure 6).

In May, the distribution of high potential fishing areas was found in the waters of southern Bone and Sinjai, while medium potential location was found in the northern part of Bone bay, as well as the coastal waters of west and east to the south of Bone Bay. In June, the distribution of high potential fishing areas was found in almost all of the northern Bone bay waters from Palopo to Malili, Bone and Sinjai and Kolaka waters, whereas area with medium potential was found in almost all coastal waters of the Bone bay to the southern part of Bone bay. In July, the distribution of high potential fishing areas lied in the northern part of the Bone bay and Kolaka waters, while the medium potential area was present along the coastal waters of eastern Bone bay and the waters of Bone and Sinjai. In August, the distribution of high and medium fishing areas was similar to July, only concentrations in the northern part of Bone Bay were higher than in the previous month. In August, the distribution of high potential fishing areas was found throughout the northern waters of Bone bay, southern Bone waters and Sinjai and Kolaka waters, while areas with medium potential was present in almost all coastal waters of the Bone bay (Figure 7).

In September, the distribution of high potential fishing areas was nearly the same in August, only moderate potential was present in all coastal waters of the Bone bay. In October, the distribution of high potential fishing areas was dominant in coastal waters north of Bone bay, from Belopa to Malili and northern waters of North Kolaka as well as parts of southern Bone and Sinjai waters, while are with medium potentials were present in almost all Bone Bay waters, the north and the middle to some in the southern waters of Bone bay such as the waters of Bulukumba and Buapinang. In October, the distribution of high potential fishing areas was found in the coastal waters of northern Bone bay, from Belopa to Malili and northern waters of Kolaka Utara to Kolaka waters as well as parts of southern Bone and Sinjai waters, while the potentials were present in almost all waters Bone bay, except the central and southern part of Bone bay. The highest potential areas for pelagic fishing was observed in November compared to other months, where the distribution of high potential fishing areas were found throughout the coastal waters of Bone Bay with the highest potential found in the waters of Palopo, Sengkang, North Kolaka, Bone and Sinjai, while other areas were included in the category of medium potential for fishing areas. In December, the potential distribution of fishing areas was almost the same as in November, only the high potential difference was concentrated in the waters of Palopo, Bone, Sinjai and Kolaka waters to the southern part of the Bombana waters, while the Bone bay coastal areas ranged from the north to the south including the medium potential category (Figure 8).

3.3. Discussion

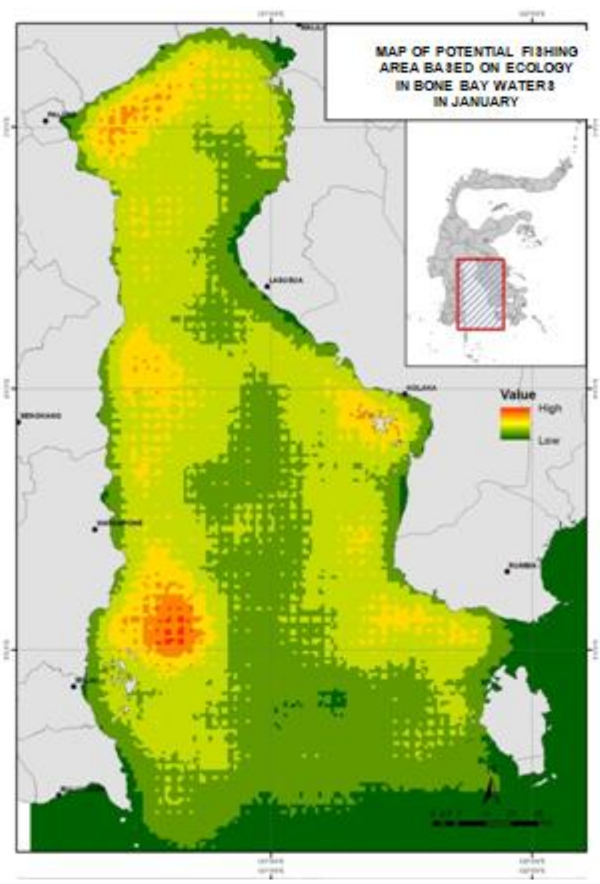
The result of point density analysis on GIS analysis conducted in this study using interval 0 - 1 interval, for ecological suitability (Se) shows that during the period of April –June, Se tended to increase (see Figure 5), ie. April (0.915); Mei (0.923); June (0.959). Study of Zainuddin (2013), showssimilar fishing season period (April-June) indicated with an increase of CPUE value (used as an index of fish abundance). CPUE fishing data are often used as an index of fish occurrence and abundance and therefore high CPUEs can be an indicator for preferred oceanographic conditions for a species.

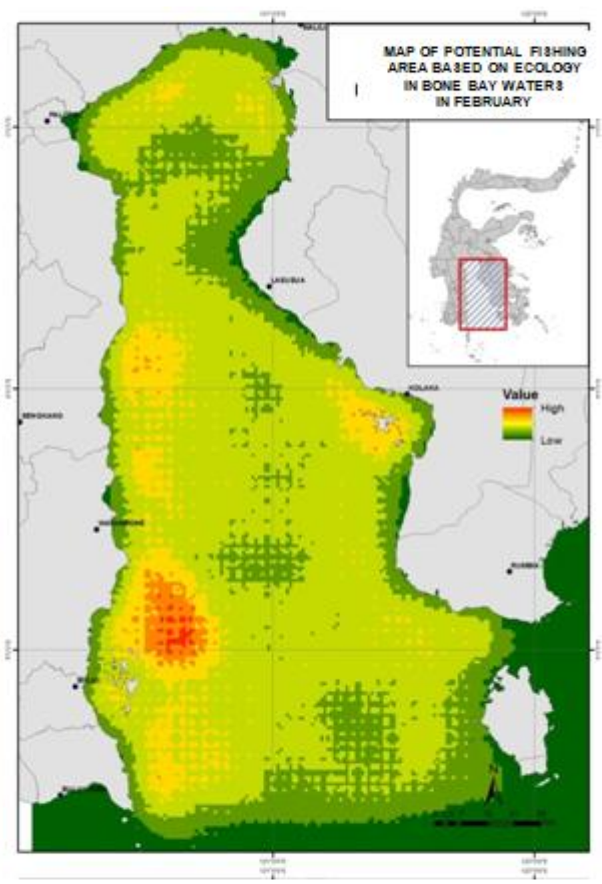
4. Conclusion of Research

1) Bone Bay waters are semi-enclosed waters with potency of pelagic fish resources spread both in the northern part starting from the waters of Palopo, northern Luwu, eastern Luwu and north Kolaka, the central part of Bone Bay covering Bone and Kolaka waters, as well as the southern part Bone Bay covers the waters of Selayar, Bulukumba, and Bombana waters.
2) Map of potential pelagic fishing area information in Bone Bay waters area can be used as a reference as a fishing planning instrument, as shown in Figure 9.
3) The territorial waters of Bone Bay that have potential as a pelagic fishing area, include:

No	Grid	Administrative Region
1	D2, D3, E2 dan E3	Bone waters to the south and the waters of northern Sinjai as well as around the Sembilang island.
2	M2, M3, M4, N2, N3, N4, O2, O3 dan O4	The waters of palopo up to the waters of eastern luwu and the waters of northern kolaka.
3	H6, H7 DAN I6	Kolaka waters
4	I2, J2, J3, J4, K2, K3, L2, L3,	Bone waters to the north and waters belopa and around lasusua waters in northern kolaka.
5	B7, B8, C7, C8, D6, D7, D8, E6, F6 dan G6	Southern waters of kolaka to the waters of bombana

4) Temporally, the best capture fishing season was in October - January, and the fishing season was quite good is March – June





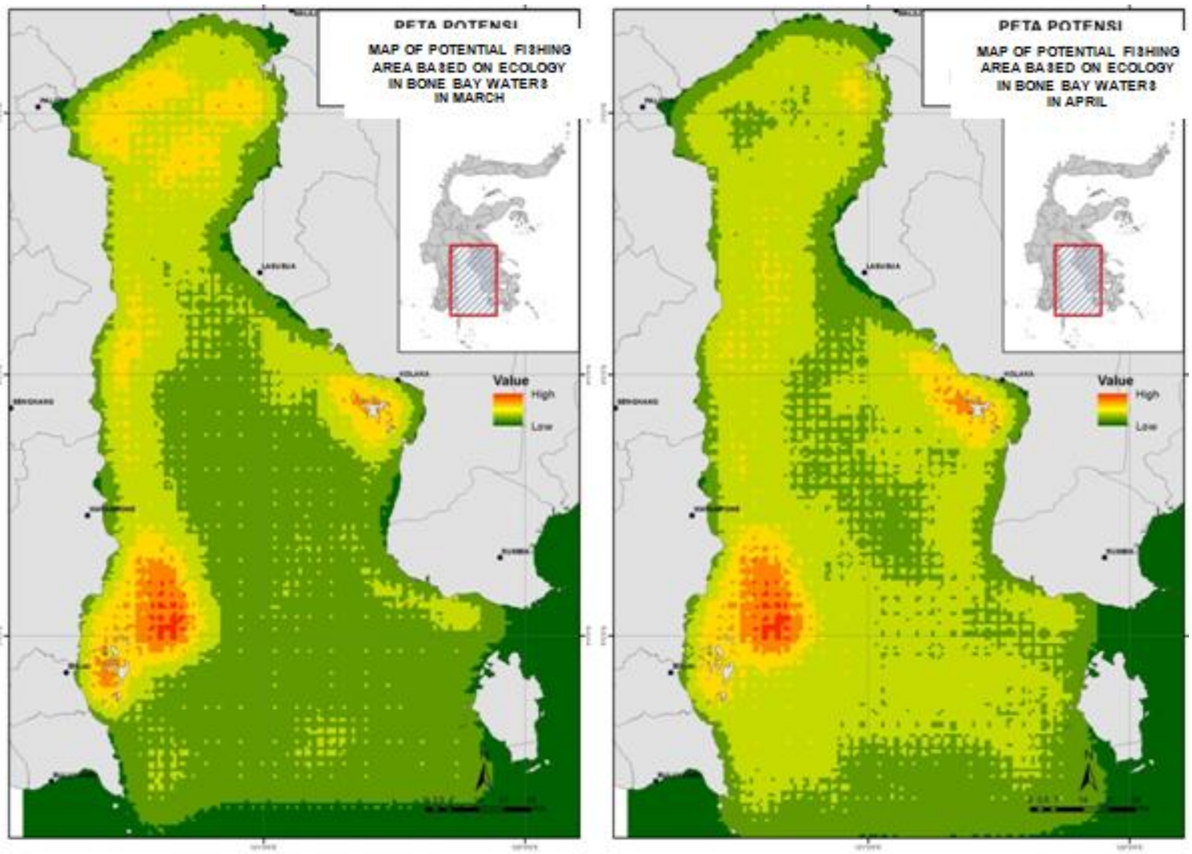
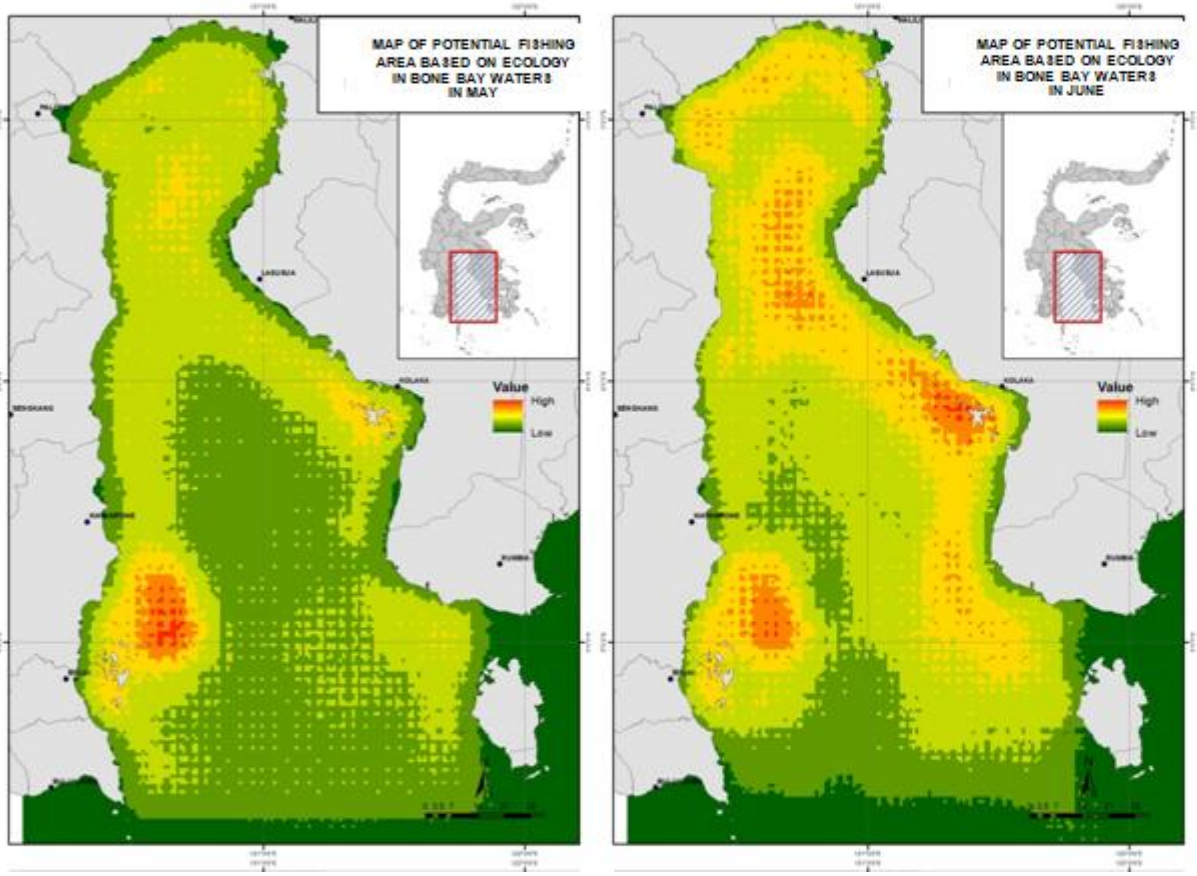


Figure 6: Prediction of potential distribution of pelagic fishing areas in the Bone bay waters in January – April



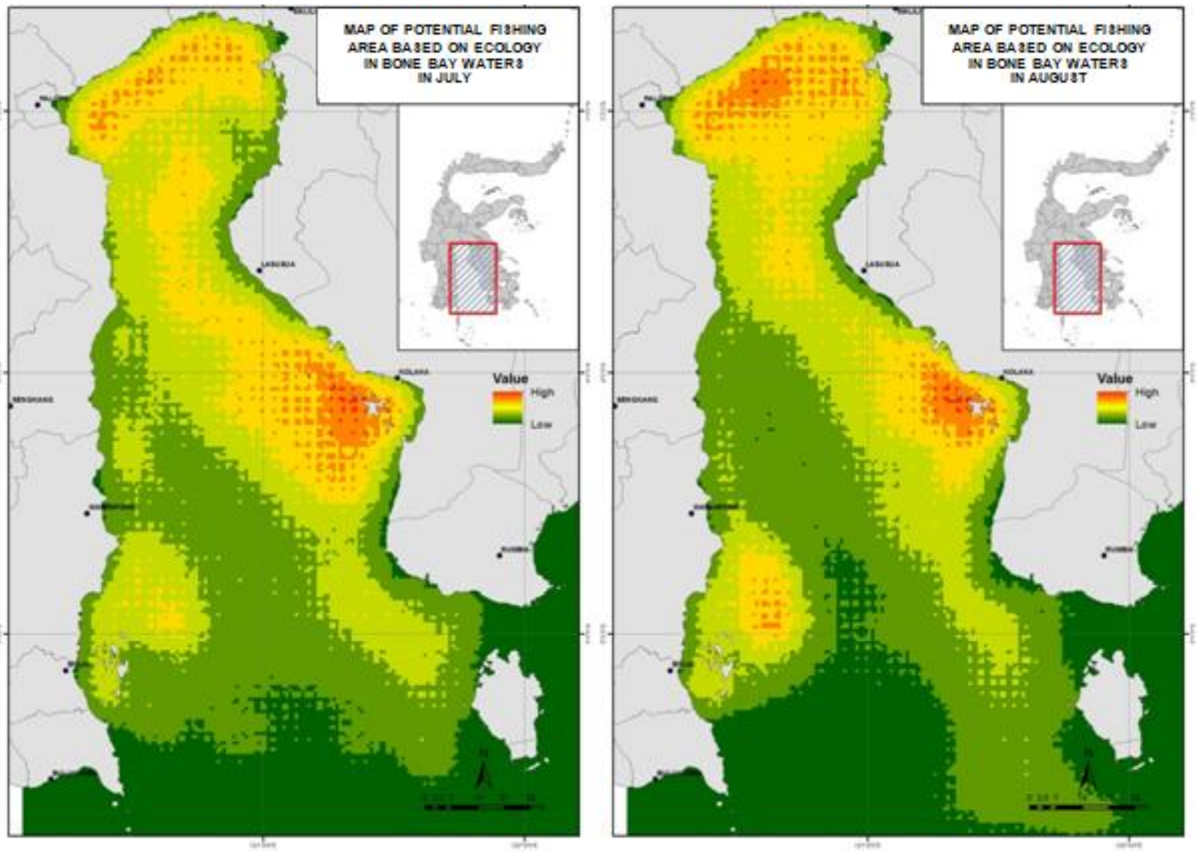
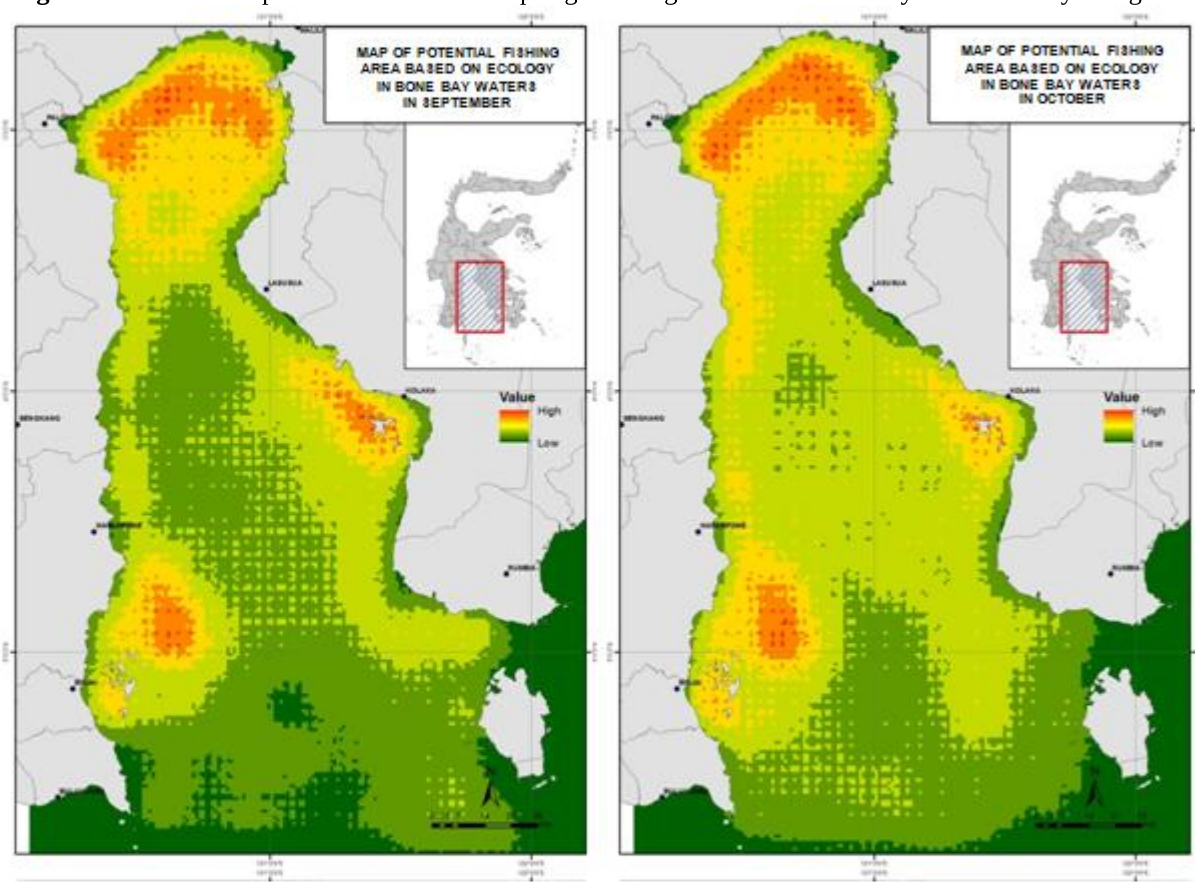


Figure7: Prediction of potential distribution of pelagic fishing areas in the Bone bay waters in May - August



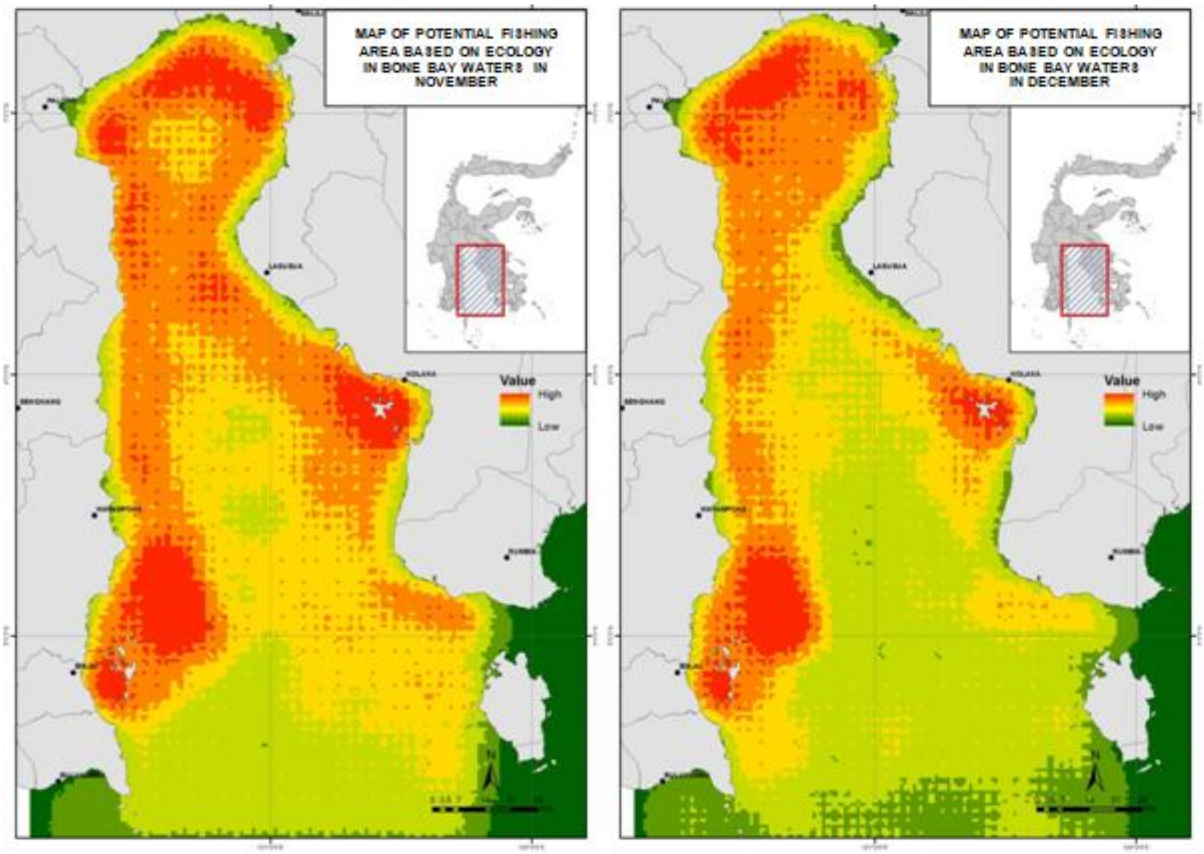


Figure 8: Prediction of potential distribution of pelagic fishing areas in the Bone bay waters in September – December.

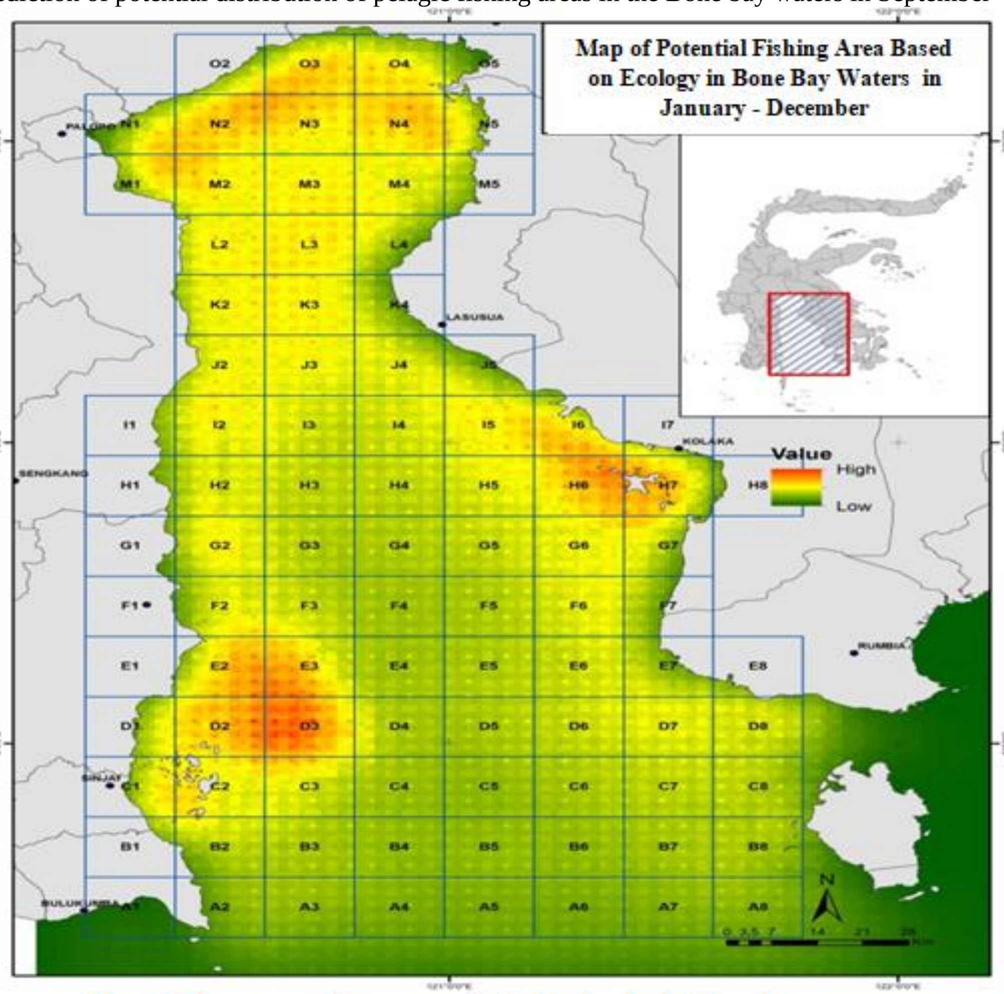


Figure 9: Instrument for capture fisheries plan in the Bone bay waters

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