International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Application of Viirs-Dnb Satellite Data to Detect Ship Distribution Patterns, Fishing Activity Index and Planning Instrument of Pelagic Capture Fisheries in Bone Bay Waters

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Abstract: ***Bone Bay has long been used for fishing business. The fishing businesses are currently in small scale and large number of ships with a fleet reaches 12,721 units per year and the weight of the ship measured between 3 - 30 GT. This research was aimed to detect fishing boat distribution pattern and determine fishing activity index (Ac) and develop fishing planning instrument using VIIRS-DNB data. The output data resulting from VIIRS-DNB interpretation will be very useful to estimate the fishing area based on the approach of ship distribution pattern aspect. The detection of fishing vessels arranged temporally in a still waters territorial will illustrate a pattern of fishing boat distribution and can be indicated as a habitat of fishermen conducting fishing operations. The results show that some regions had a similar temporarily pattern of fishing activity and had a high Ac value, including; Sinjai waters and sembilang islands, while other areas with high Ac were the Bone waters, Kolaka waters, northern of Luwu waters and some area in the southern part of Bone Bay regions with an Ac value ranging from 0.86 to 0.98. These area can be recommended as a fishing area based on approaches to aspects of previous fishing sites or habitual fishing grounds.***

Keywords: Capture fishery, VIIRS-DNB Satellite, Fishing Ship, Fishing Activity Index, Ship Distribution Pattern, Fishing Ground, Geogrphic Information System, Bone bay.

1. Introduction

Capture fishery planning instruments through the estimation of potential fishing areas in addition to the use of oceanographic data and fish behavior, may also be obtained from the data of previous fishing sites (habitual fishing grounds). According to Riswanto (2012), based on the pattern of fishing habits(fishing place), concentration of tuna in the Indian Ocean is at 130 SL coordinates and along the 300 SL line. The fishers' habitual pattern of catching fish (habitual fishing sites) is based on log book data of tuna fishing boat.

Information regarding the previous fishing sites conducted by fishermen in a waters can be obtained by using ship log book data or Vessel Monitoring System (VMS) data. However, the constraints faced by small-scale fisheries (ships size 5 to 30 GT) in Bone's bay waters are the unavailability of these instruments. Therefore, information on the geographical distribution records of the operating fishing vessels is extremely difficult to obtain.

With rapid development of technology in the field of remote sensing, a satellite namelyNational Polar-orbiting Partnership (NPP) was launched on 28thOctober 2011. One of instruments contained in the satellite is the Visible Infrared Imaging Radiometer Suite (VIIRS) with the ability to detect infra-red waves from the lights emitted by the fishing boat's lamps. This can help to obtain information about previous fishing sites conducted by fishermen in a waters, hence potential fish areas based on the position of the ship or the pattern of fishing habits can be suspected.

Various studies have been conducted in order to utilize VIIRS DNB satellite data to develop marine activities including: application of VIIRS DNB as an automated system for reporting the date, time, location and light detection of vessels. VIIRS has a spatial resolution of 45 times smaller than DMSP OLS satellite data that has been introduced by the US Air Force Defense Meteorological Satellite Program (DMSP) Operational Linescan System (OLS) in the previous years (Elvedge, 2014); The existence of VIIRS DNB data is very important to support research because this satellite data has a good ability to detect forest fires and monitor ship data based on ship light at night (Nagatani, 2012). VIIRS-DNB Nightlight Data Satellite Imagery record on September 4th, 2012 in the territorial waters of the eastern and northeastern seas of Japan indicating that fishing vessels operating in these waters can be detected by specialized low light imaging sensors of VIIRS-DNB (Elvedge, 2014).

Satellite detection of the ship's lights produces useful data for improving fisheries management, as well as detecting fishing activities in protected marine areas and managing sea shipping traffic. This study aims to detect fishing boat distribution pattern and determine fishing activity index and developcapture fishing planning instrument in Bone Bay waters by using VIIRS DNB data. The output data resulting from VIIRS-DNB interpretation will be very useful in estimating the fishing area based on the approach of ship distribution pattern aspect. The detection of fishing vessels temporally arranged in a still waters area will illustrate a fish vessel distribution pattern that can be indicated as a fishing habbit in conducting fishing operations.

2. Methods

2.1 Research Area

The scope of this research area was Bone Bay, this area was selected because 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 economic growth for the local area (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 to the southern part of the bay, limited to the coordinates of 50 40'05"South Latitude. The area is divided into 92 grids ie grid A1 - O5 with a grid area of 12 x 12 nm (Figure 1).

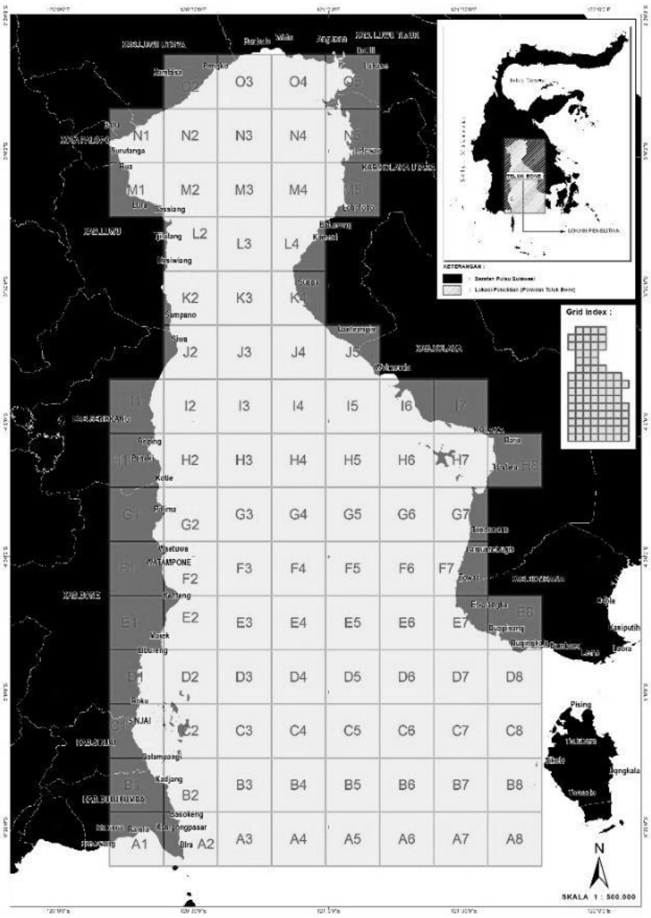


Figure 1: Research Location

2.2 Methods

Types, sources and completeness of data to detect fishing boat distribution patterns and to determine the fishing activity index in Bone Bay waters by using VIIRS-DNB satellite image data and direct observation in the field, with details as shown in Table 1.

Table 1: Types, sources, and completeness of data to detectfishing boat distribution patterns and to determine the of fishing activity index in Bone Bay waters

No	*Data*	*Source of Data*	*Atribute Completeness of Data*
1.	Number of vessels (unit)	VIIRS-DNB Satellite Image	Number of units on a periodic basis (temporal)
2.	Geographic position of the ship	VIIRS-DNB Satellite Image	Coordinate position of the ship
3.	Tonnage size of Ship	Insitu and statistical data of capture fisheries of regency / municipality, province and also national capture fisheries statistic and fish landing place at research location	The gross weight of the ship (GT), the length and width of the ship.

Detection of Fish Distribution Patterns

Fishing boat distribution pattern in Bone Bay waters wasdetected using interpretation of the light in the sea waters captured by infrared sensors on the National Polar-orbiting Partnership satellite. Subsequently, the raster data from VIIRS Day / Night Band satellites were used to detect the ship's geographic position and number of vessels were analyzed with ENVI 4.3 and ArcGis 10.2 software, and GlobalMapper 13 software with algorithms and ontologies built by Cristopher (2014). The composite groove to detect ship distribution patterns is shown in Figure 2.

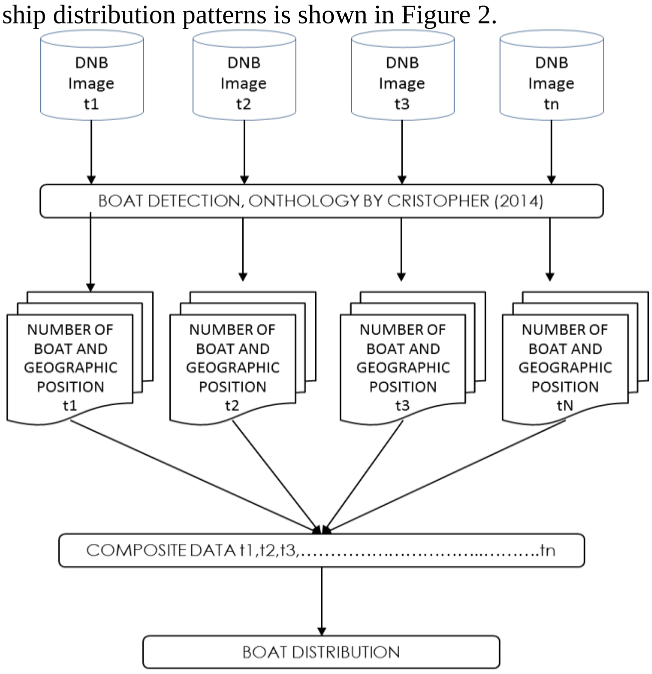


Figure 2: The composite groove to detect ship distribution patterns

The steps taken to detect fishing boat distribution patterns in the Bone Bay waterswere:

1) Collectingof ship distribution data temporarily and compilation of the VIIRS-DNB satellite image data of 2016 recordsdaily for one year to obtain time series data.
2) Compilation of boat data (number of vessels and ship geographic location) obtained from the VIIRS-DNB satellite imagery interpretation with 2015 and 2016image records every day for two years to obtain time series data of vessel number (nb or number of ship detected by VIIRS- DNB).
3) Categorization ofdata in a grid-cell through a spatial clustering process on a ship's distribution point data on a 4x4 km grid-cell to estimate the values at the grid-cell spatial level, resulting in the number of vessels and ship distribution patterns per each grid-cell :

$$\sum_{nb=0}^{nb=n} bd \quad \ldots\ldots (1)$$

where :

$\sum bd$: Number of boats on each grid-cell.

Determination of Fishing Activity Index

Kavadas (2015), defined that the fishing activityindex (Ac) is a scale indicating the total capacity of all vessels registered at each fishing port, where the Ac value is proportional to the capacity of the ship (tonnage size) and the number of ships registered in the fishing port. In this study, the Ac was estimated based on modifications of the Kavadas formulation (2015) by calculating the total capacity of all vessels operating in the waters, where the operational data of the vessel was obtained from different sources that are based on the identification of the VIIRS-DNB satellite image data ship with algorithms and ontologies built by Elvedge, et al (2014).

The method used to estimate the Ac in this study was to estimate the values at the grid-cell spatial level using spatial clustering process on each grid-cell (4x4 km) on the distribution data and the number of vessels obtained from the extraction of VIIRS-DNB Satellite Imagery data, the data can be downloaded at http://www.ngdc.noaa.gov/eog/viirs/download_indo_boat.html. Distribution data and the number of vessels depict the track record of fishermen (fishing boats) in conducting fishing operations both by location and time. The mathematical formulations used to identify the index of fishing activity (Ac) at the spatial grid-cell level are:

$$Ac = \sum_{nb=0}^{nb=n} b \; * \; \varnothing\, GT \quad \ldots\ldots (2)$$

Where :

$\sum_{nb=0}^{nb=n} b$: number of vessels;

$\varnothing$ GT : Average size of ship grosstonage on each grid cell.

Note :
Classification of Ac is categorized into five classes (very low to very high).

The steps to determine the index of fishing activity (Ac), were as follows:

1) Determination of the number of vessels on each grid cell ($\sum b$)
2) Multiply the value of the number of vessels in each grid cell ($\sum bd$)with the average grosstonage size of the vessel on each grid cell ($\varnothing$ GT).
3) Application of optimal interpolation method to spatial grid-cell level data to determine standardization of fishing activity result (Ac), with scale 0 - 1 using Arcgis software 10.2 with Fuzzy linear Membership (FM) method.

Development of the fishing planning instruments in the Bone Bay waters.

The results from the determination of the fishing activity index (Ac) in Bone Bay waters based on the time series dataprovided an overview of the previous fishing sites (habitatual fishing ground) either temporally (fishing season) or spatially (fishing area). This description of information can be used as a reference for developing the capture fishing planning instruments.

The preparation of capture fishery planning instrument wasconducted by interpreting the result of fishing ground suitability analysis that has been classified to produce planning instrument for pelagic capture fishing in the form of direction for fishing location which is arranged based on the ship distribution pattern aspect (bd) consisted of infographic (map) and direction of potential fishing areas table.

3. Result and Discussion

3.1 Fishing Boat Distribution Patterns

The exploitation activity of capture fishery resources in Bone Bay waters has benefited socio-economically and is not only done in subsistence even intensively by conventional and modern fishermen originating from the mainland as well as from other regions. Based on VIIRS-DNB Satellite Imagery data, during the observed year, the estimated number of vessels operated in Bone Bay waters were up to 12,721 units with monthly average of 1,060 units. The highest intensity period of the number of vessels operating were in August and September with 1,480 to 1,554 units, while January and February were the periods with the least number of ships operatedwith only 426 to 687 units (Figure 3).

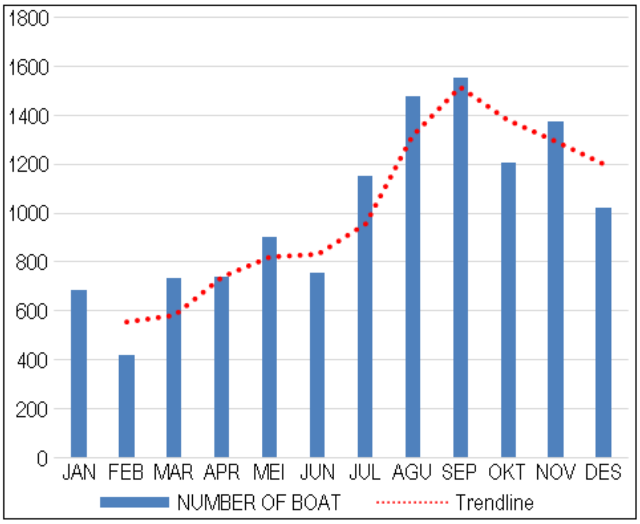


Figure 3: Average number of boat operating in the Bone Bay waters

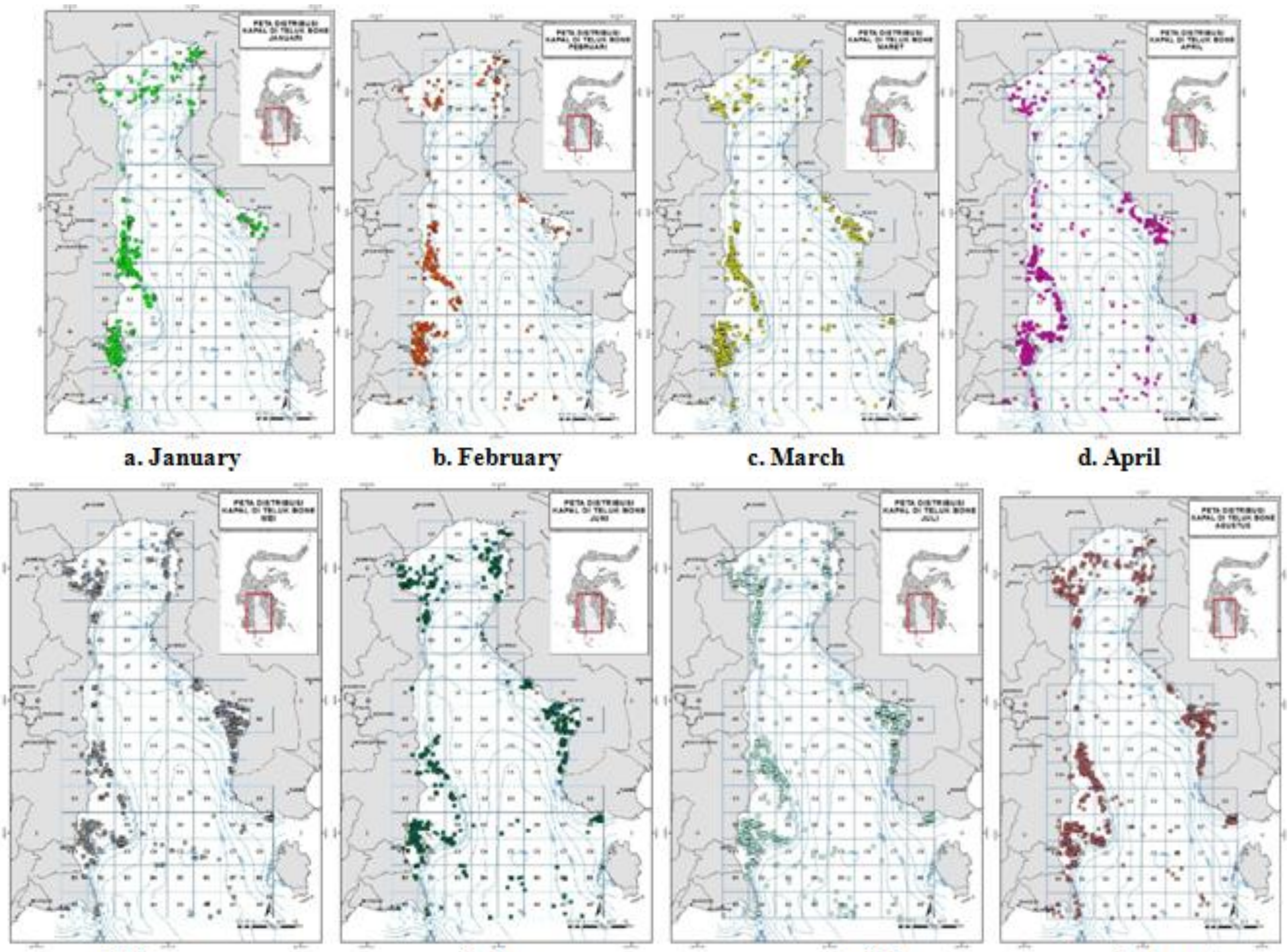
Temporal ship distribution patterns from January to December were described as follows:

- In January, the analysis showthat the average number of fishing vessels operating in the Bone Bay waters was about 687 ships, mostly operated in Sinjai waters, Bone waters, the northern waters of the Bone Bay such as Palopo, Malili, and Kolaka waters. Some boats were detected in the waters of Siwa, where the highest catching activity occurred on the grid C1 of Sinjai waters and islands of Sembilang, grid F2 and G2 ie Bone waters up to the northern waters (Figure 4.a).

- In February, the analysis showthat the average number of fishing vessels operating in Bone Bay waters was 425 ships, with distribution similaras in January, where the fishing boats mostly operated in Sinjai and Bone waters, the northern waters of Bone Bay such as Palopo, Malili, and Kolaka waters, and some are detected in the waters of Siwa. In addition, the highest catching activity occurred on the grid C1 and D1 ie Sinjai waters and islands of Sembilang up to southern Bone waters, grid F2 ie Bone waters Figure 4.b).
- In March, analysis show that the average number of fishing vessels operating in Bone Bay waters increased by about 740 vessels, with distribution was similar as in February, where the fishing vessels mostly operated in water areas of Sinjai, Bone, the northern waters of Bone Bay such as Palopo, Malili, and Kolaka waters, and some detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. The highest catching activity occurred on grid C1 and D1 ie Sinjai waters and the island of Sembilang to the southern Bone waters, the grid of F2 and G2 of Bone waters, and the grid H7 of Kolaka waters (Figure 4.c).
- In April, the analysis show that the average number of fishing vessels operating in the waters of Bone Bay continued to slightly increase compared to the previous months of about 743 ships, with distribution similar as in March, where fishing vessels mostly operated in the waters of Sinjai, Bone, northern waters of Bone Bay such as Palopo, Malili, and Kolaka waters, as well as some detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. At this time the fishing boats have started to operate in the middle of the Bone Bay which is the waters with a depth of up to 2000 masl. The highest catching activity occurred on C1 and D1 grids, namely Sinjai and Sembilang island up to southern Bone waters, F2 and G2 grids ie Bone waters, and grid H7 ie Kolaka waters (Figure 4.d).
- In May, the analysis show that the average number of fishing vessels operating in Bone Bay waters increased steadily to about 903 ships, while the distribution was similar as in April but the difference was that the distribution of ships had begun to spread throughout the Bone Bay waters, with the fishing vessels mostly operated in the waters of Sinjai, Bone, the northern waters of Bone Bays such as Palopo, Malili, and Kolaka waters. Some vessels were detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. In this month, fishing vessels began to operate in the deepest waters of Bone Bay, where the highest fishing activity still occurred on the grids C1 and D1 ie Sinjai waters and sembilang island up to the southern Bone waters, the grids F2 and G2 ie Bone waters, as well as the grid H7 ie Kolaka waters (Figure 4.e).
- In June, the analysis show that the average number of fishing vessels operating in the waters of Bone Bay continued to decline to 760 vessels, whereas for the distribution was almost similar as in May but the difference is that the distribution of vessels has begun to spread throughout the central waters of Bone Bay. The fishing vessels mostly operated in the waters of Sinjai, Bone, the northern waters of Bone Bay such as Palopo, Malili, and Kolaka waters.Some vessels were detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. The highest fishing activity still occurred on the grids C1 and D1 ie the waters of Sinjai and sembilang island up to the southern Bone waters, on the grid F2 ie the waters of the southern Bone, and the grid H7 of Kolaka waters as well as some on the grids M1, N1 and N4 which are in the northern waters of Bone Bay (Figure 4.f).
- In July, the analysis show that the average number of fishing vessels operating in Bone Bay waters increased significantly from 760 vessels in the previous month to 1,157 vessels, while for the distribution was almost the same as in July but the difference was the ships started to shift to the southern part of Bone Bay and spread throughout the waters of Bone Bay. The fishing vessels mostly operated in the waters of Sinjai, Bone, the northern waters of Bone Bays such as Palopo, Malili, and Kolaka waters. Some vessels were detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. The highest fishing activity still occured on the grid C1, D1 and D2 ie Sinjai waters and sembilang islands up to the waters of the southern Bone, on the grid F2 ie the southern Bone waters, and on the grid H7 of Kolaka waters. In addition, some vessels were found on the grid M1, M2, and N1 which are the northern waters of Bone Bay (Figure 4.g).
- In August, the analysis show that the average number of fishing vessels operating in the waters of Bone Bay continued to increase,up to 1,480 vessels, compared to the previous monthwith the same distribution as in July, where fishing vessels mostly operated in the waters of Sinjai, Bone, northern waters of Bone Bay such as Palopo, Malili, and Kolaka waters. Additionally, some vessels were detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. At this time the fishing boats have started to operate in the middle of the Bone Bay which is the waters with a depth of up to 2000 m asl. The highest catching activity occurred on grids C1 and D1, namely Sinjai and sembilang islands up to southern part of Bone waters, grids F2 and G2 ie Bone waters, and grid H7 ie Kolaka waters (Figure 4.h).
- In September, the analysis show that the average number of fishing vessels operating in the waters of Bone Bay continued to increase compared to the previous month, of about 1,554 vessels, which this month was the condition with the highest number of vessels during the fishing season. The distribution of these vessels was almost the same as in August, where the fishing vessels mostly operated in the waters of Sinjai, Bone, the northern waters of BoneBay such as Palopo, Malili, and Kolaka waters, and some were detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. At this time the fishing boats have started to operate in the middle of the Bay of Bone which is the waters with a depth of up to 2000 m asl. The highest catching activity occurred on grids C1 and D1, namely Sinjai and Sembilang islands up to southern part of Bone waters, F2 and G2 grids ie Bone waters, and H7 grid ie Kolaka waters (Figure 4.i).
- In October, analysis show that the average number of fishing vessels operating in Bone Bay waters decreased compared to September from 1,554 vessels in the previous

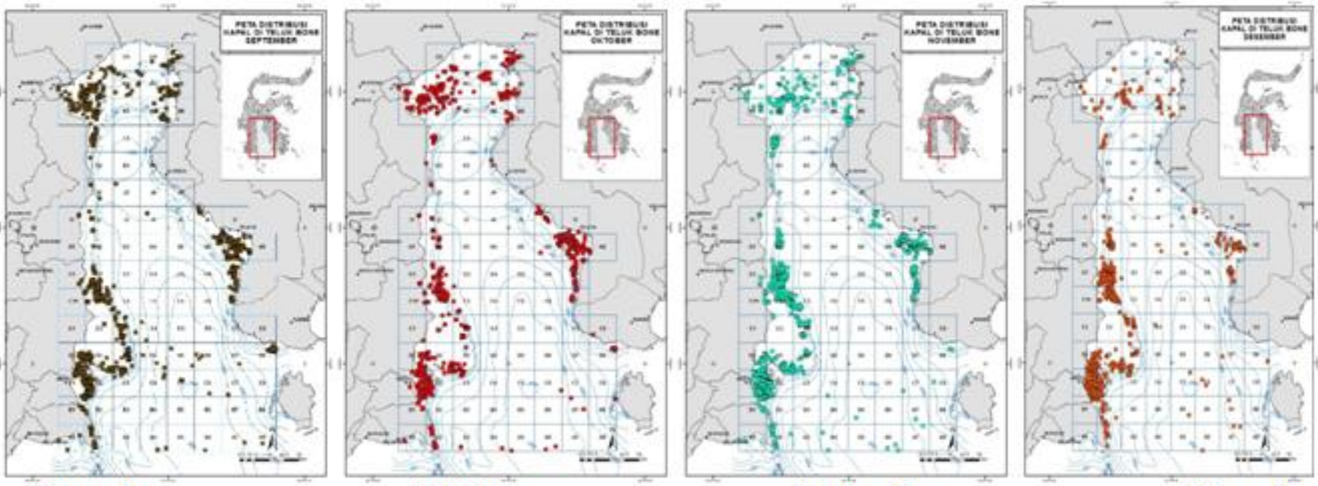
month to 1,210 vessels. Whereas the distribution of ships had begun to shift to the southern part of the Bone Bay and spread throughout the waters of Bone Bay. The fishing vessels mostly operated in the waters of Sinjai, Bone, the northern waters of Bone Bay such as Palopo, Malili, and Kolaka waters. Additionally, some were detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. The highest fishing activity still occurred on the grids of C1, D1 and D2 ie Sinjai waters and islands of Sembilang up to the waters ib the southern Bone, the grid F2 ie the southern Bone waters, and the grid H7 of the Kolaka waters as well as some on the grid M1, M2 , And N1 which is the northern waters of Bone bay (Figure 4.j).

- In November, the analysis show that the average number of fishing vessels operating in Bone Bay waters increased compared to the previous month from 1,210 vessels to 1,377 vessels. Whereas for the distribution of these fishing vessels mostly operated in the waters of Sinjai, Bone, the northern waters of Bone Bay such as Palopo, Malili, and Kolaka waters. Additionally,some were detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. At this time, the fishing boats have started to operate in the middle of the Bone Bay which is the waters with a depth of up to 2000 m asl. The highest catching activity occurred on C1 and D1 grids, namely Sinjai and Sembilang islands up to southern Bone waters, F2 and G2 grids ie Bone waters, and H7 grid ie Kolaka waters (Figure 4.k).
- In December, analysis show that the average number of fishing vessels operating in Bone Bay waters decreased compared to September from 1,377 to 1,025 vessels, while the distribution of ships had begun to shift to the southern part of the bay and spread throughout the waters of Bone Bay. The fishing vessels mostly operated in the waters of Sinjai, Bone, the northern waters of Bone Bays such as Palopo, Malili, and Kolaka waters. Additionally,some were detected in the waters of Siwa and the southern waters of Bone Bay near Bombana, Selayar. Thehighest fishing activity still occurred on the grid C1, D1 and D2 ie Sinjai waters and Sembilang islands up to the waters of the southern Bone, grid F2 ie the southern Bone waters, and grid H7 of Kolaka waters (Figure 4.l).



a. January b. February c. March d. April

e. May f. June g. July h. August



i. September j. October k. November l. December

Figure 4: Temporal Ship Distribution Pattern in Bone Bay January to December

3.2 Fish Activity Index and Pelagic Capture Fishing Planning Instrument

As described above, the average number of vessels operating in Bone Bay waters was 1,060 vessels, where they operated at different depths of water according to the size of the ship's tonnage and ship's engine capability.

Based on field observations and arrival and departure data of ships issued by Regency / City PPIs in the Bone Bay area, fishing boats operating in Bone Bay were between 3 to 30 GT, with a length of 5 to 20 meters. The fishing boats (Figure 5), were scattered throughout the districts located in the vicinity of Bone Bay waters ranging from Bulukumba Regency to Bombana Regency, with the following characteristics:

- Ship size less than 5 GT: This ship type is a ship without motor and ship with outboard motor with fishing gear and surface gillnet. These ships generally operate in coastal areas less than 1 mile from coastline or at depths below 20 m asl. Ships of this size are generally not equipped with generator sets but lighting lamps are adequate.
- Ship size 5 to 10 GT: This type of ship is a ship with an outboard engine and an inboard engine with longline fishing gear, tonda fishing line and mini purseseine. This type of ship is generally equipped with a generator and has adequate lighting. Ships of this size generally operate in coastal waters or at a distance of 1 to 2 miles from coastline or at depths below 50 m asl.
- Ship size 11 to 20 GT: This ship type isan inboard motor boat with fishing gear tone, pole and line, purse seine. This size ships generally operate around the waters of Bone Bay and can perform fishing operations at depths of 50 to 500 m asl. This type of ship is generally equipped with generator and has adequate lighting.
- Ship size 21 to 30 GT: This type of ship is an inboard motor boat with a pole and line fishing gear, purse seine. This type of ship is generally equipped with generators and has adequate lighting, and some are equipped with lights as a fishing tool. Ships of this size generally operate in the waters of Bone Bay to Banda, Flores and Java seas and can perform fishing operations at depths above 500 m asl.

This information is very useful and serves as a basis for classifying ship size based on the characteristics of water depth in Bone Bay, therefore, the fishing activity index can be calculated based on data of ship weight and ship distribution. Furthermore, the results of the index analysis of fishing activities can be used as a reference to determine the potential areas of fishing and serve as an instrument of fisheries planning by capturing potential fishing areas based on approaches to previous fishing sites or fishing grounds (Riswanto, 2012).

Figure 5: Fishing Boat operates in the Bone Bay Waters

The analysis results show that the highest index of fishing activity (Ac) was on the grid C1 in the Sinjai waters and around the sembilang islands, while other areas with high Ac values were on grid B1, G2, F2, H7, C2 and D1 with an Ac value ranging from 0.86 to 0.98 (Table 2 and Figure 6).

Table 2: Calculation of Fishing Activity Index (Ac) in Bone Bay Waters.

grid	x	y	∑b	∑Ac	Bd	Ac
C1	120° 17' 17.707" E	5° 8' 38.091" S	1269	19460	3.57	1.00
B1	120° 17' 17.707" E	5° 20' 38.100" S	282	6380	3.50	0.98
G2	120° 29' 17.716" E	4° 20' 38.057" S	789	20230	3.42	0.96
F2	120° 29' 17.716" E	4° 32' 38.065" S	865	22140	3.40	0.95
H7	121° 29' 17.759" E	4° 8' 38.048" S	1326	19270	3.32	0.93
C2	120° 29' 17.716" E	5° 8' 38.091" S	723	18400	3.12	0.87
D1	120° 17' 17.707" E	4° 56' 38.082" S	416	9210	3.07	0.86
H6	121° 17' 17.750" E	4° 8' 38.048" S	263	7500	2.86	0.80
M2	120° 29' 17.716" E	3° 8' 38.005" S	308	7640	2.81	0.79
E3	120° 41' 17.724" E	4° 44' 38.074" S	384	6580	2.71	0.76
B2	120° 29' 17.716" E	5° 20' 38.100" S	56	6500	2.67	0.75
D2	120° 29' 17.716" E	4° 56' 38.082" S	484	10530	2.64	0.74
M1	120° 17' 17.707" E	3° 8' 38.005" S	279	4710	2.58	0.72
D3	120° 41' 17.724" E	4° 56' 38.082" S	222	6460	2.50	0.70
G1	120° 17' 17.707" E	4° 20' 38.057" S	49	860	2.50	0.70
I6	121° 17' 17.750" E	3° 56' 38.039" S	199	8180	2.50	0.70
G7	121° 29' 17.759" E	4° 20' 38.057" S	365	9650	2.44	0.68
I7	121° 29' 17.759" E	3° 56' 38.039" S	58	6860	2.40	0.67
N1	120° 17' 17.707" E	2° 56' 37.997" S	122	2930	2.40	0.67
C3	120° 41' 17.724" E	5° 8' 38.091" S	223	5530	2.33	0.65
D8	121° 41' 17.767" E	4° 56' 38.082" S	376	5420	2.33	0.65
N5	121° 5' 17.741" E	2° 56' 37.997" S	115	2260	2.33	0.65
F7	121° 29' 17.759" E	4° 32' 38.065" S	128	2000	2.25	0.63
O5	121° 5' 17.741" E	2° 44' 37.988" S	206	2440	2.25	0.63
N2	120° 29' 17.716" E	2° 56' 37.997" S	234	6160	2.18	0.61
E8	121° 41' 17.767" E	4° 44' 38.074" S	1	80	2.17	0.61
H2	120° 29' 17.716" E	4° 8' 38.048" S	247	5050	2.17	0.61
N4	120° 53' 17.733" E	2° 56' 37.997" S	155	5000	2.08	0.58
F3	120° 41' 17.724" E	4° 32' 38.065" S	156	3700	2.00	0.56
I5	121° 5' 17.741" E	3° 56' 38.039" S	26	760	2.00	0.56
J5	121° 5' 17.741" E	3° 44' 38.031" S	1	60	2.00	0.56
M5	121° 5' 17.741" E	3° 8' 38.005" S	82	2510	2.00	0.56
L2	120° 29' 17.716" E	3° 20' 38.014" S	242	5120	1.88	0.53
H8	121° 41' 17.767" E	4° 8' 38.048" S	93	1240	1.80	0.50
M4	120° 53' 17.733" E	3° 8' 38.005" S	116	3910	1.80	0.50
N3	120° 41' 17.724" E	2° 56' 37.997" S	87	2490	1.80	0.50
O4	120° 53' 17.733" E	2° 44' 37.988" S	79	1610	1.80	0.50
A2	120° 29' 17.716" E	5° 32' 38.108" S	196	3710	1.67	0.47
I1	120° 17' 17.707" E	3° 56' 38.039" S	69	690	1.67	0.47
I2	120° 29' 17.716" E	3° 56' 38.039" S	91	1740	1.67	0.47
M3	120° 41' 17.724" E	3° 8' 38.005" S	43	1030	1.67	0.47
E2	120° 29' 17.716" E	4° 44' 38.074" S	44	2020	1.50	0.42
F1	120° 17' 17.707" E	4° 32' 38.065" S	32	1130	1.50	0.42
H1	120° 17' 17.707" E	4° 8' 38.048" S	1	10	1.50	0.42
K2	120° 29' 17.716" E	3° 32' 38.022" S	16	260	1.50	0.42
L4	120° 53' 17.733" E	3° 20' 38.014" S	0	700	1.50	0.42
O2	120° 29' 17.716" E	2° 44' 37.988" S	15	450	1.50	0.42
O3	120° 41' 17.724" E	2° 44' 37.988" S	17	290	1.50	0.42
A1	120° 17' 17.707" E	5° 32' 38.108" S	30	360	1.00	0.28
B3	120° 41' 17.724" E	5° 20' 38.100" S	7	270	1.00	0.28
B4	120° 53' 17.733" E	5° 20' 38.100" S	3	270	1.00	0.28
B5	121° 5' 17.741" E	5° 20' 38.100" S	10	360	1.00	0.28
B6	121° 17' 17.750" E	5° 20' 38.100" S	8	390	1.00	0.28
B7	121° 29' 17.759" E	5° 20' 38.100" S	12	600	1.00	0.28
C4	120° 53' 17.733" E	5° 8' 38.091" S	12	450	1.00	0.28
C5	121° 5' 17.741" E	5° 8' 38.091" S	9	300	1.00	0.28
C6	121° 17' 17.750" E	5° 8' 38.091" S	11	450	1.00	0.28
C7	121° 29' 17.759" E	5° 8' 38.091" S	5	300	1.00	0.28
D4	120° 53' 17.733" E	4° 56' 38.082" S	8	360	1.00	0.28
D5	121° 5' 17.741" E	4° 56' 38.082" S	5	210	1.00	0.28
D6	121° 17' 17.750" E	4° 56' 38.082" S	14	510	1.00	0.28
D7	121° 29' 17.759" E	4° 56' 38.082" S	6	260	1.00	0.28
E1	120° 17' 17.707" E	4° 44' 38.074" S	3	40	1.00	0.28

grid	x	y	∑b	∑Ac	Bd	Ac
E4	120° 53' 17.733" E	4° 44' 38.074" S	4	180	1.00	0.28
E5	121° 5' 17.741" E	4° 44' 38.074" S	2	120	1.00	0.28
E6	121° 17' 17.750" E	4° 44' 38.074" S	1	90	1.00	0.28
E7	121° 29' 17.759" E	4° 44' 38.074" S	1	60	1.00	0.28
F4	120° 53' 17.733" E	4° 32' 38.065" S	0	60	1.00	0.28
F5	121° 5' 17.741" E	4° 32' 38.065" S	1	30	1.00	0.28
F6	121° 17' 17.750" E	4° 32' 38.065" S	0	0	1.00	0.28
G3	120° 41' 17.724" E	4° 20' 38.057" S	3	180	1.00	0.28
G4	120° 53' 17.733" E	4° 20' 38.057" S	1	60	1.00	0.28
G5	121° 5' 17.741" E	4° 20' 38.057" S	1	60	1.00	0.28
G6	121° 17' 17.750" E	4° 20' 38.057" S	0	0	1.00	0.28
H3	120° 41' 17.724" E	4° 8' 38.048" S	4	120	1.00	0.28
H4	120° 53' 17.733" E	4° 8' 38.048" S	2	120	1.00	0.28
H5	121° 5' 17.741" E	4° 8' 38.048" S	2	60	1.00	0.28
I3	120° 41' 17.724" E	3° 56' 38.039" S	0	30	1.00	0.28
I4	120° 53' 17.733" E	3° 56' 38.039" S	3	120	1.00	0.28
J2	120° 29' 17.716" E	3° 44' 38.031" S	31	650	1.00	0.28
J3	120° 41' 17.724" E	3° 44' 38.031" S	3	90	1.00	0.28
J4	120° 53' 17.733" E	3° 44' 38.031" S	1	60	1.00	0.28
K3	120° 41' 17.724" E	3° 32' 38.022" S	0	30	1.00	0.28
K4	120° 53' 17.733" E	3° 32' 38.022" S	3	30	1.00	0.28
L3	120° 41' 17.724" E	3° 20' 38.014" S	1	30	1.00	0.28
A3	120° 41' 17.724" E	5° 32' 38.108" S	5	150	0.50	0.14
A4	120° 53' 17.733" E	5° 32' 38.108" S	11	390	0.50	0.14
A5	121° 5' 17.741" E	5° 32' 38.108" S	26	870	0.50	0.14
A6	121° 17' 17.750" E	5° 32' 38.108" S	17	720	0.50	0.14
A7	121° 29' 17.759" E	5° 32' 38.108" S	20	690	0.50	0.14
A8	121° 41' 17.767" E	5° 32' 38.108" S	3	90	0.50	0.14
B8	121° 41' 17.767" E	5° 20' 38.100" S	6	240	0.50	0.14
C8	121° 41' 17.767" E	5° 8' 38.091" S	2	60	0.50	0.14

Notes:
grid : grid cell size
x : x coordinate
y : y coordinate
∑b : Number of boat in grid cell
∑Ac :fishing activity value
Bd : Boat Density
Ac : fishing activity index

4. Conclusion of Research

1) The waters of Bone Bay have provided economic benefits and utilized by the communities around the area for pelagic fishing operations.
2) The fishing activity on the waters is conducted by fishing vessel fleet of 3 to 30 GT, with the average number of operated vessels for one year reached 12,721 units and the average per month reached 1,060 units,
3) Certain areas of certain waters has temporal fishing patterns that tend to be fixed and have a high index of fishing activity, such as; the waters on the grid C1 ie the waters of Sinjai and around the sembilang islands, while other areas that have a high Ac value was on the grid B1, G2, F2, H7, C2 and D1 with an Ac value ranging from 0.86 to 0.98.
4) Waters with high Ac value and temporally remain the same, can be used as a reference for developing the fishing planning instrument in the form of map of fishery catching area based on approach at previous fishing sites aspect or habitual fishing ground (Riswanto, 2012).

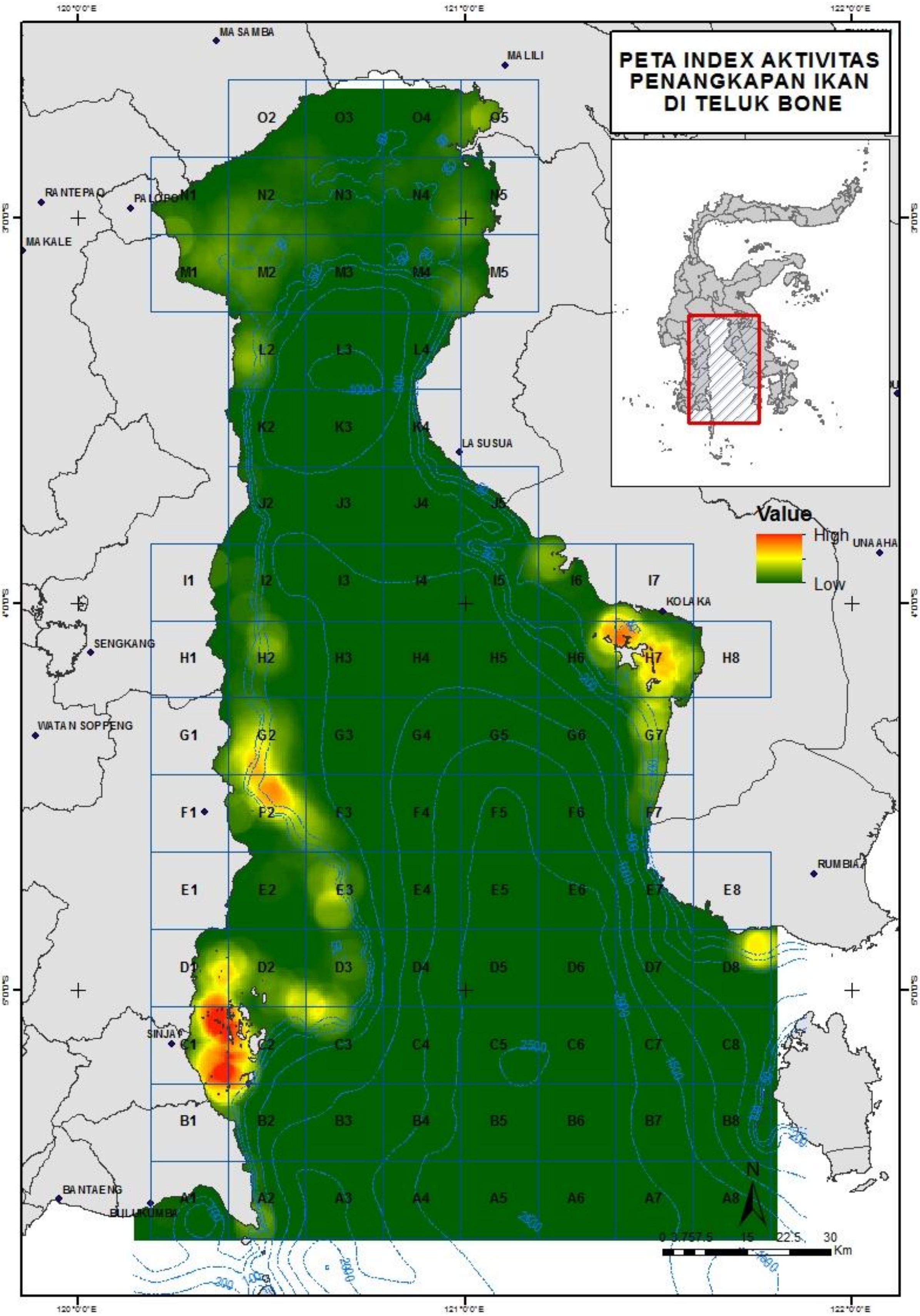


Figure 6: Fishing Activity Index (Ac) in the Bone Bay Waters

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