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MODEL DEVELOPMENT OF POTENTIAL AREA SUITABILITY DETERMINATION OF SKIPJACK TUNA CATCH USING MULTI SENSOR SATELLITE AND GEOGRAPHIC INFORMATION SYSTEM IN WEST PAPUA WATERS

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ABSTRACT

A study of the model development of potential area suitability determination of skipjack tuna (*Katsuwonus pelamis*) catch using multiple satellite sensors and GIS (Geographic Information Systems) in West Papua waters was carried out during January - June 2019. This study aimed to develop a model of potential area suitability determination of skipjack tuna catch in West Papua waters. This study was exploratory research by compiling data of pole and line skipjack catch, multi-sensor satellite imagery data, and analysis of the determination of suitability areas using GIS. The results found three main parameters: Sea Surface Temperature (SST), Chlorophyll-a, and Bathymetry waters in forming a catchment suitability area in West Papua waters. There were two categories found during the west monsoon and transitional seasons I (unsuitable and less suitable). Unsuitable categories at position 0°30'N – 2°20' S; 129°10' – 131°00' E include the eastern part of Misool Island, Kafiau Island, Gag Island and Waigeo Island. The east monsoon of the skipjack catch potential had two categories (less suitable and suitable). The suitable category tends to be found at the westward at the position of 0°20'N - 03°10'S; 127°00' - 131°00' E, including Halmahera Sea and part of Seram Sea. Seasonal Transition II is the best place for catching skipjack tuna. Based on the prediction mapping results, the potential areas are categorized as less suitable and suitable. The suitable categories found throughout the area of study: Fakfak waters, Seram Sea, Halmahera Sea, Manokwari waters, and southern Maluku islands.

KEY WORDS

Sea surface temperature, chlorophyll-a, bathymetry, catching area, skipjack tuna.

West Papua waters, part of eastern Indonesia waters, have promising marine biodiversity potential, among others, large pelagic fish such as skipjack tuna. The number of the potential of skipjack tuna resources in West Papua in 2017 was estimated at 16,203.58 tons or 7.57% of the total production of skipjack tuna fisheries in Indonesia (KPDA KKP, 2018). Skipjack tuna catch in West Papua waters is still done by hunting, following natural signs such as the herds of dolphins and whales, herds of birds and floating objects such as branches and tree trunks, logs, and the use of FADs to collect fish (Waas, 2004).

To increase the production of skipjack tuna catch in West Papua waters, we need technology to determine potential capture areas so that the fleet will be easily directed to the fishing ground to save time, cost, and fuel. Remote sensing multi-sensor satellite is one of the technologies that have been utilized by tuna and skipjack tuna industrial countries because of the high frequency of observation and lower operational costs when compared to

other methods (Robinson, 1985). Information on environmental/ecological indicators can help estimate the location, distribution, and behavior of fish (Chen et al, 2005). Based on the description above, this study aimed to develop a model of potential area suitability determination of skipjack tuna catch in West Papua waters.

METHODS OF RESEARCH

This research was conducted during January - June 2019 in Sorong Coastal Fisheries Port, which is a fishing base. Skipjack tuna catch as the research data were done using pole and line and fishing ground in Missol island waters (Seram Sea), Waigeo Island (Halmahera Sea), and Fakfak waters. While the data of the sea surface temperature, chlorophyll-a, geostrophic currents, wind, waves, and sea depth are collected during January - December 2018. Geographically, the location of the study is limited to coordinates 0°30'00" NL - 4°30'00" SL and 127°00'00" - 135°00'00" EL.

Figure 1 – Map of Reserach Location

Tools and materials:

(1) Oceanographic parameters in 2018 included:

- Sea Surface Temperature Image, Multi-scale Ultra-high Resolution (MUR) resolution 0.01°;
- Image of chlorophyll-a concentration Aqua Modis with 0.025° resolution;
- Geostrophic current image, a combination of Topex/Poisedon and ERS satellites;
- ASCAT satellite wind speed image with a resolution of 0.25°;
- Depth of GEBCO (General Bathymetric chart of the oceans).

(2) Data of fishing ground location and skipjack tuna catch from pole and line fleet in 2018 were obtained from the fishing logbook information system or *Sistem logbook penangkapan ikan* (SILOPI) of the Ministry of Maritime Affairs and Fisheries at Sorong Coastal Fisheries Port and PTCanning Citra Raja Ampat;

(3) Software ArcGIS 10.7;

(4) Software Surfer 16;

(5) Software Snipping Tool;

(6) Laptop Intel Core i5 RAM 4 GB.

This study was an exploratory research aimed to broadly explore the causes or things that influence the occurrence of something, to develop a tentative theory and model, and to open up the possibility of further research on the topics discussed.

In situ data collection of oceanographic physical conditions such as temperature, chlorophyll-a, wind, geostrophic flow velocity, and depth of water is done online. While sampling of other oceanographic physical and biological data is carried out through the

results of synoptic weeding of oceanographic satellites. Skipjack tuna catch data is focused on the capture logbook of 26 pole and line vessels with a capacity of 55 - 97 GT (Gross Ton) including vessel data, capture position, and the number of catches each trip (trip based on hauling). Determination of fishing season depends on the results of interviews with the skipper and shipowner.

Model development of potential fishing area suitability determination is carried out using oceanographic multi-sensor satellite imagery data. This is based on the relationship between water surface conditions and the processes in the water column, meaning that the oceanographic processes in the water column can be detected through the water surface conditions. Determination of potential fishing areas is made based on the results of overlay characterized by the condition of SST, chlorophyll-a, and certain water depths without the presence of oceanographic features. Potential areas are divided into three categories: category 1 or non-potential areas (not suitable), category 2 or less potential area (less suitable), and category 3 or high potential area (suitable). Criteria is arranged based on the data of skipjack tuna catch in 2018 using pole and line. The analysis was performed using a geographic information system. Determination of potential area criteria is the result of modification of water suitability parameters for capture fisheries issued by the Directorate of sea spatial planning, the Ministry of Maritime Affairs and Fisheries in 2016.

RESULTS AND DISCUSSION

The results of the analysis showed that during 2018, the highest SST was in January by 30.67 °C with average SST of 30.15°C and the lowest in July by 25.69°C with average SST of 28.48 °C (Figure 2).

Figure 2 – SST concentration in January and July 2018

Changes in monthly SST also influenced the dynamics of seasonal SST. Table 1 shows the SST seasonal profile.

West monsoon SST concentrations higher than 30° C occurred in January, covering almost all West Papua and Maluku waters. However, in February, March, and December of

the next period, the conditions of SST were relatively lower than 29.73 °C. The eastern part of Seram sea, Berau bay, and Fakfak waters had an average SST above 30 °C.

SST average value of west monsoon and transitional season I did not differ much. The SST of the transitional season I only decreased the temperature by 0.08 °C. Transitional season image I shows that high temperatures >30 °C occurred in two areas: the northern part of west Seram in between the islands of Obi and Missol and the northeastern part of Seram sea up to the southern part of Papua island (Figure 3).

Table 1 – Seasonal SST Profile in West Papua waters and the surroundings

SEASON	Sea Surface Temperature (°C)			
	Min	Max	Mean	STD
WEST MONSOON	29.34	30.24	29.81	0.15
TRANSITION I	29.02	30.50	29.73	0.30
EAST MONSOON	26.20	30.13	28.54	0.99
TRANSITION II	28.47	30.08	29.37	0.29

A real change occurred during the east monsoon (June - September). Sea surface temperature ranged from 26.20 - 30.13°C with an average temperature of 28.54°C. The analysis showed the decrease in minimum temperature by 2.82°C and the maximum temperature by 0.37 from the transition season I. The lowest temperature of 26.20°C occurred in Kaimana waters, Fakfak waters, and the southern part of Maluku island where the temperatures ranged between 27 - 28°C. The SST of Seram Sea, Berau bay, and western part of Raja Ampat Islands ranged between 28 - 29°C. While Halmahera, Waigeo islands, and northern part of West Papua's SST was above 29°C.

The east monsoon showed that cold temperatures were dominant in the south to the eastern part of West Papua and Maluku waters. The analysis results of east monsoon (June - September) showed that there was a movement of cold temperatures drifting from the bottom (southeast) and then rose up to pass the Kei Islands to Fakfak waters and the Seram Sea.

During the transitional season II (October - November), the sea surface temperature had increased from 28.47 to 30.08°C with an average of 29.37°C. The results of the analysis showed a minimum temperature increase of 2.27 °C. It indicated that the maximum temperature did not increase from the previous season period. The average SST rose 0.83°C from the east monsoon. Distribution of transitional season II SST is distributed throughout West Papua waters and its surroundings.

Figure 3 – SST fluctuations in West Papua waters and the surrounding areas in January to December of 2018

The monthly average of the distribution of chlorophyll-a concentrations in West Papua waters and the surrounding areas showed that chlorophyll-a concentrations ranged from

0.309 - 0.579 mg/m³ higher in the east monsoon and lower in the west monsoon. Temporally, the high peak chlorophyll-a concentration starts from May to August with the highest peak in June (Figure 4).

Table 2 – Average Chlorophyll-a Concentration by Season

SEASON	Chlorophyll-a concentration (mg/m ³)			
	Min	Max	Mean	STD
WEST	0.077	44.846	0.304	0.85
TRANSITION 1	0.071	166.184	0.446	2.00
EAST	0.071	69.412	0.480	1.07
TRANSITION II	0.053	106.40	0.358	1.09

Figure 4 – Fluctuations of average chlorophyll-a concentration between January-December 2018 in West Papua Waters

Figure 5 – Chlorophyll-a Concentration of West Monsoon and Transition I

The average chlorophyll-a concentration of the west monsoon (December - March) was 0.304 mg/m³. The highest average chlorophyll-a concentration was in December by 0.352 mg/m³ while the lowest in March by 0.309 mg/m³. The average chlorophyll-a concentration of

the transitional season I (April - May) was 0.446 mg/m^3 . The highest average was in May by 0.503 mg/m^3 and the lowest in April by 0.401 mg/m^3 . The average chlorophyll-a concentration of transitional season I increased 0.142 mg/m^3 from the west monsoon (Figures 4 and 5). The average chlorophyll-a concentration of east monsoon (June - September) was 0.483 mg/m^3 . The highest average was in June by 0.579 mg/m^3 and the lowest in September by 0.431 mg/m^3 . The east monsoon was the peak of high concentrations of chlorophyll-a which covers all West Papua, Maluku, and North Maluku waters. In transitional season II (October - November), the highest average chlorophyll-a concentration was 0.394 in October, and the lowest was 0.346 mg/m^3 in November.

Image data in West Papua waters and its surroundings showed that chlorophyll-a concentrations were categorized high throughout the season with a range between $0.304 - .480 \text{ mg/m}^3$.

The average chlorophyll-a concentration was generally low during the west monsoon and transitional seasons II. The average concentration of chlorophyll-a increased $> 0.40 \text{ mg/m}^3$ from April (transitional season I) to September with the highest peak in June by 0.579 mg/m^3 (east monsoon) and decreased again in October (Figures 4 and 6).

Figure 6 – Chlorophy Concentration of East Monsoon and Transition II

The data showed that the movement of ocean currents in West Papua waters and its surroundings in 2018 had a different speed and direction each month.

Table 3 – Average current speed based on the season in West Papua waters and surrounding areas

SEASON	Current Speed (m/s)			
	Min	Max	Mean	STD
WEST MONSOON	0.037	1.107	0.308	0.156
TRANSITION 1	0.025	1.114	0.253	0.129
EAST MONSOON	0.043	0.950	0.271	0.123
TRANSITION II	0.026	1.552	0.301	0.188

In the west monsoon, the current velocity ranged from $0.037 - 1.107 \text{ m/s}$ with an average current speed of 0.308 m/s . The fastest current speed was there around Adi islands in March, reaching up to 1.929 m/s . In general, during the west monsoon, there are 2

directions of currents in West Papua waters and its surroundings: a movement from the bottom (southeast to northwest) and from upper (north to south). This confluence brings eddies around the eastern part of Seram Sea and moves east into the Berau bay.

The currents in the ocean are caused by internal and external factors. The internal factors include differences in seawater density, horizontal pressure gradients, and water layer friction. While the external factors include the tensile force of the sun and the moon influenced by the resistance of the seabed and the Coriolis force, the difference in air pressure, gravity, tectonic, and wind forces (Gross, 1990).

In the transitional season I (April - May), the average current speed was 0.253 m/s and the speed and direction of the current was different. In April, the current velocity in Missol Island reached up to 1.97 m/s with an average of 0.26 m/s. The current direction above Missol Island tends to move northwest to Seram Sea. While the current direction from Berau bay goes out westward then down south and forms an anti-cyclonic circulation pattern around Fakfak waters. In May, the current velocity decreased up to 1.35 m/s with an average of 0.23 m/s. It was mostly happened in the Maluku sea (northern part of Maluku) with the current direction to the north.

Nontji (1993) stated that during the west-east transitional season, the flow to the east is starting to weaken and even begin to reverse until causing eddies in some places. Birowo (1980) also proposed that during the transitional season, the flow is volatile and difficult to determine.

The average current velocity of the east monsoon was 0.271 m/s. The highest speed was in July, reaching up to 2.46 m/s with an average month of 0.29 m/s. In August and September, the current velocity decreased again. The lowest average speed was 0.25 m/s in September. The direction of the currents movement tends to move north. This was influenced by the east monsoon and the SST in the southern part of West Papua, which is relatively lower so that the current movement from Banda Sea got into the eastern part of Seram Island to the north. However, in September, the direction of the current speed from Raja Ampat Island tended to move south and turned east through Seram Sea and met the current heading to the Berau gulf.

The current velocity of transitional season II (October – November) ranged from 0.026 - 1.552 m/s with an average of 0.301 m/s. In October, the current velocity in Missol Island and the northern part of Seram sea reached up to 1.42 m/s with an average of 0.27 m/s. While in November, the highest current speed in Berau and Kamrau bay reached up to 2.59 m/s with an average of 0.32 m/s (see table 3).

The results of the analysis showed that seasonal wind speeds ranged from 4.07 – 28.39 knots with average wind speeds between 15.21 - 15.48 knots (Table 5)

The wind direction of the next season's west monsoon tends to move southeast with a velocity range of 5.17 - 25.96 knots and an average of 15.48 knots. Whereas at the transition I, the wind blew from the southeast to the northeast with a speed range of 4.07 – 28.39 knots with an average of 15.21 knots. During the east monsoon, the wind tended to blow to the northeast with a range of 5.37 – 27.3 and an average of 15.25 knots. Based on the results of the monthly analysis of Seram Sea, the wind speed tended to be higher than in other regions. The direction of the wind during the transition II in October was still going northeast and changed to the southeast in November with a speed range of 5.33 - 27.66 knots and an average of 15.32 knots.

Table 4 – Seasonal wind speed in the waters of West Papua and the surrounding areas

SEASON	MIN	MAX	MEAN	STD
WEST	5.17	25.96	15.48	3.71
TRANSITION I	4.07	28.39	15.21	3.98
EAST	5.37	27.3	15.25	4.05
TRANSITION II	5.33	27.66	15.32	4.09

The analysis showed that the wave heights in West Papua waters and surrounding areas in 2018 varied between 0.04 - 2.28 m (Figure 7). Wave characteristics are influenced

by wind speed, the faster the wind speed, and the higher the waves will be. Also, the waves are affected by depth differences, the shallower the waters, the quicker the waves will break (Hasriyanti et al, 2015). In the west monsoon, the wave height ranged from 0.06 - 1.37 m, evenly throughout West Papuawaters and its surroundings. In January, it ranged from 0.05 – 1.46 m, but the height of the wave dominantly ranged between 0.5 – 1 m. In February, the wave height in the western part of Seram sea and Raja Ampat islands ranges from 0.06 – 1.25. While in the Berau bay to Fakfak waters, the wave height tended to be under 0.5 m. In contrast to the previous month, the wave heights in March increased between 0.06 – 1.52 m, predominantly occurring in the eastern waters of West Papua (132° -135° WL). In the west monsoon of the next period, the wave height does not differ much; it still ranged between 0.09 – 1.10 m but dominantly between 0.5 - 1 m throughout West Papua waters.

The average height during the transitional season I ranged from 0.06 to 1.32 m. In April, it ranged from 0.04 to 1.09 m, decreasing 0.43 m from the west monsoon in March. The depth of the northern part of West Papua waters tended to be deeper than Seram sea and the southern part of Maluku whose the wave height is relatively small under 0.5 m. In May, the wave height rose between 0.08 - 1.55 m. In the position of 3° – 4.30° SL, the dominant wave height is between 1 - 1.5 m.

Figure 7 – Graph of average monthly wave height in 2018 in West Papua waters and the surrounding areas

The east monsoon is the peak of high waves in West Papua waters and its surroundings with an average range from 0.09 to 2.17 m. The wave height in June, July, August, and September is 0.12 -2.02 m, 0.07-2, 27, 0.07 - 2.28 m, and 2.11 m, respectively. The wave height in West Papua waters and its surrounding areas during the transitional season II was relatively decreased, between 0.07 – 1.05 m, while in October and November, it ranged from 0.11 – 1.16 m and 0.06 - 1.01, respectively.

The depth of West Papua waters and its surroundings area is different. The northern part of West Papua waters tends to be deeper than that of the southern part. It is directly adjacent to the Pacific sea whose depth > 2500 meters, while the depth of the western and southern part of West Papua waters is <2000 meters.

Vertical spread (depth strata) of skipjack tuna started from the surface to a depth of 260 m during the day and tended to go to the surface at night (Munirah, 2018). Opportunities of skipjack tuna catch at a depth of 51-100 m are higher compared to a depth of > 100 m (Munirah et al, 2015).

Depth analysis of West Papua waters, which is a skipjack fishing area, displays a different depth profile (see figure 8). Profile A of Seram Sea (Missol Island to Seram Island/Maluku) showed the extending sea trench form a channel/pool with a depth up to 2000 meters. The movement to the west will deepen the channel/pool up to 2500 meters. Fakfak Waters (Fakfak to Seram Island/eastern Maluku) show fluctuation dept reaching 1980 meters, getting closer to shallow waters of Seram Island. The sea trough (Seram Sea) connects Fakfak waters and Banda Sea. Halmahera Sea (Waigeo Island - South Halmahera) shows that the closer the distance to southern Halmahera, the much more sea through with a depth of up to 2600 meters.

Figure 8 – Waters dept profile of A Seram Sea (Missol I. - Seram I.), B Fakfak Waters (Fakfak – eastern part of Seram Sea), C Halmahera Sea (Waigeo I. - South Halmahera)

Based on the research data, the catch of skipjack tuna during 2018 reached up to 1,818.30 tons. The number of pole and line vessels operating was 26 ships with a total fishing operation of 937 trips (total trip is calculated based on the time of capture at a certain place) so that the 2018 catch per unit (CPUE) was 1,941 tons/trip.

Most skipjack catch during the west monsoon was in March with an average of 2577 kg/trip. Its SST range was 29.45 - 29.83°C with an average of 29.66 °C. Chlorophyll-a ranged from 0.12 to 0.32 mg/m³ with an average of 0.18 mg/m³. Current speeds ranged from 0.03 to 0.50 m/s with an average of 0.18 m/s. Wind speed ranged from 10.13 - 12.68 knots with an average of 11.03 knots. Sea waves ranged from 0.59 to 1.03 meters with an average of 0.81 meters, and the sea depth ranged from 217 - 2089 meters. The average skipjack tuna were caught at the dept of 1389 meters. The highest catch in Fak-Fak waters was at position 3.350° SL; 132.37° EL with a catch of 6.65 tons at SST 29.73°C and chlorophyll-a 0.30 mg/m³.

In Transition Season I, the highest catch was in April with an average of 2236 kg/trip, the SST ranged from 29.68 - 30.24 °C with an average of 29.88°C and a mode of 30.01°C. Chlorophyll-a ranged from 0.11 to 4.14 mg/m³ with an average of 0.25 mg/m³ and mode of 0.19 mg/m³. Current velocity ranged from 0.07 to 0.50 m/s with an average of 0.22 m/s. Wind speed ranged from 6.05 - 9.23 knots with an average of 7.6 knots. Sea waves ranged from 0.2 - 0.56 meters on average 0.35 meters with the depth of the sea from 154 - 2553. The average skipjack were caught at a depth of 1262 meters. The highest catch in Fak-Fak waters was at position 3.47° SL; 132.30° EL with a catch of 4.65 tons at SST 30.12 °C and chlorophyll-a 0.212 mg/m³.

In the east monsoon, the highest catch occurred in August and September. The average number of catch in August was 2230 kg/trip. The SST ranged between 27.10 - 29.15°C with an average of 28.01 °C and mode 28.57 °C. Chlorophyll-a ranged from 0.24 to 0.70 mg/m³ with an average of 0.37 mg/m³ and a mode of 0.13 mg/m³. Current speeds ranged from 0.07 to 0.66 m/s with an average of 0.24 m/s. Wind Speed ranged from 10.90 - 14.23 knots with an average of 12.87 Knots. Sea waves ranged from 0.85 to 1.65 meters, with an average of 1.29 meters. The sea depths ranged from 60 - 2094 meters. The average skipjack tuna is caught at a depth of 1270 meters. The highest catch in Fak-Fak waters is at

3,50⁰ SL; 132,13⁰ EL with a total catch of 4.97 tons at SST 27.19 °C and chlorophyll-a 0.36 mg/m³. The average catch in September was 2513 kg/trip. The SST ranged between 27.82 – 28.64 °C with an average of 28.41 °C and the mode was 28.62 °C. Chlorophyll-a ranged from 0.14 to 0.31 mg/m³ with an average of 0.19 mg/m³ and a mode of 0.17 mg/m³. Current speeds ranged from 0.06 to 0.43 m/s with an average of 0.09 m/s. Wind Speed ranged from 10.67 – 13.63 knots with an average of 12.29 Knots. Sea waves ranged between 0.81 – 1.48 meters with an average of 1.15 meters. The sea depths ranged from 273 – 2044 meters. The average skipjack tuna was caught at a depth of 1438 meters. The highest catch was in Seram Sea at 2.53⁰ SL; 130.27⁰ EL with a total catch of 6.23 tons at SST 28.60° and C chlorophyll-a 0.21 mg/m³.

The highest catch of transitional season II was in October with an average of 2062 kg/trip. The SST ranged between 28.96 - 29.26 °C with an average of 29.10 °C and mode 29.24 °C. Chlorophyll-a ranged from 0.15 to 0.33 mg/m³ with an average of 0.21 mg/m³ and mode 0.15 mg/m³. The current velocity ranged from 0.07 to 0.69 m/s with an average of 0.23 m/s. Wind speed ranged from 6.67 – 8.7 knots with an average of 7.4 knots. Sea waves ranged from 0.24 – 0.50 meters, with an average of 0.34 meters. The sea depth ranged from 733 – 2646 meters. The average skipjack tuna was caught at a depth of 1464 meters. The highest catch was in Seram Sea at 2,70⁰ SL; 130.65⁰ EL with a catch of 6.16 tons at SST 29.02 °C and chlorophyll-a 0.24 mg / m³.

The results of image data analysis showed that the characteristics of oceanography in West Papua waters and its surroundings are classified as productive areas for the survival of skipjack tuna. According to Bambang (2004), Papua has potential tuna fish resources. Nontji (1993) stated that the optimum temperature for skipjack tuna is 16 – 30 °C. The results of the study by Simbolon et al. (2005) stated that the optimum temperature for skipjack catch ranged from 28 – 31 °C. Based on Edmondri (1999), skipjack tuna had an optimum temperature range of 28 – 29 °C. This was because SST had a great influence on the distribution and migration of skipjack tuna (Zainuddin & Jamal, 2009). If examined further, the value of chlorophyll-a concentration > 0.2 mg/m³ indicated that the existence of phytoplankton in the water is adequate to sustain the development of commercial fisheries (Gower, 1972).

According to Nugraheni (2015), one of the factors that cause a decrease in the catch is the state of the wind during fishing operations. Changes in weather and climate have influenced fisherman to change the fishing effort. Current is a very important parameter in the marine environment and directly or indirectly influences the marine environment and the biota within, including determining fish migration patterns. The currents in the sea are influenced by many factors, one of which is the monsoon (Wibisono, 2005).

The effort of catching skipjack tuna can be optimized by knowing the potential fishing grounds so that fisherman will generate benefit from the fishing operations.

Potential areas of skipjack tuna in West Papua waters and the surrounding areas have been mapped out based on the SST, chlorophyll-a, and the depth of the overlayed waters using a geographic information system. Jufri (2014) stated that potential of skipjack tuna have close links with environmental parameters, especially the optimum SST at 29.9 – 31.00C, and optimum chlorophyll-a in the range of 0.12 – 0.22 mg/m³.

Suitability of potential areas is divided into three categories: category 1 or non-potential areas (not suitable), category 2 or less potential area (less suitable), and category 3 very high potential areas (suitable). The criteria are arranged based the data skipjack tuna catch in 2018 using pole and line and the value of the SST oceanographic parameters, chlorophyll-a, and depth of water taken based on the number of catches (Table 5).

The results of the mapping showed that not all regions have a suitable category (Figures 9 and 10). The distribution of potential fishing areas with the suitable category is found during the east monsoon and transitional seasons II (Figures 11 and 12).

West monsoon and transitional season I in West Papua waters and the surrounding areas are categorized as not suitable and less suitable. Both seasons have small spots, meaning they are not suitable for becoming potential areas at the position 0°30"NL –

2°20"SL; 129°10"- 131°00 EL. It includes the eastern part of Misool Island, Kafiau Island, Gag Island, and Waigeo Island (Figures 9 and 10).

Table 5 – Model of potential area suitability criteria of skipjack tuna catching

No	Parameter	Unit	Criteria of Conformity			
			Weight	Suitable (3)	Less suitable (2)	Not Suitable (1)
1	Sea Surface Temperature	°C	35	28 - 30.5	27 - 28	<27
2	chlorophyll-a	mg/m ³	35	>= 0.2	0.1 - 0.19	< 0.1
3	Waters depth	m	30	>800	41 - 800	< 40
Total			100	Score 3	Score 2	Score 1

Figure 9 – Potential Areas to catch Skipjack Tuna West Monsoon

Figure 10 – Potential Areas to catch skipjack tuna Transitional Season I

In the east monsoon, the potential areas in West Papua waters are still dominant in the category of less suitable to fish skipjack tuna. The appropriate category as the skipjack fishing area tends towards the west at position 0°20"NL - 03°10"SL; 127°00"- 131°00"EL, including the Halmahera Sea and part of the Seram Sea (Figure 11). Transitional Season II is a good skipjack fishing area. Based on the results of prediction mapping, the potential areas are categorized as less suitable. The suitable category is there in all research areas including Fakfak waters, Seram sea, Halmahera sea, Manokwari waters, and southern Maluku islands (Figure 12).

Figure 11 – Potential Areas of skipjack tuna catch East Monsoon

Figure 12 – Potential Areas of skipjack tuna catch Transitional Season II

CONCLUSION AND SUGGESTION

The results of the parameter characteristics of oceanography showed that West Papua waters have good potential marine resources for the survival of pelagic fish, especially skipjack fish. Skipjack fishing catch can be done throughout the year with a fishing ground where the most catch in Seram Sea and Fakfak waters. Predictions of potential areas show that the East Monsoon and Transitional seasons II are very suitable for skipjack fishing operations.

To determine the potential areas of skipjack catch with a better level of accuracy, further research is recommended using daily and weekly multi-sensor satellite image data.

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