Journal of Advanced Zoology

ISSN: 0253-7214
*Volume **44** Issue **04 Year 2023** Page **438:446***

Analysis of Determining the Level of Feasibility of Skipjack Fishing Potential Zones (ZPPI) in Barru Waters, Makassar Strait

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Article History

Received: 20 June 2023
Revised: 11 Sept 2023
Accepted: 19 Nov 2023

Abstract

This research aims to analyze the oceanographic conditions of catches in Barru waters, as well as analyze the feasibility of ZPPI of Skipjack based on image data in Barru waters. The research was carried out in September 2022 – June 2023 using a survey method by collecting two types of datasets, both primary and secondary. The data analysis used in this research is GAM (Generalized Additive Model), PHI (Pelagic Habitat Index), and Cohen's Kappa. The research results show that the oceanographic parameters that have a positive effect on skipjack tuna are chlorophyll-a (Chl-a), salinity, and current speed, with an R2 (adj) value of 0.211, which means the presentation of the influence of the dependent variable (chlorophyll-a, salinity, and speed). current) on the independent variable (catch of skipjack tuna) was 24.8% and the rest was influenced by other factors. Mapping the ZPPI of skipjack tuna based on the PHI value, it was found that the red color on the map was considered to be the area that best suited the environmental preferences of skipjack tuna so it was indicated as a potential area. PHI during September – June 2023 in the range 0.06 – 1.00. As for the feasibility of the ZPPI, which is measured based on the size of the fish, and the coordinate point which is right in the ZPPI, shows a value of 0.422 (good) because the k value>0.4 means that the reliability of the agriment between the two measurements is good, so the ZPPI of skipjack tuna can be said to be suitable for fishing.

Keywords: ***Oceanographic Parameters, Skipjack Tuna, PHI, ZPPI, GAM***

1. Introduction

The potential for pelagic fish in the Makassar Strait region is influenced by oceanographic conditions. The fertility level of waters is based on influencing oceanographic parameters such as SST, chlorophyll-a, and salinity (Nahdyah, 2017). One of the fish most often caught by Barru fishermen is skipjack tuna. Skipjack tuna live in large flocks. Fish will look for suitable places to eat, lay eggs, migrate, and as a shelter. Skipjack tuna is a species that has a wide migration pattern in waters both vertically and horizontally. Data on skipjack tuna production for five years (2017 – 2021) in Barru Regency shows that catches of skipjack tuna have increased every year. This data shows that the potential for skipjack tuna in Barru is still quite large even though the rate of fish production has decreased in 2021. The decrease in total production is influenced by the increase in the number of fishing gear, the number of fishing trips, and the limited information of fishermen regarding accurate fishing areas.

In the coastal waters of Barru Regency there are several types of fishing gear used by coastal communities. However, the dominant ones are Bandrong (Blanket Net) and Purse seine. Bandrong have been used long before the use of other modern fishing gear. The method of catching this tool is passive (Malik et al., 2021). In research, Mallawa, et al., (2020) said that skipjack tuna was 37.84% worth catching using bandrong compared to other traditional scale skipjack fishing equipment such as hand fishing, trolling lines and upright longlines. And purse seine fishing gear is the fishing gear most often used by the community to catch skipjack tuna, where this tool is the main fishing gear in catching skipjack tuna in the Makassar Strait, and this tool is active (Safruddin, 2020)

When making arrests, it is very important to determine potential zones. This is because fishermen still use personal experience to catch fish, which makes the fishing process wasteful of time and money. In an effort to optimize the fishing process, remote sensing technology is applied, namely creating a map of fish potential zones which is expected to improve the welfare of the government and society, especially people who work as fishermen in the waters of the Makassar Strait.

Several studies regarding the potential zone for skipjack tuna in Barru, stated that the locations for skipjack tuna fishing based on optimum oceanographic parameters found large catches and were in accordance with the fishing locations carried out by fishermen (Amir, 2018; Abudarda, 2021; Novianti, 2021). However, in general, fishing areas are not fixed and always change following environmental conditions, so naturally fish will choose more suitable habitats (Putri, 2018).

Based on several studies above, it still has shortcomings, namely that it does not pay attention to the suitability of ZPPI for bandrong and purse seine fishing operations. Based on the results of interviews with fishermen in Barru, it was stated that the catch obtained using Bandrong fishing gear was quite large, but in 2021 the catch would decrease. And catches in purse seines have also decreased. Therefore, it is necessary to analyze the feasibility of potential fishing zones using ban pusher and purse seine fishing gear, to see whether the skipjack fishing zone has entered the potential zone based on oceanographic parameters. This is also for the sustainability of skipjack tuna in Barru waters.

One reliable method used to determine fish's preferred habitat is through analysis of satellite image data and field data support. The results of satellite observations are then mapped using geographic information system techniques. This geographic information system technique combines various oceanographic and fisheries information necessary to create a map of potential fishing zones. Information regarding fishing zones is very necessary in the fisheries sector, especially fishing activities. To determine fishing locations, one way that can be done is by utilizing remote sensing technology.

2. Methods

This research was carried out in September 2022 – June 2023 by participating in skipjack tuna fishing operations using purse seine and bandrong vessels. Catch data and oceanographic parameters were carried out around the waters of Barru Regency, with fishing bases in Lawallu Village and Siddo Village, Barru Regency. Next, data analysis will be carried out at the Fisheries and Marine Geospatial Information Systems Laboratory, Faculty of Marine and Fisheries Sciences, Hasanuddin University, Makassar.

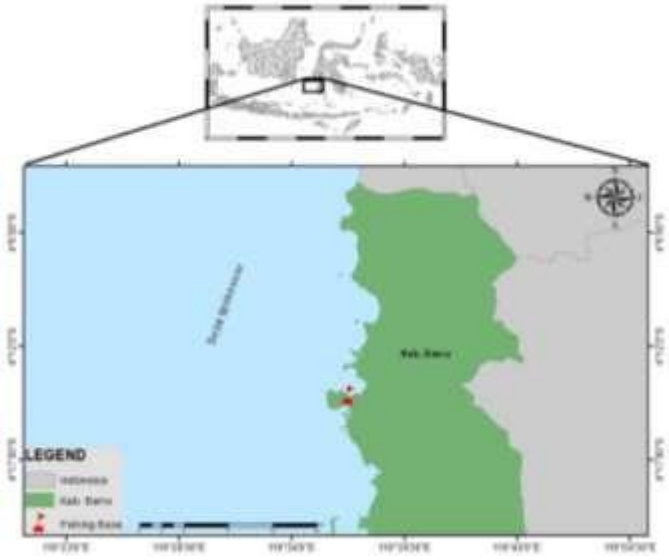

Figure 1. Map of research locations in the Makassar Strait

Data Collection Method

Data collection was carried out using a survey method by collecting two types of datasets, both primary and secondary. Primary data collection (ex-situ) was obtained when participating in fishing operations directly using purse seine and bandrong fishing gear, by taking data on coordinate points, number of catches, parameters of sea surface temperature (SPL), salinity and current speed. Secondary data collection (in-situ) is complementary data obtained from image data. The spl and chl image data were downloaded in Ocean Color with a spatial resolution of 4 km and a monthly temporal resolution. Salinity and current data are downloaded via the Copernicus Marine Environment website. Data is downloaded based on research time.

Data analysis

Primary data obtained in the research was then analyzed with secondary data. To achieve the research objectives with the following analysis:

***Generalized Additive Model* (GAM)**

The data collected are the results of catches of skipjack tuna during the operation of bandrong and purse seine fishing gear, ex-situ oceanographic parameters in the waters of the Makassar Strait during September 2022 - June 2023 which have been processed in ArcGis10.8, then processed using Generalized Additive The model contained in the RStudio4.0.0 software. This research is based on the nature of the relationship between skipjack tuna catch (tail/hauling) as a response variable, SST, and chlorophyll-a as a predictor variable produced by GAM. The application of the GAM statistical model is as follows Wood (2017):

$$g(\mu i) = Ai\theta + s(spl) + s(chl) + s(salinitas) + s(arus)$$

Information:

g	= Link function
μi	= Predicted value of the dependent variable
$A_i\theta$	= Constant coefficient
s	= Smoothing function

Before GAM modeling is carried out, an exploration of the data set is first carried out with the aim of identifying collinearity outlier data between each explanatory variable. The libraries contained in the R language are the formation of the GAM model. Skipjack tuna is the y variable, while the oceanographic parameters are the x variable.

***Pelagic Habitat Index* (PHI)**

Determining the ZPPI of Skipjack tuna applies the Pelagic Habitat Index (PHI) method, which is a spatial and temporal mapping of skipjack tuna hotspots in the research waters. Data processing is the skipjack tuna abundance index (CPUE), and the frequency of skipjack tuna fishing is related to oceanographic variables (SST, CHL, currents and salinity). The PHI formula equation by Zainuddin et.al (2017) can be written as follows:

$$PI_{CPUE} = \frac{\Sigma \frac{CPUE_{ij}}{CPUE_{imax}}}{n}$$

$$PI_f = \frac{\Sigma \frac{f_{ij}}{fi_{max}}}{n}$$

$$PHI = \frac{(PI_{CPUE} + PI_f)}{2}$$

Information:

PI_{CPUE}	= average probability index for skipjack tuna
$CPUE_{ij}$	= CPUE value of oceanographic variable *i* for class interval j
$CPUE_{i\,max}$	= maximum CPUE value for oceanographic variables *i*
n	= total number of variables
PI_f	= average probability index based on frequency relationships skipjack tuna fishing and oceanographic variables for histogram graphs
f_{ij}	= value of the frequency of catching skipjack tuna from oceanographic variables *i* for class intervals *j*.
$f_{i\,max}$	= maximum frequency value of skipjack tuna fishing in oceanographic variables *i*
PHI	= pelagic hotspot index

PHI analysis uses a weighting of 0.00 – 1.00, where a value close to 1.00 or equal to 1.00 indicates a high probability of finding skipjack tuna.

Cohen's Kappa

Determining the feasibility of skipjack ZPPI using Cohen's Kappa analysis is a measure that states the consistency between two measurement methods or can also measure the consistency between two measurement tools. Cohen's kappa test to determine the level of agreement between the two raters. The data used is secondary data on the size and number of fish caught during the last 5 years, starting 2019 - 2023 to see the feasibility level of ZPPI skipjack in Barru district. The formula used in this analysis is as follows:

$$\kappa = \frac{\Pr(a) - \Pr(e)}{1 - \Pr(e)}$$

Information:

Pr(a) = The percentage of measurements that are consistent between raters

Pr(e) = Percentage of the number of changes in measurements between raters

According to several experts, the grouping of kappa values is Landis and Koch (1977) in Brestoff and Broek (2013):

Table 1. Interpretation of KAPPA

Kappa Index	Agreement
< 0.40	Poor Agreement
0,41 – 0,75	Good
>0.75	Excellent agreement

3. Results and Discussion

Relationship between Oceanographic Parameters and Skipjack Fish

Skipjack tuna habitat was determined based on analysis carried out using the GAM (General Additive Model) method with R software (4.0.0). Based on the results of the GAM analysis (Table 2), it can be seen that chlorophyll-a, salinity and current speed have a positive influence on the distribution of skipjack tuna. The relationship between the four oceanographic parameters and skipjack tuna catches based on the analysis results can be explained by the significant value of SPL 0.368, Chl-a 0.008416, Salinity 0.005023, and Current significant value 0.000149 with the R2 (adj) value of 0.211 which means the presentation of influence the dependent variable (sea surface temperature, chlorophyll-a, salinity, and current speed) to the independent variable (catch of skipjack tuna) was 24.8% and the rest was influenced by other factors. Overall, analysis based on the GAM model shows that chlorophyll-a, salinity and current speed have a greater influence than sea surface temperature parameters. This is thought to be influenced by the catches of skipjack tuna obtained during the research from purse seine vessels that use FADs in their fishing activities. Zainuddin et al., 2019 stated that the area around FADs is a good foraging area for skipjack tuna which then significantly increases the catch of skipjack tuna in the waters of Bone Bay.

Based on the rug plot, most skipjack tuna catches are concentrated in the SPL range of 30.2 – 31.8°C (2a). The chlorophyll-a concentration value tends to be favorable and the abundance of skipjack tuna is around 0.2 – 0.4 mg/m3 (2b). Rugplot catches with salinity are mostly concentrated in the range of 33.6 – 34.2 ppt (2c). And the current speed that skipjack tuna tends to prefer is the current speed value ranging from 0.05 – 0.27 m/s (2d).

Table 2. Analysis of catch data on oceanographic parameters using the Gam method

Variable	edf	Ref.df	F	p-value
s (Arus)	8.457	8.885	3.783	0.000149 ***
s (Salinitas)	3.193	3.795	3.932	0.005023 **
s (suhu)	1	1	0.811	0.368473
s (CHL)	1.589	1.968	5.395	0.008416 **

Note: Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1; R^2(adj)=0.211, Deviance explained = 24.8%

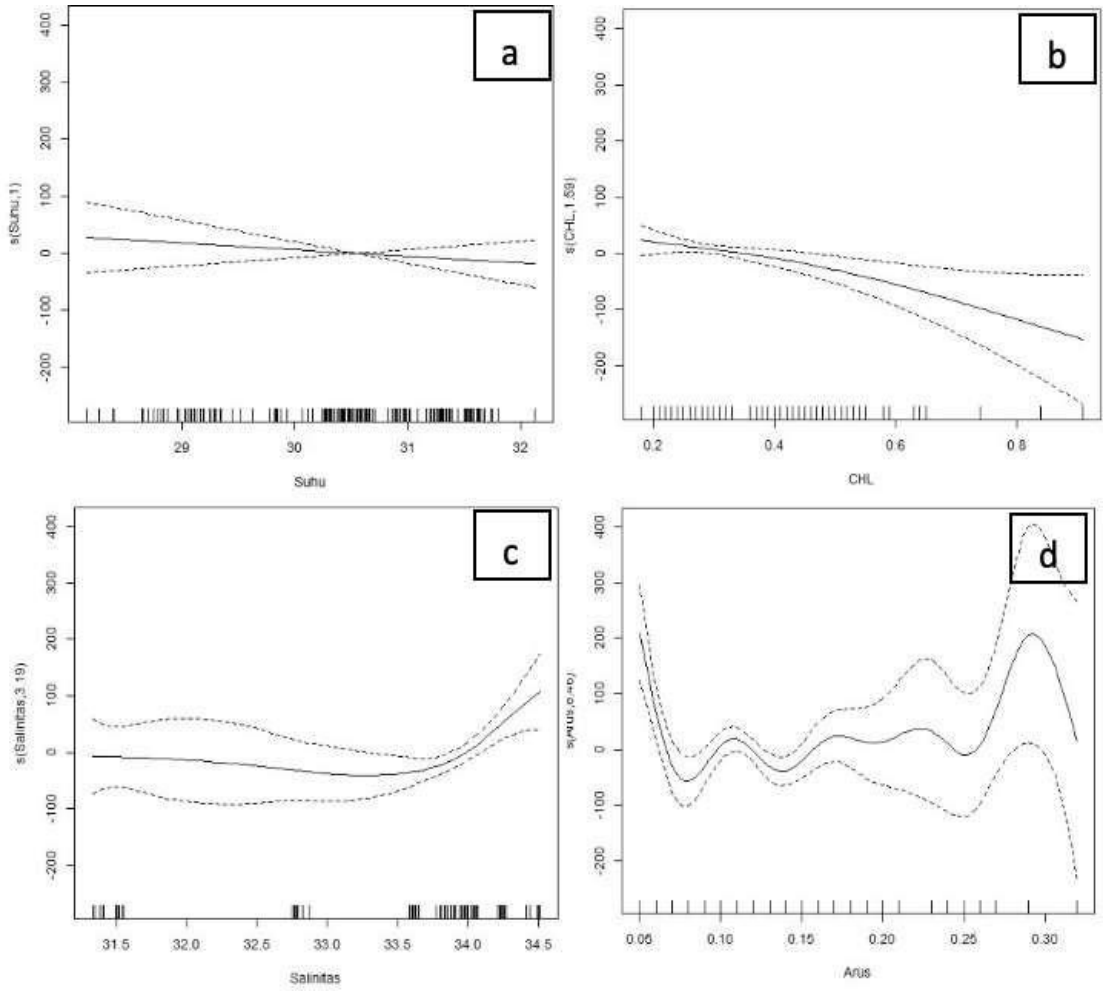

Figure 2. Relationship between Oceanographic Parameters a) SST, b) Chl-a, c) Salinity, d) Current Rate

The overall results of skipjack tuna fishing were carried out in the SST concentration range of 29.52 – 31.6 °C, chl-a in the range of 0.13 – 0.93 mg/m^3, salinity in the range of 31 – 34.6 ppt, current speed in the range of 0.07 – 0.37 m/s. SST fluctuations and geographical changes determine the grouping of fish in a body of water. Each species of fish in the water wants an optimal temperature so that it can carry out activities at a temperature that suits its body. Abudarda et al., (2021) said that skipjack tuna was caught in the range of 0.14 – 0.32 mg/m^3.

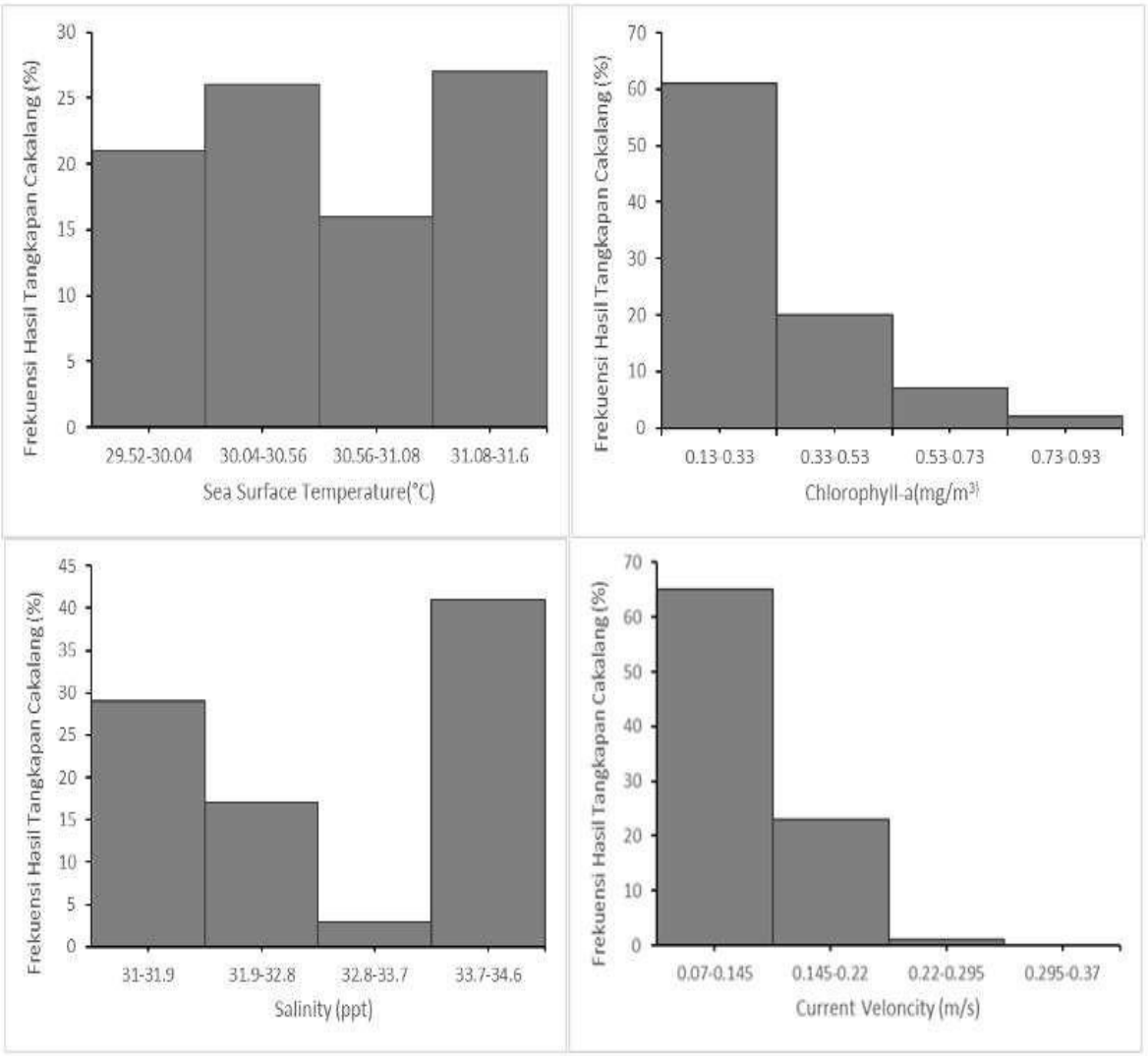

Figure 3. Frequency of Catch Results with a) SST, b) Chl-a, c) Salinity, and d) current speed.

Skipjack Potential Fishing Zone (ZPPI). (*Katsuwonus pelamis*)

ZPPI mapping of skipjack tuna is based on PHI values obtained through data processing and analysis in Microsoft Excel 2019, and visualized in ArcGIS 10.8 software (Figure 4). Chlorophyll-a, Salinity and Current are used to determine PHI. Next, overlay the PHI for skipjack tuna with a value range of 0.00 – 1.00, where the higher the value, the greater the chance of the presence of skipjack tuna in the area. PHI in September 2022 – June 2023 will be in the range of 0.06 – 1.00. The area colored red is considered to be the area that best suits the environmental preferences of skipjack tuna and is therefore indicated as a potential habitat area. As in Figure 4, it is known that the catch point is in accordance with the predicted potential fishing zone. This happens because the equipment operation time is in accordance with the skipjack tuna fishing season and the point corresponds to the area favored by skipjack tuna in Barru Regency.

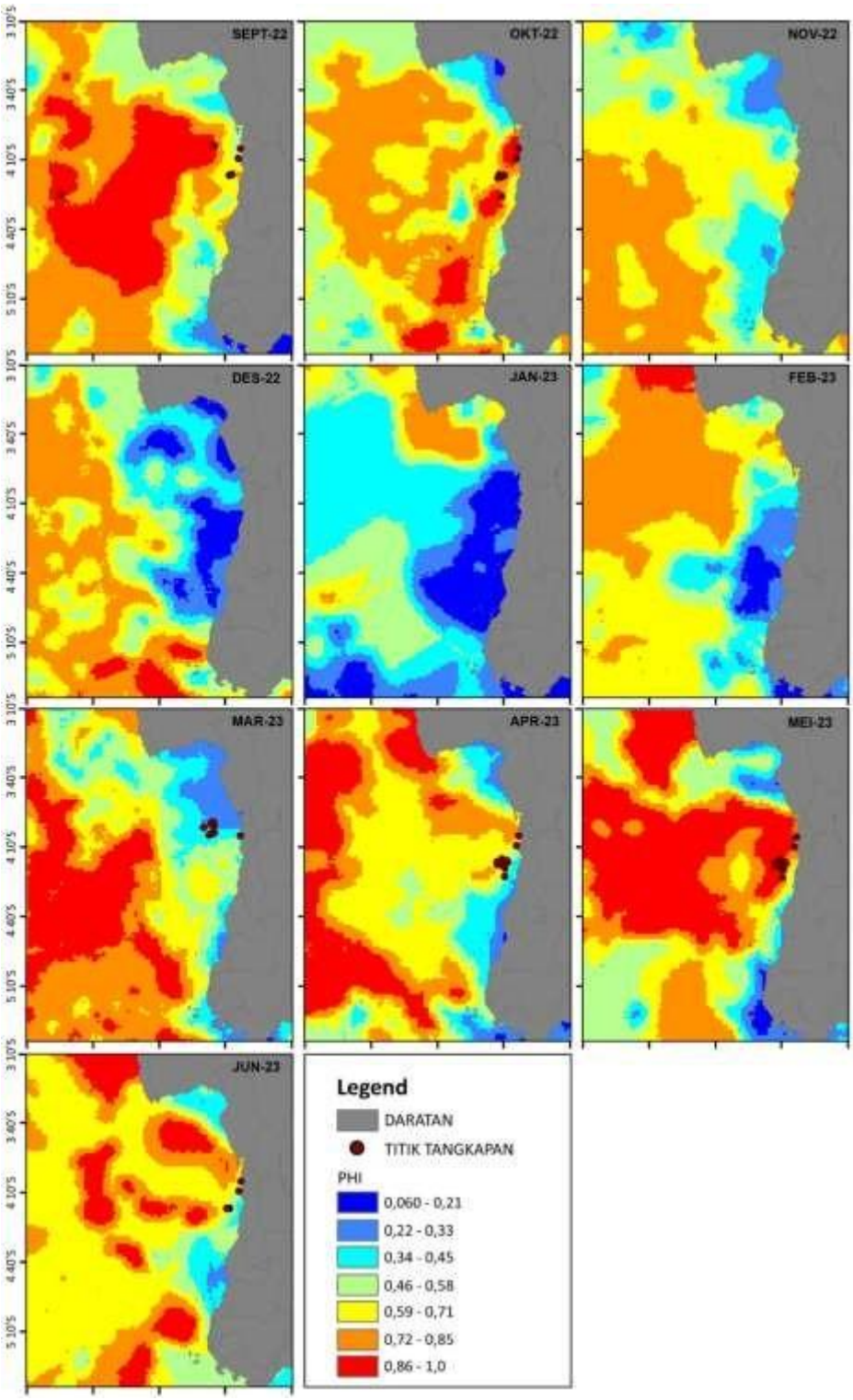

Figure 4. PHI of Skipjack in the September 2022 – June 2023 Catching Season in the Makassar Strait

The spatial and temporal map (Figure 4) shows that the peak season for skipjack tuna in the Makassar Strait is September 2022 and May 2023. Meanwhile, in December 2022 and January 2023, the abundance of skipjack tuna may be the lowest compared to the previous month. In research, Zainuddin et al., (2017) stated that the peak catch of skipjack tuna in the Makassar Strait was in May.

Feasibility of Potential Zones for Skipjack Fishing

The feasibility of the skipjack tuna zone is determined based on measuring the length of the fish and the location of the catch point within the ZPPI location. The reliability test in this research was carried out by calculating inter-rater reliability (Kappa coefficient) to see measurement consistency. Table 3 shows the measurement consistency. It can be seen that 305 variables (catch points) were assessed, there were 103 points that did not enter the zone, 202 were within the zone. There were 141 fish measuring <50 cm, 164 fish measuring > 50cm. The results also show 140 fishing locations that are suitable for fishing operations.

Table 3. P. Fish Size* P. ZPPI Crosstabulation

		P. ZPPI		Total
		0	1	
P. Fish Size	0	79	62	141
	1	24	140	164
Total		103	202	305

Based on the results of the KAPPA analysis (Table 4), it can be seen that the inter-rater reliability coefficient (kappa) is 0.422. Based on Table 1, the Kappa coefficient can be interpreted in the good category because the Kappa coefficient k>0.4. This means that the reliability of the agriment between the two gauges is good. So, based on the results of the analysis, it is stated that the ZPPI of skipjack tuna is good/worth catching.

Table 4. KAPPA coefficient

	Value	Asymp. Std. Eror	Approx. T[b]	Approx. Sig.
Measure of Agreement Kappa	.422	.051	7.621	.000
N of Valid Cases	305			

Differences in the size of the catch are influenced by the season and the fishing gear used, as in research by Mallawa et al., (2016) which states that the size of skipjack tuna suitable for catching according to season and purse seine fishing gear is still very low in the Makassar Strait. This is because purse seine fishing gear operates around FADs, where the use of FADs causes an increase in the number of young and unsuitable skipjack tuna in the catch (Mallawa, 2020)..

4. Conclusion

Chl-a, salinity, and current speed have a greater influence than the SST parameter. This is thought to be influenced by the catches of skipjack tuna obtained during the research from purse seine vessels that use FADs in their fishing activities. The overall catch of skipjack tuna was carried out in the SST concentration range of 29.52 – 31.6 °C, chl-a in the range of 0.13 – 0.93 mg/m3, salinity in the range of 31 – 34.6 ppt, current speed in the range of 0.07 – 0.37 m/s.

The PHI spatial and temporal map shows that the peak season for skipjack tuna in the Makassar Strait is September 2022 and May 2023. Meanwhile, in December 2022 and January 2023 the abundance of skipjack tuna may be the lowest compared to the previous month. With the catch point being in accordance with the predicted potential fishing zone.

The inter-rater reliability coefficient (kappa) is 0.422. The kappa coefficient can be interpreted in the good category because the kappa coefficient value k>0.4. This means that the reliability of the agriment between the two gauges is good. So, based on the results of the analysis, it is stated that the ZPPI of skipjack tuna in Barru waters, Makassar Strait is good/fit for fishing.

Suggestion

Based on the research that has been carried out regarding the feasibility of potential zones for catching skipjack tuna, it is better to add other measurement parameters to accurately test the fishing locations that have been carried out during this research

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