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ON THE RELATIONSHIP BETWEEN AREA OF UPWELLING AND POTENTIAL FISHING ZONE IN MAKASSAR STRAIT

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ABSTRACT

This study aims to describe the relationship between the upwelling area and the ZPPI area of skipjack tuna using the Generalized Additive Model (GAM) method and to map out the distribution pattern of skipjack in Barru waters, Makassar Strait. The research was conducted in November and December 2020, located in Barru waters, Makassar Strait. The research method used two methods by collecting primary data in the form of catches by following the purse seine fishing operation in Barru and secondary data in the form of satellite imagery data on sea surface temperature and chlorophyll-a. The data were analyzed using the GAM and upwelling area analysis. The upwelling area was obtained from the combination of the referred values of the two parameters. The results showed that sea surface temperature parameters had a significant effect on the catch of skipjack tuna with favored range of 28.5 - 29.7 ^{o}C. Preferred chlorophyll-a ranged from 0.15 to 0.23 mg m^{-3}. We found that the upwelling event in the Flores sea does not have a direct effect on the distribution pattern of skipjack tuna, there is probably a time lag required after upwelling in which in turn has an impact on the distribution of skipjack tuna in the southern Malassar Strait.

Keywords: skipjack distribution, Makassar Strait, upwelling area, Flores Sea, potential fishing zone area

INTRODUCTION

The Makassar Strait is included in the WPP-RI 713 area, has the potential for large pelagic fish resources of 193,600 tons per year including skipjack tuna (Amir et al., 2018). According to Oktari et.al (2019), the Makassar Strait includes highly productive waters, high rainfall in the west monsoon increases fertility in the waters due to flow from the mainland of Kalimantan and Sulawesi. In addition, several locations in the waters of the Makassar Strait experienced an increase in water mass (upwelling) in the east monsoon.

According to Amir and Achmar (2015) skipjack (*Katsuwonus pelamis*) has high economic value which is mostly exploited by small and medium fishermen. The total production of skipjack tuna in Barru Regency in 2015 – 2019 was 6,298.6 tons (DKP Sul-Sel Province, 2019). Statistical data from South Sulawesi DKP for 2019, shows that the total production of skipjack in Barru waters from 2015 - 2019 decreased, namely 2,043.6 tons, down to 1,132.2 tons. This 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 about fishing areas.

In general, many fishermen are constrained in the process of catching fish, especially in determining the season and fishing area. Fishermen in Barru Regency still rely on traditional methods when determining fishing areas. The ripples of birds above sea level is a sign that is often used by fishermen. As a result of information related to fishing areas that are still lacking, the fishing process takes a lot of fuel and time but with less than optimal catches. Uncertain climate change makes determining fishing areas more difficult for fishermen (Fauzan et al., 2018).

The distribution and abundance of biological resources in a waters cannot be separated from the conditions and variations of oceanographic parameters. Fluctuations in environmental conditions have a significant influence on the seasonal migration period, as well as the presence of fish in a waters (Cahya, 2016). Utilization of information systems in determining fishing areas is one effective way. Efforts to predict fishing areas are carried out by approaching oceanographic parameters, especially sea surface temperature and chlorophyll-a (Harahap et al., 2019). Remotely sensed data on sea surface temperature and chlorophyll-a concentrations can be used to determine upwelling areas (Anom et al., 2017).

The abundance of chlorophyll-a in the waters indicates the high productivity of the waters and the abundance of food sources for large pelagic fish such as skipjack tuna. Research related to skipjack tuna in Barru Waters is still rarely done. Potential fishing zone (PFZ) detection of skipjack tuna in the Makassar Strait can be done by using the SST and Chl-a variables (Putri et al., 2021).

Several studies such as Mallawa et al. (2016) regarding the aspect of skipjack fish fisheries. Amir and Mallawa (2015) examined the assessment of skipjack tuna stocks. Based on this description, research on the relationship between upwelling area and PFZ area needs to be carried out as a reference in determining the area and season for skipjack fishing by fishermen and also as a reference for further research.

MATERIALS AND METHODS

This research was conducted for 2 (two) months, from November to December 2020. The fishing base is located in Siddo Village, Kec. Soppeng Riaja, Kab. Barru. Primary data collection was carried out by following the operation of the purse seine ship. The data collected are the point of capture, temperature data measured using a thermometer and the catch/hauling and secondary data obtained from NASA Ocean Color in the form of image data of sea surface temperature and chlorophyll-a. Sea Surface Temperature image data and chlorophyll-a image data were obtained from NASA Ocean Color (https://oceancolor.gsfc.nasa.gov/). The data used is monthly data in November and December 2020.

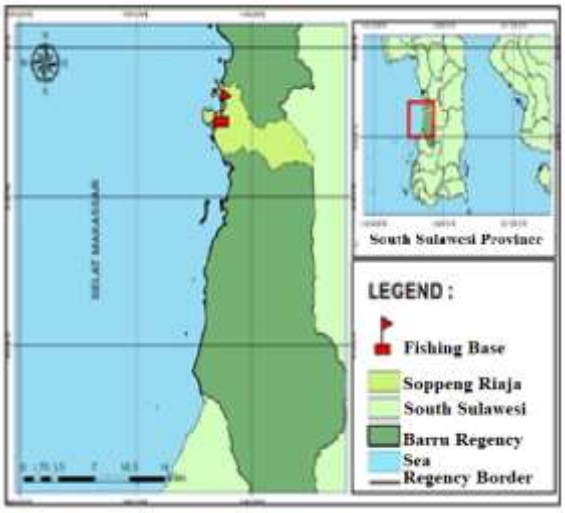

Figure 1. Map of study area with fishing base at Siddo, Soppeng Riaja, Barru District

Determination of Upwelling Area

Upwelling was determined based on the overlay of SST and chlorophyll-a data. The upwelling area has a temperature indicator <28 0C and a chlorophyll-a concentration > 0.35 mg/m3. The upwelling area is obtained by combining the two parameters modified from Anom et al. (2017).

Generalized Additive Model (GAM)

The oceanographic parameter data obtained will be further tested using the GAM method. The selection of the GAM model was carried out to estimate how the variables were related to the abundance of skipjack tuna.

The linear model in this study is based on the nature of the relationship between CPUE (tail/hauling) as the SST response variable and chlorophyll-a as a predictor variable generated by GAM.

$$skipjackgam = \propto + gam\,(cpue \sim s\,(sst) + s(chl), data = data) + \varepsilon$$

Where;

cpue: catch/hauling, α: konstanta, s(.): *smoothing spline* function from predictor variables (SST and Chl-a), data=data, and ε : standard error.

RESULTS AND DISCUSSION

Purse Seine Operating Method

Fishing operations started from a trip to an area that has a lot of fish based on the experience of fishermen, during the trip the crew will be at the bow of the ship and some will stand on the mast of the ship to see fish schools from a distance. The signs of the presence of schools of fish seen by fishermen are the ripples of birds above the sea surface, the presence of foam that appears and fish jumping on the surface of the sea. Purse seine operation is divided into 3 stages, namely setting, pursing and hauling.

When the school of fish has been found, setting or lowering the net will be carried out where at this stage the crew have their respective roles. Pursing or pulling the corrugated rope is done immediately when the setting is complete. Pulling the corrugated rope aims to avoid the horizontal escape of fish by making a bowl-shaped net. The corrugation rope is pulled using a roller machine by 2 people while the weight lifting is carried out by 4-5 people using wooden blocks.

Relationship of Oceanographic Parameters to Skipjack Catches

Skipjack tuna can be caught all year round, but the amount of catch varies from season to season. According to Nurdin (2017) the fishing season for skipjack tuna takes place during the transitional season II, namely September as the peak season and in December. Ilhamdi (2016) found the same results where June to December included skipjack catching season. Based on the results of the research that has been carried out, it was recorded that the total catch was 5,540 fish. In November the catch of skipjack tuna obtained was 2,072 fish and in December the catch was 3,468 fish.

Tabel. 1 Summary results of GAM analysis

	Edf	Ref.df	F	p-value
s(SST)	6.221	7.388	4.564	0.000161 ***
s(Chl)	5.626	6.796	1.432	0.211133
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1				

Table 1 shows that from the analysis of oceanographic parameters of sea surface temperature and chlorophyll-a using the GAM method, it was found that the p-value of sea surface temperature was smaller which indicated that sea surface temperature had an effect on skipjack catch. The p-value of chlorophyll-a shows a different value from sea surface temperature where the significant value is greater so that it can be said that chlorophyll-a has no significant effect on catches. According to (Putri et al., 2018; Sarianto et al., 2018) an increase in chlorophyll-a in waters is not always accompanied by an increase in fish catches, there is a

time lag required before chlorophyll-a affects fish, this is due to the formation of the food chain.

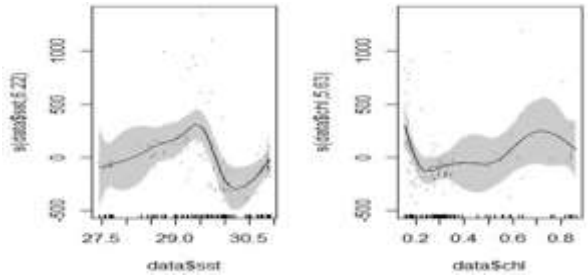

Figure 2. Trend of catch distribution in relation to SST (left) and chl-a (right).

Figure 2 shows the distribution of catches based on both oceanographic parameters of sea surface temperature and chlorophyll-a during november and december 2020 using the gam (general additive model) aic test analysis with 95% confidence intervals indicated by gray shadows. It is known that at a temperature of 28.5 – 29.7°c based on the gam test results, it is the sea surface temperature favored by skipjack tuna.

The results of research conducted by amir et al., (2018) showed similar things where skipjack fish were caught in a temperature range of 28.18 – 30.89°c as well as safruddin et al., (2018) also found a temperature range of 28 - 31°c which indicates that skipjack tuna tend to be in relatively warm waters. While the concentration of chlorophyll-a in the range of 0.15-0.23 mg/m^{-3}. Pratiwi (2018) with analysis of the gam model shows that the range of chlorophyll-a concentrations favored by skipjack tuna ranges from 0.20 -0.35 mg/m^{-3}

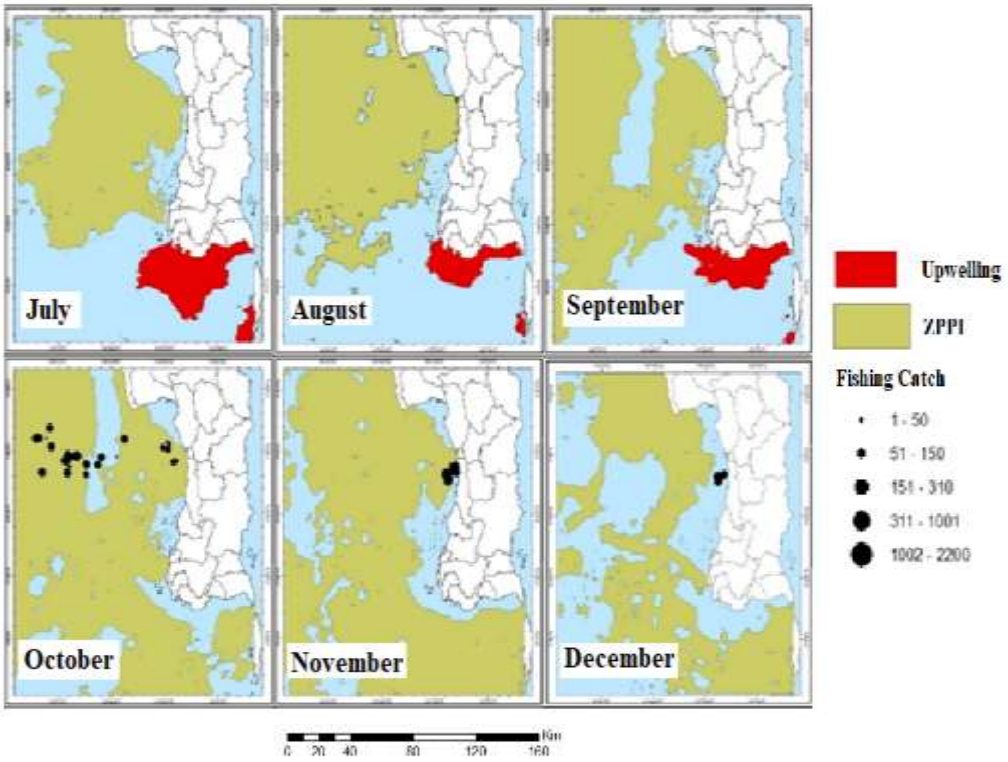

Figure 3. Upwelling area and potential fishing zone (PFZ) distribution from July to December

Relationship Between Upwelling Area and ZPPI Area

Upwelling is an increase in the mass of surface water when there is a vacuum due to continuous wind-driven encouragement (Ika et al., 2017), characterized by cooler sea surface temperatures compared to its surroundings and higher chlorophyll-a compared to its surroundings. The upwelling area is obtained by overlaying the two oceanographic parameters of sea surface temperature and chlorophyll-a concentration. The map resulting from the overlay of the two

oceanographic parameter images will later be combined and produce a new map that provides specific information regarding the upwelling area.

Figure 3 shows the upwelling formed around the southern Makassar Strait which lasted from July - September and no more upwelling was found in these waters in October - December. Based on the results of overlay data, it is known that upwelling takes place from July to September and ends in October. The results of research conducted by Kurniawan (2018) found the same thing where upwelling occurred in the east season, namely June - August and September as the beginning of the second transition season, and it was estimated that October was the end of the upwelling.

In the upwelling period from July to September, there was no distribution of skipjack tuna around the waters where upwelling occurred, considering that during upwelling the sea surface temperature was lower and in October – December it could be seen that the

distribution of skipjack tuna was found in the southern waters of the Makassar Strait. sea surface temperature gradually warms. This shows that there is a tendency for fish to be in a condition that suits their needs.

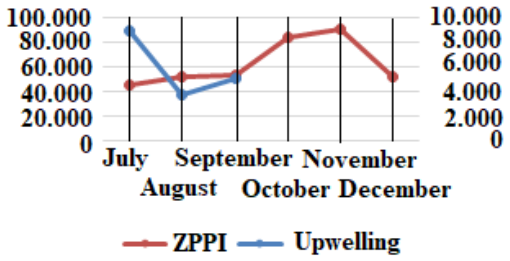

Figure 4. Histogram graph of upwelling area (blue line) and PFZ/ ZPPI area (red line) from July to December).

According to Putri et al. (2018) Skipjack tuna tend to migrate when there is a change in their environment and towards suitable waters. The greater the upwelling area, the lower the PFZ distribution of skipjack tuna. An increase in the distribution area of PFZ at the end of the upwelling period was due to the condition of the water temperature gradually warming which caused skipjack tuna to be found in these waters, this is in accordance with the statement (Zainuddin and Farhum, 2010; Zainuddin et al., 2013) that the distribution and abundance of skipjack tuna is in the range of sea surface temperatures which tend to be warm.

Based on the research results displayed in the form of map layouts and histogram graphs, it can be seen that upwelling does not directly affect the distribution of skipjack tuna.

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There is a time lag from the formation of upwelling in July – September to the discovery of the distribution of skipjack tuna in waters where upwelling occurs, namely in October and November. The same thing was found by Raditya (2013) that the extent of upwelling does not directly affect the catch, it takes a time lag of about 1-2 months from upwelling to the peak of the catch. Other researchers also stated that it takes a lag of about 2 to 3 months before the increase in chlorophyll-a and nutrients during upwelling affects the catch of sardinella/ lemuru (Rintaka, 2015).

CONCLUSIONS

Based on the objectives of the study, it can be concluded that: Upwelling has no direct effect on increasing the area of skipjack tuna PFZ. Skipjack tuna tends to be at optimum conditions for both sea surface temperature parameters and chlorophyll-a, it takes a time lag for the formation of a food chain before the area becomes a food source for skipjack tuna.

The results of the overlay map of the upwelling area with the distribution of skipjack tuna shows that the movement of fish distribution from July to December moves towards the south of the Makassar Strait and is almost found in all waters of the Makassar Strait.

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