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Potential big eye tuna (*Thunnus obesus*) fishing zone in western Sumatra Sea, Indonesia based on Sub-surface Temperature

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Abstract
Tuna is a large pelagic fish that has high economic value, so knowledge of the potential bigeye tuna fishing zone is needed to facilitate fishermen in conducting tuna fishing operations. This study was conducted using bigeye tuna catch logbook data from 2022-2023 obtained from Bungus Fishing Port, Padang, Indonesia. Sub-surface temperature data was obtained from global modeling data conducted by CMEMS at depths of 77m, 100m, and 130m. The results of potential bigeye tuna fishing zones in the Western Waters of Sumatra, Indonesia based on sub-surface temperature using the ECDF method found that in the east season, bigeye tuna has an optimum temperature in the range of 26.9-30^{O}C at 77m depth, while the west season has an optimum temperature in the range of 15.7-27.6^{O}C at 109m depth. The algorithm used in spatial modeling of potential bigeye tuna fishing zones in the east season is y = -0.0134x2 + 0.7688x - 10.968 and the west season is y = -0.0031x2 + 0.1332x - 1.3354.

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Keywords: Bigeye tuna, sub-surface temperature, potential fishing zone

Introduction

Indonesia's geographical location directly facing two oceans, namely the Indian Ocean and the Pacific Ocean, makes Indonesia have a large potential tuna resource because Indonesia is a body of water that is passed by the tuna route. Tuna in Indonesia is spread from western to eastern regions. (Firdaus, 2018) [6]. Tuna is a large pelagic fish that has a high economic value so tuna management is carried out by regional and international institutions or organizations. Tuna management in Western Sumatra Waters is part of the IOTC (the Indian Ocean Tuna Commision) area of competence (Nikijuluw, 2009) [10]. Tuna obtained from the Indian Ocean, especially the Western Sumatra Sea, is landed at the Bungus Fishing Port which is the Tuna Center in the western region of Indonesia (MMAF, 2018).

Tuna is a large pelagic fish that has high economic value. Tuna is considered an important marine fishery resource in tropical and temperate waters at coordinates 45o North and South of the Equator (Collete and Nauen, 1983). The genus *Thunnus* has different endothermic specializations divided into two subgroups, namely the group with warm water endotherms (Neothunnus) and the group with cold water endotherms (Bluefin group). (Block *et al*. 1997) [3] said that yellowfin tuna and bigeye tuna belong to the warm water group (Block *et al*. 1997) [3], therefore they are generally more frequent right at the top of the thermocline. This study focuses on the bigeye tuna species (*Thunnus obesus*).

(Hartoko, 2010) [7] said that tuna is a poikilothermic fish where its body temperature is influenced by the temperature of the surrounding waters so it must adapt to the temperature of its environment or look for waters with a suitable temperature range. Temperature is an important oceanographic parameter to determine the potential tuna fishing zone. Based on previous research, *T. obesus* in the southern waters of Java was found at a depth of about 150m with an optimum temperature of 16-21^{O}C (Sukresno *et al*. 2015).

(Hartoko, 2010) [7] said that in the southern waters of Java in the eastern season, bigeye tuna were dominantly caught at a depth of 100-280m and a temperature of 18-25°C. Research on bigeye tuna in Western Sumatra Waters using sub-surface temperature is very rarely done, therefore this study aims to see the potential zone of bigeye tuna fishing in Western Sumatra Waters based on sub-surface temperature.

Research Location

This study was conducted at Bungus Fishing Port, Padang, Indonesia, in April-May 2023.

Methodology

This study used bigeye tuna fishing logbook data from 2022-2023 representing the west and east seasons and temperature data derived from Copernicus Marine Environment Monitoring Service (CMEMS) global modeling at 77m, 109m, and 130m depths. Both data were used to create the spatial database.

Temperature data was extracted and interpolated using ArcMap 10.8 which was then overlaid with logbook data to determine the catch of bigeye tuna and water temperature at a fishing point.

Data Analysis

The results of the extraction and interpolation were then analyzed using the Empirical Cumulative Distribution Function method based on hook rate analysis, hookrate generally uses the number of eyes, but the fishing gear used is handline, so the number of fishing eyes is replaced by the length of time fishing. The hook rate equation according to (Nasution 1993 in Amirullah *et al*. 2014) [1].

$$HRi = \frac{I}{H} \times 100\%$$

Description:
HRi: hook rate
I: weight or fish caught
H: length of fishing time

The ECDF method is analyzed using the equation (Andrade and Garcia, 1999 in Zainuddin, 2011) [14].

$$f(t) = \frac{1}{n} \times \sum l(xi) \quad (1)$$

$$l(xi) = 1 \ if \ xi \leq t, 0 \ otherwise$$
$$g(t) = \frac{1}{n} \times \left(\sum (yi/\bar{y}) \times l(xi)\right) \quad (2)$$

$$D(t) = max\,|f(t) - g(t) \quad (3)$$

Description
F (T): cumulative frequency empirical distribution function
T: depth
N: number of fishing trips
L (11): indication function. xi: value of sub-surface temperature extracted from the fishing point
G (T): cumulative distribution function of weighted catches
YI: hook rate of each point
D (T): absolute value of the difference between f(t) and g(t)

Spatial modeling is done by using the highest coefficient of determination (R2) value from the polynomial regression analysis of the D (t) value. Hartoko (2022) [7] used the highest R^2 value to determine the spatial distribution of tuna.

Results

The division of the fishing season into two seasons is based on (Supari *et al*. 2017) [13]. The east season consists of May to October 2022 and the west season consists of November to April 2023. The spatial model of bigeye tuna used the algorithm with the highest R^2 value resulting from polynomial regression using data analyzed using the ECDF method between 77m, 109m, and 130m depth. The east season polynomial regression results obtained an R^2 value of 0.5004 at 77m depth, and the algorithm obtained was $y = -0.0134x^2 + 0.7688x - 10.968$. The west season polynomial regression results get an R^2 value of 0.7627 at a depth of 109m, and the algorithm obtained is $y = -0.0031x^2 + 0.1332x - 1.3354$. The results of polynomial regression in the east and west seasons are presented in Figure 1 and Figure 2.

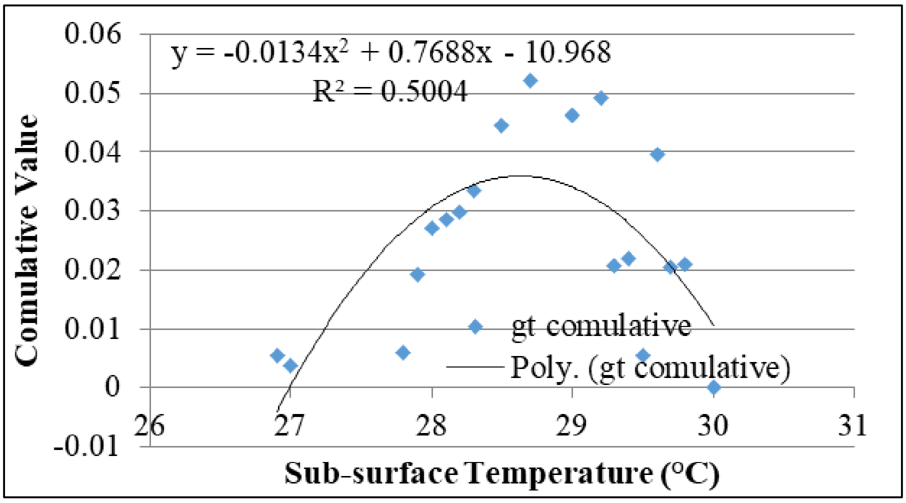

Fig 1: Polynomial Regression Results for East Season 2022

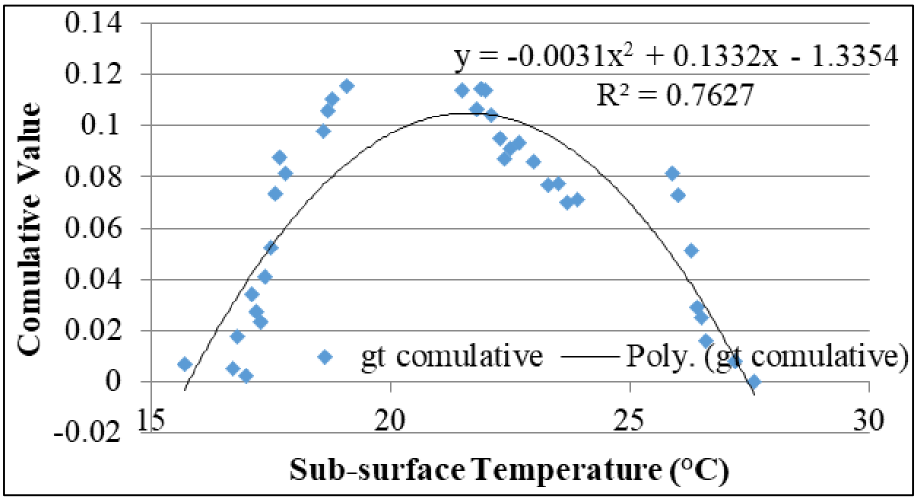

Fig 2: Polynomial Regression Results for West Season 2022-2023

Bigeye tuna in the Western Sumatra Sea in the east season at 77m depth has an optimum temperature value in the range of 26.9-30^{O}C. Bigeye tuna in the west season in the Western Sumatra Sea has an optimum temperature in the range of 15.7-27.6^{O}C. This can occur because bigeye tuna is a tuna that is generally in the thermocline region so it is at a depth that is not too low.

(Barata *et al*. 2011) [2] reported that bigeye tuna were caught at a depth range of 92.23-470.12m with temperatures between 18.35-26.80^{O}C. (Kusmedy *et al*. 2020) [9] showed that the swimming depth of bigeye tuna was at a depth of 41-327.48m. Based on research (Nurdin, 2017) [11] large tuna tend to be in a position deeper than 100m below the sea surface.

The equation generated from the regression is then used as an algorithm in determining the potential zones of bigeye tuna fishing in the Western Sumatra Sea. Maps of the results of the application of spatial models to determine the potential zones of bigeye tuna fishing are presented in Figure 4 for the east season and Figure 5 for the west season.

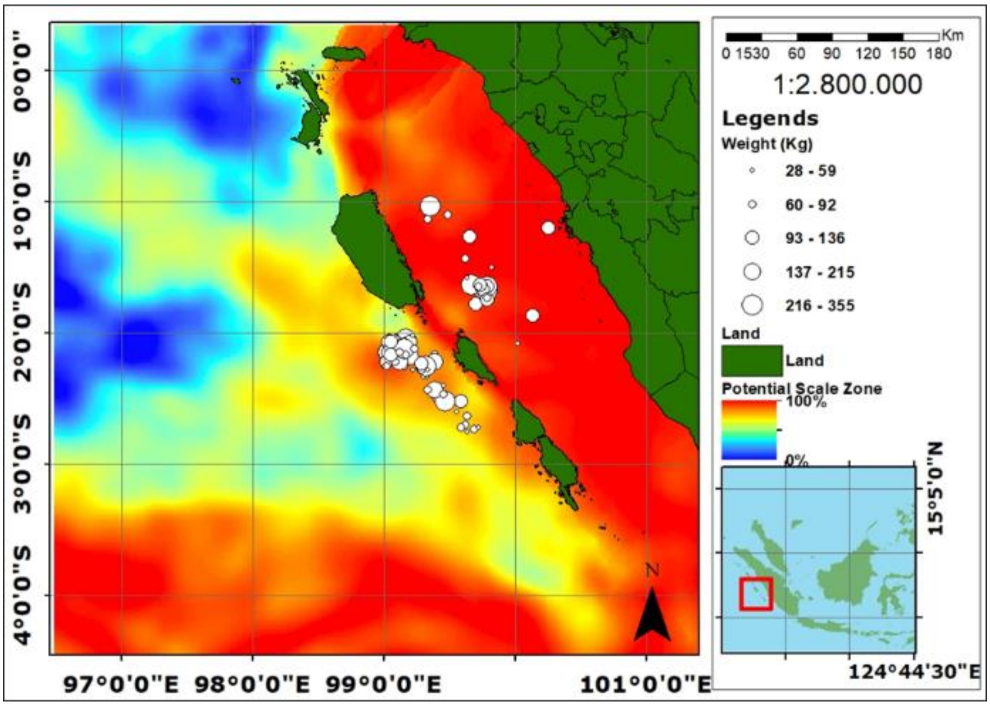

Fig 3: Map of the 2022 East Season Bigeye Tuna Fishing Potential Zones

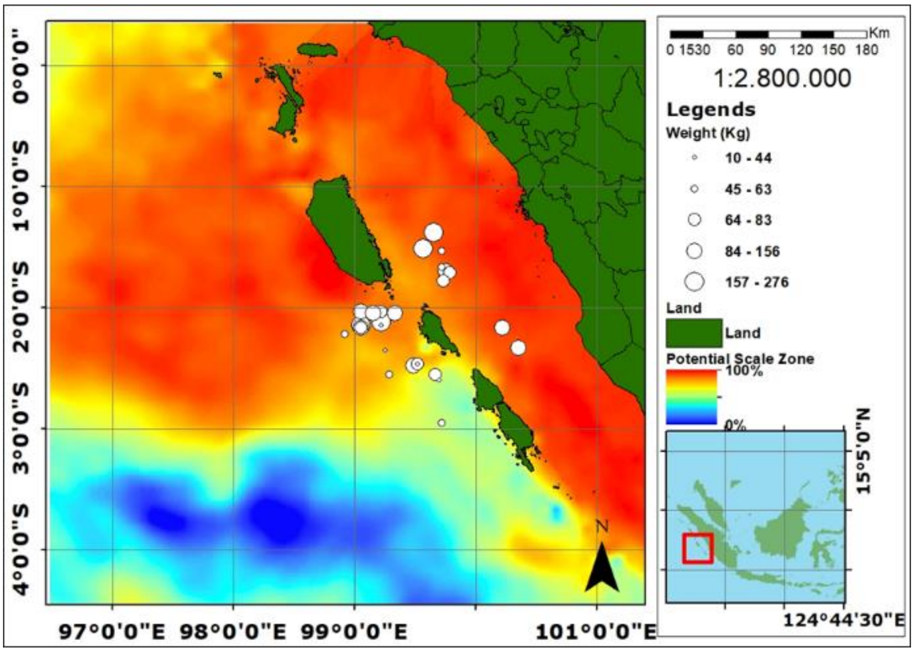

Fig 4: Map of Potential Fishing Zones for Bigeye Tuna Western Season 2022-2023

The catch of bigeye tuna in the Western Sumatra Sea is much less when compared to yellowfin tuna, this can be due to limited fishing gear and fishing line length. Based on the results of fishermen's interviews, bigeye tuna is only caught during the full moon. This can be reinforced by the statement (Dewi *et al*. 2020) [5] that tuna, which are predators that are positive phototaxis, need light to find food, therefore at night, the tuna will rise to the surface 0-100m to look for food. Thus, during the full moon, the light entering the waters will be brighter than the crescent moon.

The results of the bigeye tuna potential fishing zone map in Figure 4 and Figure 5 show that the red color shown on the map indicates a higher potential fishing scale when compared to the blue color. It can be seen that in the east season, the bigeye tuna fishing potential zone is in the east region after the 98^{O}E coordinate. The fishing potential in the western season is in the northern region with coordinates above 3^{OS}.

Based on the catch data obtained from the fishermen's logbook, it can be seen that fishermen only catch in the area around Mentawai Island. This is due to the limited vessels used by fishermen. Tuna fishermen in the Western Sumatra Waters generally use vessels with a size of less than 30 GT, so that these vessels cannot support fishermen to catch in more distant areas.

Kesimpulan

The results of potential bigeye tuna fishing zones in the Western Sumatra Sea, Indonesia based on sub-surface temperature using the ECDF method found that in the east season, bigeye tuna has an optimum temperature in the range of 26.9-30^{O}C at 77m depth, while the west season has an optimum temperature in the range of 15.7-27.6^{O}C at 109m depth. The algorithm used in the spatial modeling of the potential bigeye tuna fishing zone in the east season is $y = -0.0134x^2 + 0.7688x - 10.968$ and the west season is $y = -0.0031x^2 + 0.1332x - 1.3354$.

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