

PAPER • OPEN ACCESS

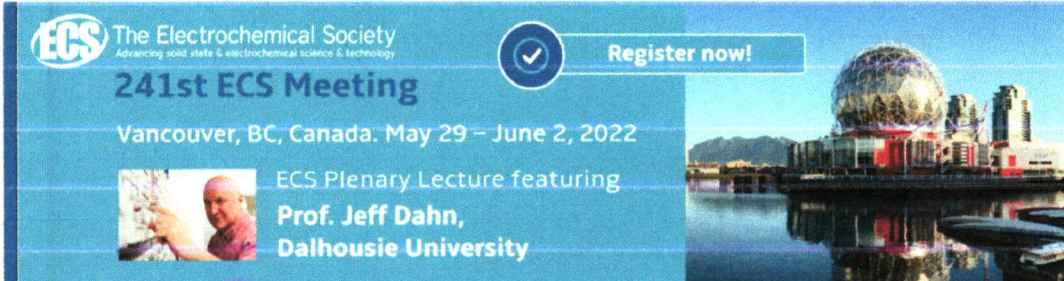
The distribution of yellowfin tuna based on sea surface temperature and water depth parameters in the Bone Gulf, Indonesia

To cite this article: Safruddin *et al* 2020 *IOP Conf. Ser.: Earth Environ. Sci.* **564** 012064

View the [article online](#) for updates and enhancements.

You may also like

- [Comparison of the catch of two fishing technologies for yellowfin tuna \(*Thunnus albacares* Bonnatere 1788\) in Bone Bay waters, South Sulawesi, Indonesia](#)
A Mallawa, F Amir and I Halid
- [Tunabot Flex, a tuna-inspired robot with body flexibility improves high-performance swimming](#)
Carl H White, George V Lauder and Hilary Bart-Smith
- [Application of remotely sensed data and maximum entropy model in detecting potential fishing zones of Yellowfin tuna \(*Thunnus albacares*\) in the eastern Indian Ocean off Sumatera](#)
Achmad Fachruddin Syah, Emma Suri Yanti Siregar, Vincetius P Siregar *et al.*



The Electrochemical Society
Advancing solid state & electrochemical science & technology

241st ECS Meeting

Vancouver, BC, Canada: May 29 – June 2, 2022

ECS Plenary Lecture featuring
Prof. Jeff Dahn,
Dalhousie University

Register now!

The banner features the ECS logo, a 'Register now!' button with a checkmark, and a photograph of Prof. Jeff Dahn. The background of the banner shows a cityscape with a large spherical building, likely the Science World in Vancouver.

The distribution of yellowfin tuna based on sea surface temperature and water depth parameters in the Bone Gulf, Indonesia

Safruddin¹, Rachmat Hidayat¹, Yashinta Kumala Dewi², Moh. Tauhid Omar¹, St. Aisjah Farhum¹, Achmar Mallawa¹, and Mukti Zainuddin¹

¹ Department of Fisheries, Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar 90245, Indonesia

² Department of Regional and City Planning, Engineering Faculty, Hasanuddin University, Makassar 90245, Indonesia

Email: safruddin@fisheries.unhas.ac.id

Abstract. This study aimed to visualize the distribution of yellowfin tuna *Thunnus albacores* in Bone Gulf, Indonesia. Yellowfin tuna is among the most important large pelagic fish species caught by local fishermen using pole and line gear. This study is a preliminary process in identifying suitable habitat for yellowfin tuna using Sea Surface Temperature (SST) and water depth parameters. It used oceanographic and fishery data from satellite remote sensing of Geographic Information System (GIS). The SST data was gained from Terra/MODIS. The waters depth data was gained from the ETOPO2 satellite database, whereas some points were later confirmed through the Echo sounder record. The experimental fishing was conducted from May to 2019. The result showed that the yellowfin tuna distributions were relatively higher in 30.0 to 31.0 °C SST and 500 to 1,000 m water depth. Both of the parameters analyzed in this study played an important role in the distribution. The numbers represented preferences in defining the optimal habitat of the yellowfin tuna, especially in the study area. This information could be useful to predict the potential fishing zones where yellowfin tuna would be distributed in abundance.

1. Introduction

Marine fisheries sustainable management concepts in Indonesia applied as known as Indonesian Fisheries Management Areas (IFMA). The IFMA had been divided into 11 fisheries management areas based on the characteristics of the fish resources and its environment, including the Makassar Sea, Flores Sea, Bali Sea, and Bone Gulf are known as is IFMA 713. Large pelagic fish such as skipjack tuna, yellowfin tuna, and little tuna is an important species targeting local commercial fisheries in FMA 713 [1] as showed in Figure 1.

The Gulf of Bone, one of the potential areas for the utilization of large pelagic fish in the Sulawesi corridor region, is a strategic asset to be developed on the basis of economic activities for the purpose of the prosperity of coastal communities and increasing the acquisition of regional original income. Large pelagic fish resources as a commodity that has high economic value and has a wide market share, the use of large pelagic fish has played a role in the development of the Indonesian economy. This fish resource has the potential to be utilized in the Bone Gulf area because it is thought to be a major pelagic



Content from this work may be used under the terms of the Creative Commons Attribution 3.0 licence. Any further distribution of this work must maintain attribution to the author(s) and the title of the work, journal citation and DOI.

Published under licence by IOP Publishing Ltd

fish migration area (Figure 1). However, the distribution and abundance of large pelagic fish such as tuna species in the Gulf of Bone water strongly influenced by changes in oceanographic conditions (i.e., sea surface temperature and water depth) both in spatial and temporal.

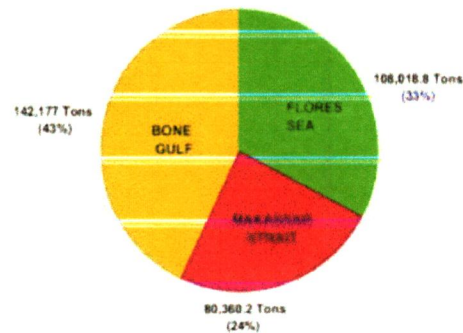


Figure 1. The Production of large Pelagic Fish in Indonesian Fisheries Management Area 713, South Sulawesi Province.

Based on Figure 1. The Gulf of Bone is mainly large pelagic fish production in IFMA 713, South Sulawesi Province, around 143,177 tons or 43% if compare in three fishing ground potential areas [2]. To increase the productivity of tuna fisheries in the waters of Bone Gulf, it is necessary to determine the potential areas for a fishing ground candidate in spatially and temporally. Determination of tuna fishing areas accurately can be done by making forecasting, namely utilizing the biological characteristics of the fish concerning the oceanographic conditions of water such as temperature, depth, chlorophyll-a, frontal zone, upwelling, and so on [3–5]. At present, the opportunity to utilize oceanographic satellite imagery data is wide open, and combining it with field data (in-situ) is very useful especially to assess relatively large areas of potential capture quickly.

The results of the statistical analysis of the two data (searching for optimum habitat) can then be visualized systematically and in detail (containing various levels of information) in the form of a thematic map constructed using geographic information systems (GIS) techniques. Thus various information integrated into the thematic map is expected to greatly assist fishermen in finding potential areas to catch tuna. Identification of potential fishing areas using remote sensing technology is a way of indirect identification. From remote sensing data, observations are made, for example, on sea surface temperature, and the estimated depth of water. The results of these observations are outlined in the form of a contour map so that it can be estimated the fertility level of a water location or the suitability of water conditions with habitats preferred by the schooling of fish such as tuna [1,6]. Yellowfin tuna (*Thunnus albacores*) is an iconic species in the Gulf of Bone, local availability of yellowfin tuna is a key economic, yet a little information about this tuna distribution in spatially and temporally. This study aims to identify the distribution of sea surface temperature and water depth preferred by yellowfin tuna in the Bone Gulf based on oceanographic satellite imagery data. Therefore, the information will be used to improving the successful fishing by detecting yellowfin tuna fishing grounds; it is also can be used for tuna fisheries management policies.

2. Research methods

The study was conducted in the Gulf of Bone (3S-5°S) and (120-122E) (Figure 2). The survey method was applied in this study by collecting two types of datasets (primary data and secondary data). Primary data is data from direct observations in the field by following fishing operations (experimental fishing)

using a pole and line with the fishing base at Murante fish landing, South Sulawesi (Figure 2). The primary data includes the number of catches and the geographical position of the yellowfin tuna capture location. Furthermore, secondary data consists of TERRA satellite image data and MODIS (Moderate Resolution Imaging Spectroradiometer) sensor with a spatial resolution of approximately 4 km and monthly temporal resolution (monthly average) from May through August 2019, which are oceanographic sea surface temperature (SST). The bathymetry data was gained from the ETOPO2 satellite database, whereas some points were later confirmed through the Echo sounder record (KODEN CVS 128 B Echo Sounder Type). Other secondary data is the tuna catch production data in the IFMA, South Sulawesi Province. Furthermore, existing datasets are visualized and analyzed using a set of computers equipped with spatial data processing software, including: Matlab version R2016b (9.1.0.441655), R program version 64 bit.3.6.3 [7], SeaWiFS Data Analysis System (SEADAS), and ArcGIS 10.3 (ESRI, USA)

The quantitative relation of yellowfin tuna distribution to changes in SST and depth can be determined by using the latest statistical techniques (Generalized additive model, GAM) with the formula: $g(\mu_i) = \alpha_0 + s_1(\text{SST}) + s_2(\text{depth}) + \epsilon$ (GAM model) where g is link function, μ_i is the expected value of the dependent variable for a number of yellowfin tuna (in individuals), α and β_0 are the models constant, s_n is a smoothing function of the predictor variables, and ϵ is a random error term, β_n is the vector of model coefficients [8].

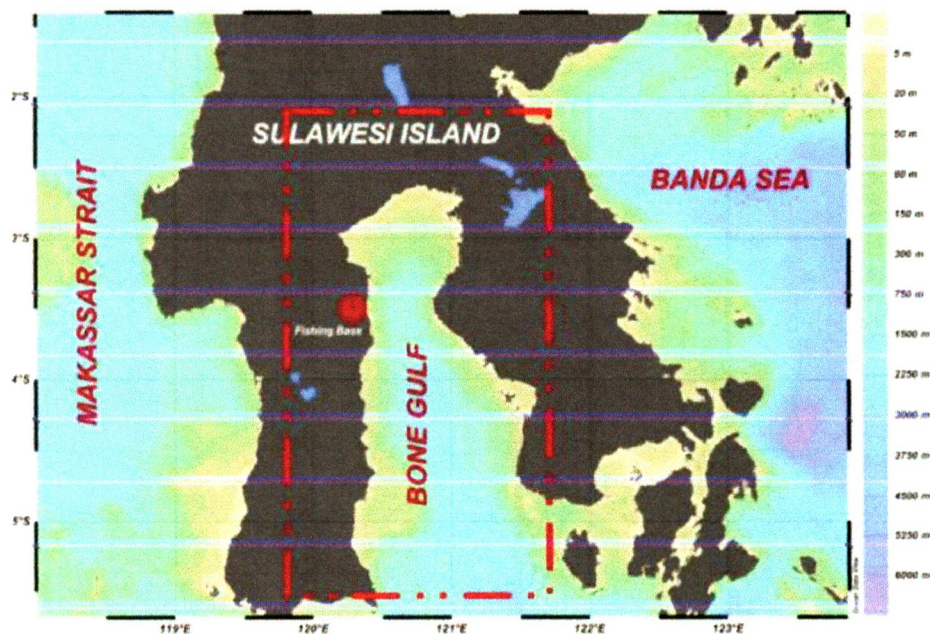


Figure 2. Indonesian Fisheries Management Areas (IFMA) 713. The Area Study in the Gulf of Bone, Indonesia. A bathymetric profile was also shown.

3. Result and Discussion

3.1. Pole and Line Fishery Data

The total catch of yellowfin tuna during fishing operations (77 trips in 4 months) is 1,779 individuals. Yellowfin tuna's catch is in the range of 1 - 28 individuals. The catch of yellowfin tuna from May to

August experienced fluctuations that tended to decrease in August. This trend shows the highest number of catches, namely 881 individuals in July, and the lowest is 220 individuals (August). However, the highest fishing productivity occurred in May (12 individuals/ trip), and the lowest was in August (8 individuals/ trip).

3.2. SST with Fishery data

Each species of fish requires oceanographic conditions that are suitable for its growth and survival. Therefore, understanding oceanographic conditions have a very important role in studying the distribution and abundance of fish resources. This is because each species of fish will always look for the optimum conditions in its environment. Thus, the water temperature and depth change may influence the yellowfin tuna distribution and abundance in the waters column. To verify this phenomenon, the current study provided the horizontal profiles of an oceanographic condition such as SST and water depth in the study area.

Sea surface temperature indicated significant differences among sites of the study area. In Figure 3 showed the satellite images of SST, it can be seen that the distribution of SST in the Gulf of Bone varies in the range from 26 °C to 35 °C, wherein the waters of the Gulf of Bone have a relatively warm SST in May and decreased slowly from June to August. Relatively cold SST distribution was found in August caused by the season changing. These SST profile results were reinforced by the previous findings [9] noted that the horizontal distribution of sea temperatures in Indonesia. The high SST found in northern of Bone Gulf due to the position of the latitude, which is closer to the equator, which has a higher intensity of expansion and also caused the area is shallow waters. The dynamics of the temperature of these waters affect the pattern of movement and distribution of tuna [1,7]. The distribution and abundance of yellowfin tuna are assessed by the temporal change in the SST in the gulf, which is related to seeing the pole and line fishing ground. It is important to note that yellowfin tuna distribution tends to be favored by relatively warm in offshore areas (Figure 3).

Remotely sensed satellite data of SST from May to August 2019 were used identification of SST profiles each month. The result showed that the yellowfin tuna distributions were relatively higher in 29.0 to 30.0 °C SST. Based on the results of research from various references, in general, there are no permanent fishing ground areas for large pelagic fish such as yellowfin tuna; they are always changing and moving to follow the changing in environmental conditions caused by water masses movements, which naturally fish will choose a more suitable habitat [3,5]. This affects the dynamics of the oceanographic condition both horizontally and vertically, which in turn affects the distribution and abundance of fish. Changes and variations in oceanographic factors indicate that the pattern of distribution of fish resources is uneven and also causes an uncertain amount of fish catches. To increase the number of fish catches by taking into account the sustainability of fish resources, it is very important to know the certainty of the existence of fish and the oceanographic condition in yellowfin tuna fishing grounds.

Although fishing operations are carried out in the gulf area, yellowfin tuna fishing grounds are found in offshore waters. Yellowfin tuna fishing grounds based on Figure 5 tend to be permanent, meaning that local fishermen, who are generally traditional fishermen, catch fish in relatively similar fishing areas during the study. This is because fishermen generally catch large pelagic fish using fish aggregating devices (FADs) as an auxiliary fishing tools. [2] explains that large pelagic fish such as skipjack tuna begin to enter the waters of Bone Gulf in March and develop and reach a peak in May. The Large pelagic fishing season occurs from April to September every year.

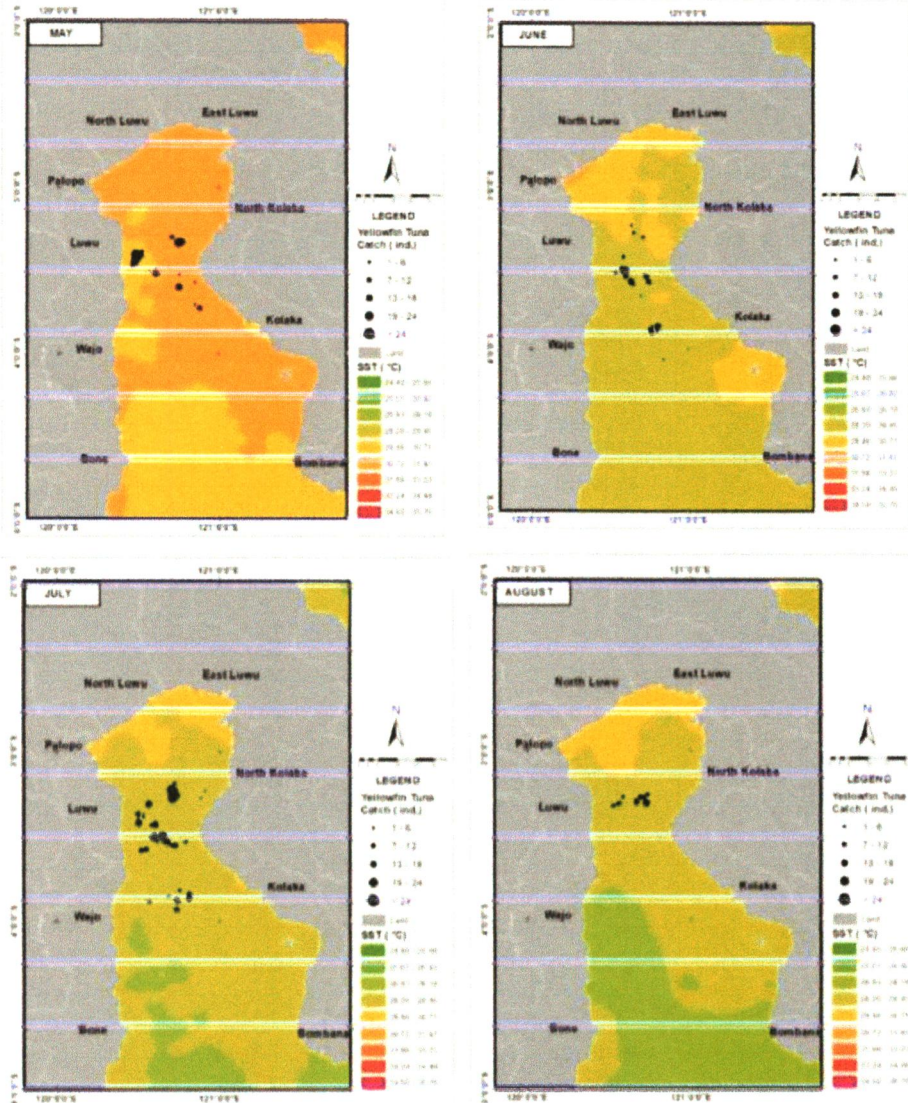


Figure 3. The horizontal profiles of sea surface temperature (SST) from May to August 2019. The SST provided by AQUA-MODIS, NOAA.

3.3. Water Depth with Fishery data

The water depth profiles of the Gulf of Bone show that the depth of the maximum water in the Gulf of Bone, approximately 4,000 m (Figure 4). The deepest waters are located in the Southern part of the gulf between the territorial waters between the Regencies of Bulukumba and Sinjai (South Sulawesi Province) in the West with the Muna and Buton Regencies (Southeast Sulawesi Province) directly adjacent to the Flores Sea. Vice versa, in the Northern part of the Gulf of Bone between the territorial waters of Luwu Raya and the Regencies of Kolaka and North Kolaka, they are relatively shallow waters.

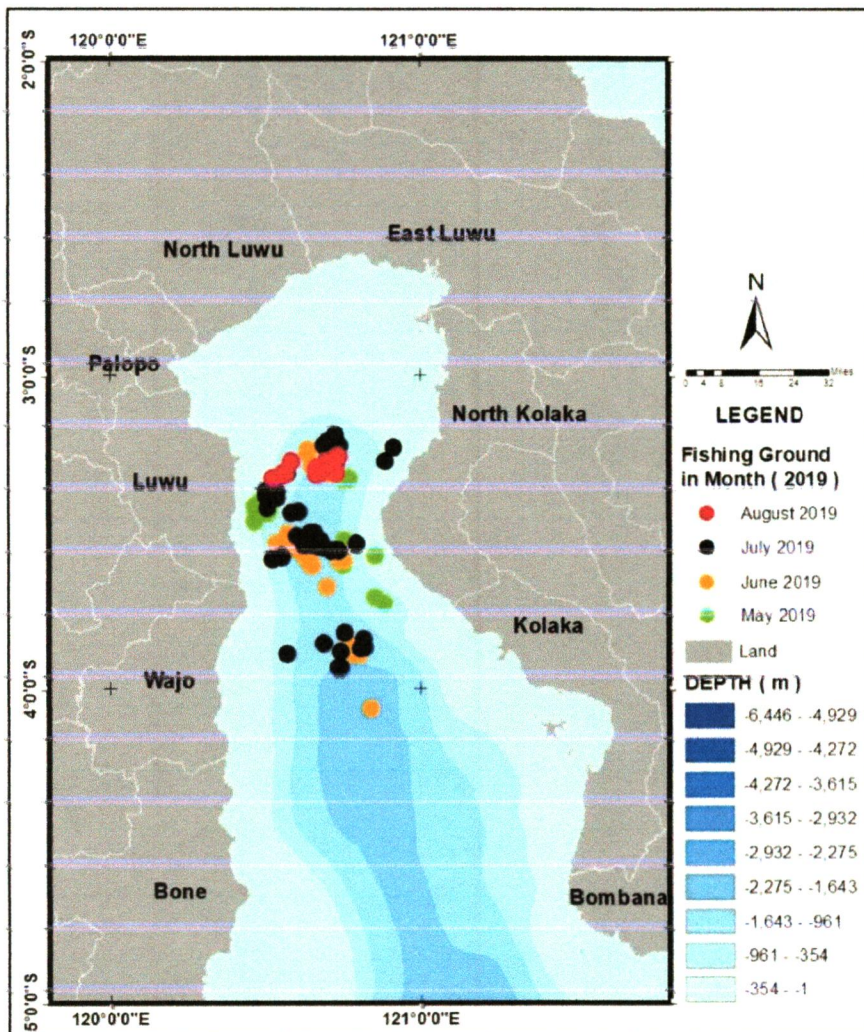


Figure 4. Bathymetric Profiles Overlaid with Fishing Ground Positions from May to August 2019. The Bathymetric Data Derived from Satellite Remote Sensing.

3.4. Habitat Characteristics

Gulf of Bone has been identified as an area of interest for large pelagic fish such as tunas. The fishing operation of pole and line with species target is tunas in the study area was carried out in May to August. The findings of this study showed that most of the yellowfin tuna distribution tends to be highest in the SST specific in ranges of 29.0 – 31.0°C. The fishing operation occurred in the offshore area in the range from 500 m to 2,000 m. Yellowfin tuna distribution tended to be highest in the specific water depth of 500 to 1,500 (Figure 5).

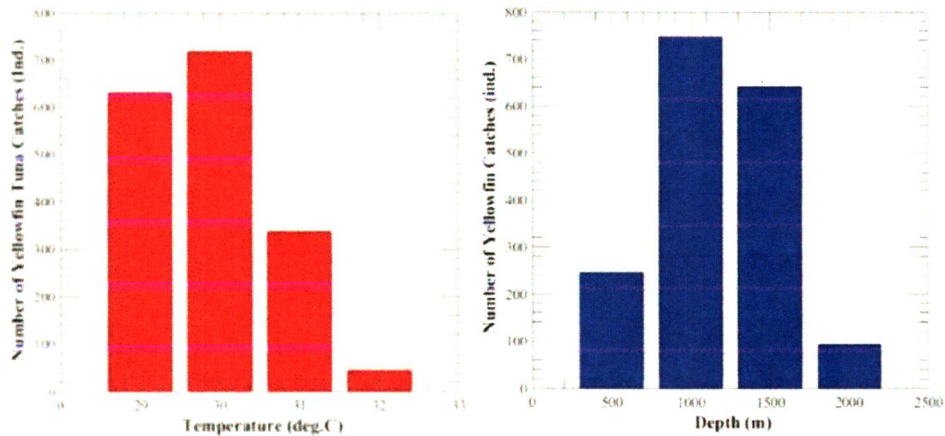


Figure 5. Histograms of Yellowfin Tuna Catches. Oceanographic variable showing; SST (left) and Depth (right). All datasets from April to September 2019 were used.

3.5. GAM Prediction

Generalized Additive Model (GAM) is used to identify the optimum conditions of oceanographic for each parameter shown with a positive effect that can be seen in Figure 7. The generalized additive model as a nonlinear model was successful in identifying the effects of oceanographic factors on the yellowfin tuna distribution. Sea surface temperature has a positive effect in the range of 30 - 31 °C. Yellowfin tuna are found in the range of water depths of 500 to 1,000 m (offshore). In Figure 6 it can be seen that large pelagic fish require certain environmental conditions to do with their distribution and abundance in waters, especially in Bone Gulf. The results of research for other species of fish such as anchovy [4] and skipjack tuna [6] also show the same thing, so it can be concluded that each fish species requires certain environmental conditions for its life and growth.

Furthermore, the SST and depth water in the Gulf of Bone plays a great role in determining the variability of the yellowfin tuna quantitative distribution in the study area. The results were supported by GAM prediction (Figure 6). Due to a lack of robust data, there is no detailed information on the optimum habitat preference of yellowfin tuna distribution. Future work is needed to get more reliable information about yellowfin tuna distribution in the Gulf of Bone and its surrounding areas with the considerations of other factors such as abiotic and biotic factors [10] in the study. This is because such information is required to understand the yellowfin migration patterns in this area and the effect of fisheries on yellowfin stock fluctuation after the fishing season.

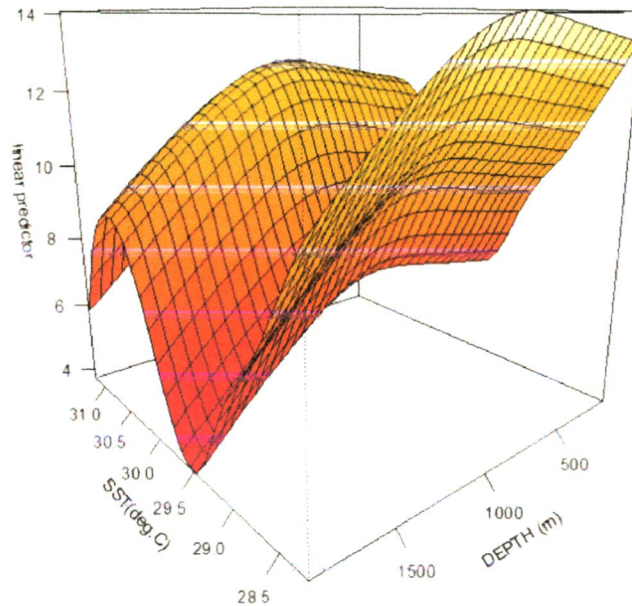


Figure 6. Responses shape of oceanographic factors effects in the presence of YellowfinTuna distribution for the best model predictor of two variables.

4. Conclusion

The result based on the GAM prediction model showed that the yellowfin tuna distributions were relatively higher in 30.0 to 31.0 °C SST and 500 to 1,000 m water depth. Both of the parameters analyzed in this study played an important role in the distribution. The numbers represented preferences in defining the optimal habitat of the yellowfin tuna, especially in the study area. This information could be useful to predict the potential fishing zones where yellowfin tuna would be distributed in abundance.

Acknowledgments

I would like to acknowledge the Ministry of Education and the Culture Indonesia Republic for their contributed greatly in financial support. The research was funded under a National Competitive Research Grant (PTUPT 2019 and PDUPT 2020). We thanked all members of the Laboratory of Marine Fisheries Information System, Faculty of Marine Science and Fisheries, Hasanuddin University, who provided us with some discussions and helped in gathering data. Last but not least, I would like to thank everybody who was important to the prepared and reviewed manuscript.

References

- [1] Safruddin, Aswar B, Ashar MR, Hidayat R, Dewi Y K, Umar M T, Farhum S A, Mallawa A and Zainuddin M 2019 The Fishing Ground of Large Pelagic Fish during the Southeast Monsoon in Indonesian Fisheries Management Area-713 *IOP Conference Series: Earth and Environmental Science* vol 370 (IOP Publishing) p 12045
- [2] Ministry of Marine and Fisheries Affairs of the Republic of Indonesia. 2018 Statistics Report of Marine Fisheries. South Sulawesi Province. Makassar

- [3] Zainuddin M, Farhum A, Safruddin , Selamat M B, Sudirman S, Nurdin N, Syamsuddin M, Ridwan M and Saitoh S-I 2017 Detection of pelagic habitat hotspots for skipjack tuna in the Gulf of Bone-Flores Sea, southwestern Coral Triangle tuna, Indonesia *PLoS One* **12** e0185601
- [4] Safruddin, Hidayat R and Zainuddin M 2018 Effects of environmental factors on anchovies *Stolephorus* sp distribution in Bone Gulf, Indonesia *AACL Bioflux* **11** 387–93
- [5] Selayo A, Malik A A, Yani F I, Mallawa A, Safruddin 2019 Remote Chlorophyll-a and SST to Determination of Fish Potential Area in Makassar Strait Waters Using MODIS Satellite Data *IOP Conference Series: Earth and Environmental Science* vol 270 (IOP Publishing) p 12047
- [6] Hidayat R, Zainuddin M, Safruddin, Mallawa A and Farhum SA 2019 Skipjack Tuna (*Katsuwonus pelamis*) catch in relation to the Thermal and Chlorophyll-a Fronts during May–July in the Makassar Strait *IOP Conference Series: Earth and Environmental Science* vol 253 (IOP Publishing) p 12045
- [7] Team R C 2013 R: A language and environment for statistical computing
- [8] Wood S N 2017 *Generalized additive models: an introduction with R* (CRC press)
- [9] Gordon A L 2005 Oceanography of the Indonesian seas and their throughflow *Oceanography* **18** 14–27
- [10] Jalil J, Mallawa A, Amir F and Safruddin 2020 Size composition and length-weight relationships of the Yellowfin Tuna (*Thunnus albacares*) in Bone Bay **153** 1006

The distribution of yellowfin tuna based on sea surface temperature and water depth parameters in the Bone Gulf, Indonesia

ORIGINALITY REPORT

20%
SIMILARITY INDEX

12%
INTERNET SOURCES

16%
PUBLICATIONS

5%
STUDENT PAPERS

PRIMARY SOURCES

- 1** A Selao, A A Malik, F I Yani, A Mallawa, Safruddin. "Remote Chlorophyll-a and SST to Determination of Fish Potential Area in Makassar Strait Waters Using MODIS Satellite Data", IOP Conference Series: Earth and Environmental Science, 2019
Publication **3%**
- 2** cronfa.swan.ac.uk
Internet Source **2%**
- 3** Safruddin. "Estimates of Japanese sandeel (*Ammodytes personatus*) distribution and biomass in the northern coast of Hokkaido, Japan, using a quantitative echosounder [an abstract of dissertation and a summary of dissertation review]", Hokkaido University Collection of Scholarly and Academic Papers, 2013.
Publication **2%**
- 4** garuda.ristekbrin.go.id
Internet Source

2%

-
- 5 Achmad Fachruddin Syah, Jonson Lumban Gaol, Mukti Zainuddin, Nadela R. Apriliya, Dessy Berlianty, Dendy Mahabrur. "Habitat Model Development of Bigeye tuna (*Thunnus obesus*) during Southeast Monsoon in the Eastern Indian Ocean using Satellite Remotely Sensed Data", IOP Conference Series: Earth and Environmental Science, 2019

Publication

-
- 6 [researchid.co](https://www.researchid.co) 1%

Internet Source

-
- 7 A Mallawa, F Amir, I Halid. "Comparison of the catch of two fishing technologies for yellowfin tuna (*Thunnus albacares* Bonnaterre 1788) in Bone Bay waters, South Sulawesi Indonesia", IOP Conference Series: Earth and Environmental Science, 2021

Publication

-
- 8 www.seafdec.org 1%

Internet Source

-
- 9 Rini Sahni Putri, Muhammad Bibin, Surianti, Hasrianti, Damis, Andi Rani Sahni Putri, Ully Wulandari, Mentari Puspa Wardani. "Analysis of small pelagic fishing grounds using a generalized additive model in the Makassar

Strait", IOP Conference Series: Earth and Environmental Science, 2021

Publication

-
- | | | |
|----|---|------|
| 10 | Andi Rani Sahni Putri, Mukti Zainuddin, Musbir Musbir, Muzzneena Ahmad Mustapha, Rachmat Hidayat, Rini Sahni Putri. "Impact of increasing sea surface temperature on skipjack tuna habitat in the Flores Sea, Indonesia", IOP Conference Series: Earth and Environmental Science, 2021
Publication | <1 % |
| 11 | Submitted to Udayana University
Student Paper | <1 % |
| 12 | pure.aber.ac.uk
Internet Source | <1 % |
| 13 | www.smujo.id
Internet Source | <1 % |
| 14 | eprints.untirta.ac.id
Internet Source | <1 % |
| 15 | garuda.kemdikbud.go.id
Internet Source | <1 % |
| 16 | onlinelibrary.wiley.com
Internet Source | <1 % |
| 17 | Tianqi Hu, Yuegang Tan, Ruiya Li. "Research on cooperative control strategy of multi- | <1 % |

motor system based on fuzzy inference",
Journal of Physics: Conference Series, 2022

Publication

18

core.ac.uk

Internet Source

<1 %

19

Kuo-Wei Lan, Yi-Jay Chang, Yan-Lun Wu.
"Influence of oceanographic and climatic
variability on the catch rate of yellowfin tuna
(Thunnus albacares) cohorts in the Indian
Ocean", Deep Sea Research Part II: Topical
Studies in Oceanography, 2019

Publication

<1 %

20

Mukti Zainuddin, St. Aisjah Farhum, Safruddin
Safruddin, Rachmat Hidayat, Andi Rani Sahni
Putri, Muhammad Ridwan. "Dynamics of
Thermal Fronts Distribution in the Flores Sea,
Indonesia: An implication for locating
potential skipjack tuna fishing ground", IOP
Conference Series: Earth and Environmental
Science, 2021

Publication

<1 %

21

P. Punya, V. Kripa, Shelton Padua, K. Sunil
Mohamed, P.O. Nameer. "Impact of
environmental changes on the fishery of
motorized and non-motorized sub-sectors of
the upwelling zone of Kerala, southeastern
Arabian sea", Estuarine, Coastal and Shelf
Science, 2021

<1 %

Publication

22

www.fao.org

Internet Source

<1 %

23

www.longdom.org

Internet Source

<1 %

24

www.researchgate.net

Internet Source

<1 %

25

R Hidayat, M Zainuddin, S Safruddin, A Mallawa, S A Farhum. " Skipjack Tuna () catch in relation to the Thermal and Chlorophyll-a Fronts during May - July in the Makassar Strait ", IOP Conference Series: Earth and Environmental Science, 2019

Publication

<1 %

Exclude quotes On

Exclude matches < 5 words

Exclude bibliography On

The distribution of yellowfin tuna based on sea surface temperature and water depth parameters in the Bone Gulf, Indonesia

GRADEMARK REPORT

FINAL GRADE

/0

GENERAL COMMENTS

Instructor

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8

PAGE 9

PAGE 10
