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Size Frequency, Sustainability Index of the Yellowfin Tuna *(Thunnus albacares*) Landed in PPI Ujong Baroh, West Aceh, Indonesia

Burhanis[1*], Alaudin[1], Radhi Fadhillah[2], Zulfadhli[2], Anhar Rozi[3], Hamidi[3], Edwarsyah[4] , Rika Anggraini[5]

[1]Marine Science Department, Faculty of Fisheries and Marine Science, Teuku Umar University Meulaboh, 23615 West Aceh, Indonesia
[2]Aquaculture Department, Faculty of Fisheries and Marine Science, Teuku Umar University Meulaboh, 23615 West Aceh, Indonesia
[3]Aquatic Resources Department, Faculty of Fisheries and Marine Science, Teuku Umar University Meulaboh, 23615 West Aceh, Indonesia
[4]Fisheries Department, Faculty of Fisheries and Marine Science, Teuku Umar University Meulaboh, 23615 West Aceh, Indonesia
[5]Marine Science Department, Faculty of Marine Science and Fisheries, Raja Ali Haji Maritime University, Tanjungpinang, Indonesia

***Coresponding Author: burhanis@utu.ac.id**

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ABSTRACT

The South-west waters area of Aceh Province features extensive topography and encompasses a vast sea. The waters area was included in the Republic of Indonesia State Fisheries Management Area (WPPNRI) 572, which directly neighbors the Indian Ocean. The area was contained in marine biodiversity, including tuna species. However, in marine areas in the world, marine resources are currently facing environmental threats, including illegal fishing, coral reef degradation, pollution, and climate change. The research aimed to assess and analyze the frequency distribution of size and sustainability of yellowfin tuna (*Thunnus albacares*) in WPPNRI 572 which landed on PPI Ujong Baroh. Descriptive and quantitative approaches were used in the current study to collect and analyze data on the length frequency, and sustainability of yellowfin tuna. It was determined that the catch of yellowfin tuna landed at PPI Ujong Baroh with a frequency of fork with a length that ranged between 44- 95.2cm. In the rapid appraisal fisheries analysis (Rapfish), the institutional dimension scored 76.02, classifying it as sustainably good (score 76-100), while the results of the economic dimension analysis scored 72.67, fell into the quite sustainable category (score 51- 75).

INTRODUCTION

The South-west waters area of Aceh Province feature extensive topography and encompass a vast sea. The waters area was included in the Republic of Indonesia State Fisheries Management Area (WPPNRI) 572, which directly neighbors the Indian Ocean. The Indian Ocean in western Indonesia is one of three large oceans surrounding the Indonesian archipelago. The region has unique and important geographical characteristics in the context of Indonesia's geography, climate, economy, and culture. One of these unique features is the significant richness of marine resources and natural wealth. Marine resources include capture fisheries, which have great potential. The marine resources in the western part of South Aceh have significant economic potential including yellowfin tuna **(Burhanis *et al*., 2018)**.

The yellowfin tuna is a type of tuna. Tuna migrated throughout tropical and subtropical waters without being influenced by differences in longitude and latitude **(Burhanis *et al*., 2018)**. The potential fish resources are spread across Fisheries Management Area (WPP) 572. The area has an important role in the Indonesian fisheries sector. The main source of animal protein for the Indonesian populations is the fish landed. The potential for commercial fishery lies in tuna fish **(Burhanis *et al*., 2019)**.

Tuna is a fishery commodity that has very high economic value, and it is a mainstay of exports from the fisheries sector. However, the availability of several tuna species is starting to be threatened. The availability of yellowfin tuna stocks in the Indian Ocean is currently estimated to be overfished **(Arnenda *et al*., 2019)**. As we know, in several marine areas in the world, marine resources are currently facing environmental threats, including illegal fishing, coral reef degradation, pollution, and climate change.

The current conditions are certainly very worrying, especially for traditional fishermen. Fishermen are part of the spearhead of Indonesian fisheries management. It is hoped that with the potential of fish resources, especially tuna species which are very abundant, it can provide more contribution and ensure the welfare and sustainability of the lives of fishermen and their families. The sustainable utilization of fishery resources will continuously yield optimal economic impacts. The problems and utilization of the tuna fishing process are not yet optimal, hence it didm't have a significant impact from an economic perspective for the fishing community. One of the appropriate management approaches involves adopting sustainable patterns of utilization and management. The utilization can be carried out optimally for the welfare of the community **(Anna, 2019)**.

The maritime ocean in the western part of Indonesia is a very valuable asset for the country and society. Conservation and wise management efforts are very necessary to protect natural resources and ensure the sustainability of marine ecosystems, which will contribute to sustainable development goals (SDGs) point 14 **(Christanto, 2014)**. Based on the background, the aim of the research carried out was to study and analyze the frequency distribution of size and sustainability of the yellowfin tuna (*Thunnus albacares*) on WPPNRI 572 which landed in PPI Ujong Baroh.

MATERIALS AND METHODS

Time and place of research

The research was conducted at Ujong Baroh PPI, Johan Pahlawan District, West Aceh Regency, Aceh Province, from April to June 2023.

Method of collecting data

The descriptive method was used in this research with a quantitative approach. Observations and measurements of yellowfin tuna samples were carried out randomly every week for 3 months. Fish body length measurements (biological data) were carried out directly from fishermen's catches which landed in Ujong Baroh PPI, Meulaboh. The caught yellowfin tuna was then used as a sample for measurements, as shown in Fig. (1). The data collected are in the form of fish length measurments. The interview process (depth interview) took a sustainable approach to the potential management of yellowfin tuna fisheries at Ujong Baroh PPI, Meulaboh, Aceh Province.

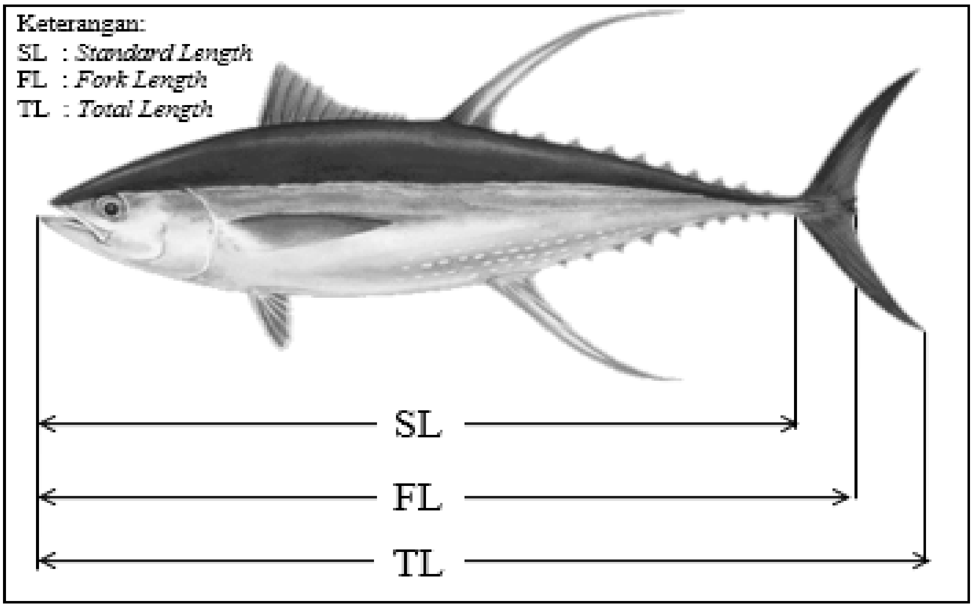

Fig. 1. Measurement of the length of yellowfin tuna

Data analysis

Frequency distribution of length size of yellowfin tuna

Observing and collecting biological data on yellowfin tuna samples included measuring certain parts of the fish's body. Yellowfin tuna measurements were carried out without distinguishing between genders. The size of the fish was different between one body part and another **(Burhanis *et al*., 2018)**. The body parts of the fish that were observed and measured included body height, total length, standard length, fork length, head length, and the distance between the first dorsal fin, second, and anal fins.

The frequency of fish length measurements was analyzed to determine the class interval, middle value, and number in each group. The equation of the frequency distribution was used as a formula to obtain the length of the fish **(Walpole & Raymond, 1995)**. Determining the class interval includes the maximum length minus the minimum length divided by the number of classes **(Supranto, 2000)**.

$$k = 1+3,322 \log n$$

$$i = R / K$$

Where :

K = Number of classes
N = Number of data
i = Class interva
R = Maximum value and minimum value

Sustainability

The data were collected to determine the sustainability status of yellowfin tuna, and it is quantitatively descriptive, involving the collection of both primary and secondary data. Primary data were obtained from surveys and monitoring of respondents/informants through distributing questionnaires using the purposive sampling method. Obtaining a value from the analysis of two adjacent points, the expectation is for the point to be as close as possible to the origin on the ordination scale. MDS distance determination is based on Euclidian distance with the following formula:

$$d = \sqrt{(|x_1 - x_2|^2 + |y_1 - y_2|^2 + |z_1 - z_2|^2 + \dots\dots)}$$

Next, this point is applied, and the Euclidian difference (dij) from point i to point j is regressed using the equation:

$$d_{ij} = a + bd_{ij} + e$$

The least squared technique equation is used interchangeably based on the root of the Euclidean distance (squared distance) or is called the ALSCAL algorithm method. The ALSCAL algorithm method involves an equation with an intercept effort equal to zero (a=0) **(Tony & Preikshot, 2001)**. This method optimizes the squared distance dijk of squared data (origin = 0ijk) in three dimensions (i, j, k) called S-stress with the equation:

$$s = \sqrt{\frac{1}{m}\sum\left[\frac{\sum\sum(d^2 i\,jk - O^2 i\,jk)^2}{\sum\sum O^4 i\,jk}\right]}$$

The most sensitive attribute showed changes to the index and sustainability status based on the highest root mean square (RMS) value.

The quantitative and qualitative data that have been obtained are then tabulated and analyzed. The analysis was used by Microsoft Excel software and the Rapfish (Rapid appraisal of fisheries) program. The category of sustainability status based on the MDS analysis index score is displayed in Table (1) **(Purwaningsih & Santosa, 2015)**.

Table 1. The category of sustainability status based on the MDS analysis index score

Index values	Sustainability category
0- 25	Not sustained / Continued
26- 50	Less sustainable / Continues
51- 75	Self sustaining / Continuing
76- 100	Continuing / Continuing

(Purwaningsih & Santosa, 2015)

RESULTS

Frequency distribution of length size of yellowfin tuna

The yellowfin tuna caught by fishermen were observed and measured at Ujong Baroh PPI Meulaboh during the research period on 160 individuals. The distribution of size classes of fishermen's catches varied greatly, starting from the minimum fork length ranging from 44cm to the maximum fork length ranging from 95.2cm. The distribution of yellowfin tuna size classes is exhibited Fig. (2).

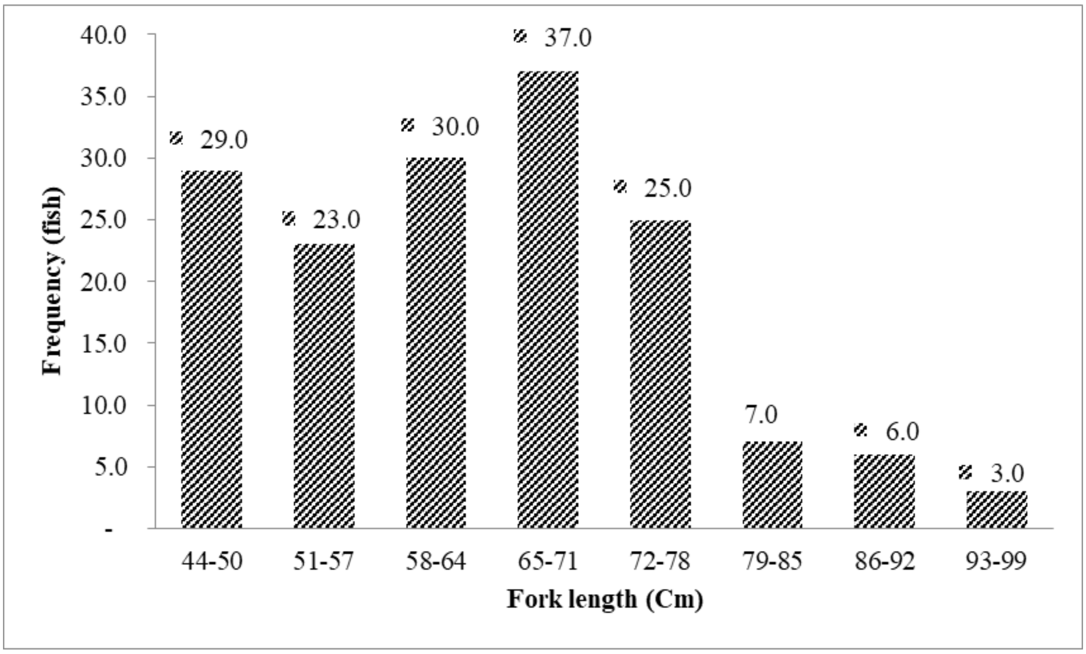

Fig. 2. Frequency distribution of caught yellowfin tuna

The smallest yellowfin tuna caught with a size class ranging from 44- 50cm was 29 individuals. The dominant yellowfin tuna caught falls within the size class range of 65- 71cm, totaling 37 individuals. This is followed by the size class between 58- 64cm, with 30 individuals. The least caught yellowfin tuna falls within the size range of 93- 99cm, with only 3 individuals.

Sustainability of institutional dimensions

The sustainability analysis of yellowfin tuna fishery management from the institutional dimension through an assessment of eight sustainability attributes in the institutional dimension, including tuna fishery potential, equitable catch, local wisdom, institutional support, fishing equipment and infrastructure, vessel/ capture device legality, social togetherness, and implementation of an arrest. The Rapfish analyzed using the ordination techniques through the MDS method showed a sustainability status of the institutional dimension with a value of 76.08, as seen in Fig. (3). The results of the analysis value indicated that the sustainability of yellowfin tuna management from the institutional dimension, based on the categorization proposed by **Purwaningsih and Santosa (2015**), was classified in the good/ very sustainable category. This value was in the range 76- 100.

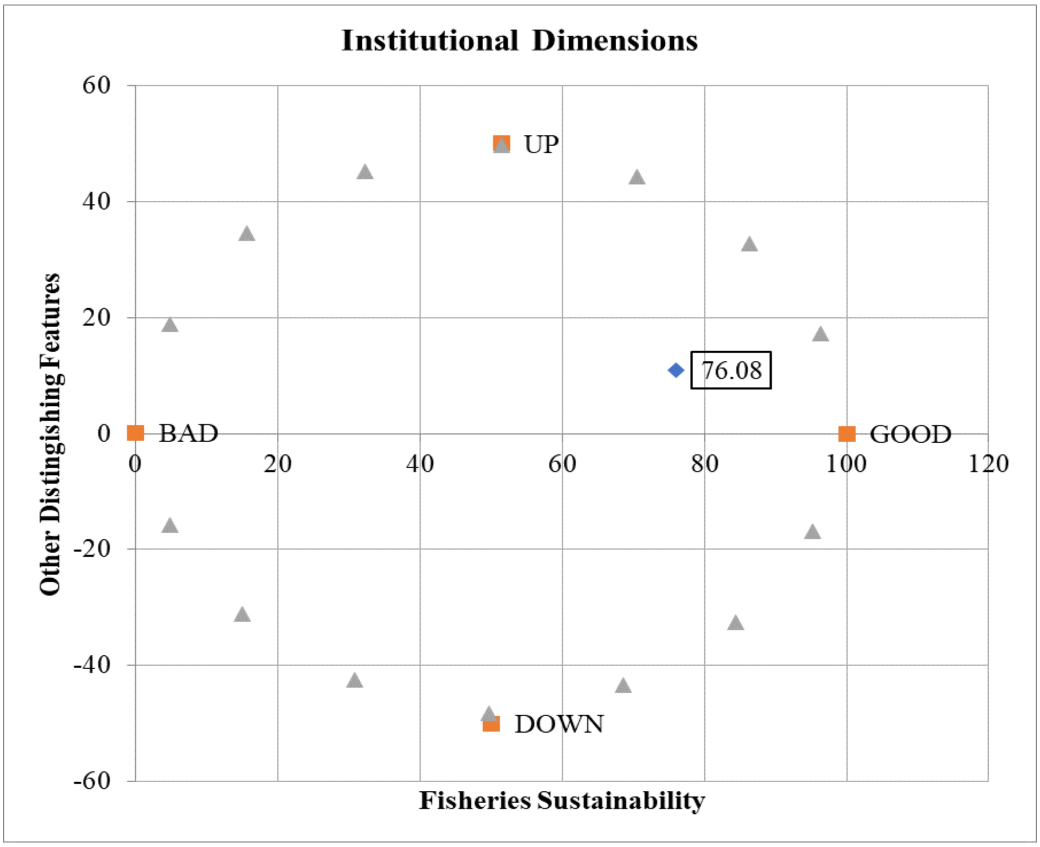

Fig. 3. Index analysis and sustainability status of institutional dimensions

The Monte Carlo analysis was used to examine the influence of errors or galat in sustainability analysis, which originated from differences in the assessments of each respondent toward attributes, errors in data entry, and incomplete or missing data **(Kavanagh, 2001)**. Based on the analysis results, the Monte Carlo sustainability index is displayed in Table (2).

Table 2. Index values and sustainability status of yellowfin tuna for institutional dimensions

Yellowfin tuna	SUSTAINABILITY	
	INDEX	**STATUS**
	76,08	Continuing / Continuing
Stres : 0,138 R^2 : 0,950		

The Monte Carlo analysis with a confidence interval value of 95% (the results obtained do not experience much difference) less than 1 between the results of the Monte Carlo and MDS analysis. The low difference in values proved that the influence of errors can be avoided. The leverage analysis was used to detect the influence on the sustainability score of the institutional dimension (Fig. 4). There were several attributes that were sensitive and showed the value of the yellowfin tuna sustainability index. These attributes included fishing equipment and infrastructure, equitable distribution of catches, and tuna fishery potential.

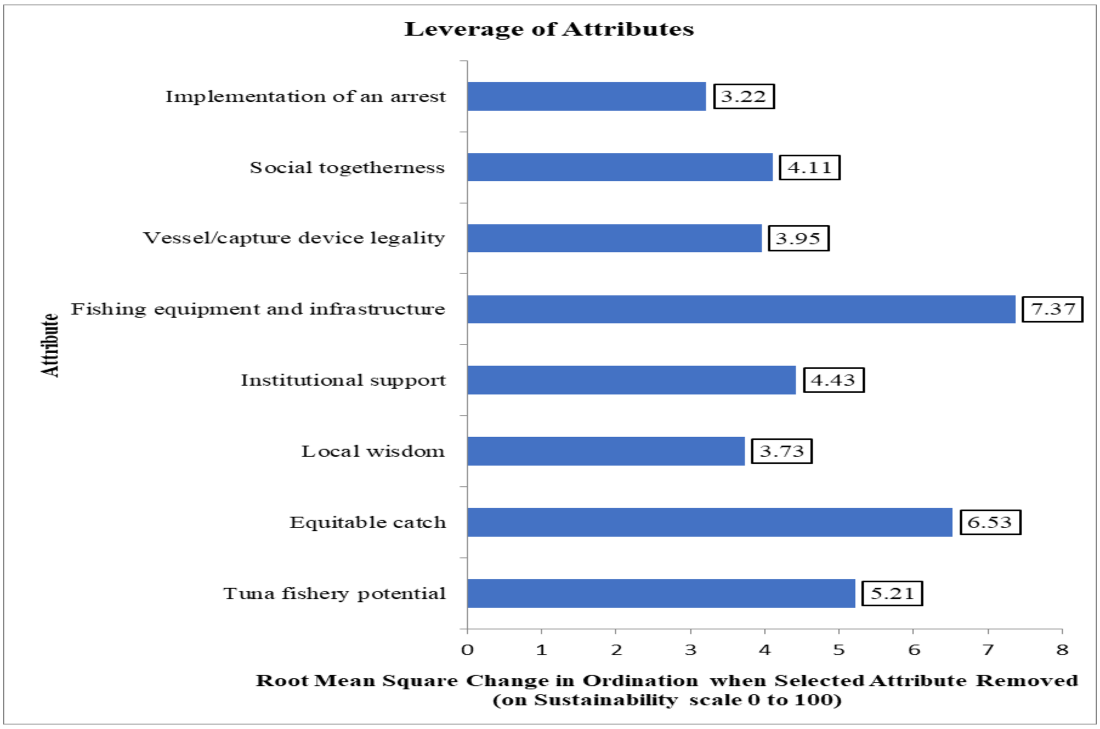

Fig. 4. Leverage analysis of institutional dimensions

Fig (4) displays the sustainability leverage analysis of institutional dimensions (Fig. 4) showing that, out of the 8 attributes analyzed, there are 3 attributes that are sensitive and significantly affected the management system of yellowfin tuna fisheries, including fishing facilities and infrastructure, equitable catch, and tuna fishery potential. These three attributes were closely interconnected. Fishing facilities and infrastructure where mobilization facilities for fishing at sea used a 5 GT boat type, then the type of equipment used was a hand line with small hooks (size 7 or 8), and the average catch size of fishermen was similar to data exhibited in Fig. (2).

Economic dimensions of sustainability

The economic dimension was analyzed by assessing eight sustainability attributes, including regional income contribution, fishing volume, income level, regional economic growth, community growth rate, economic value, fulfillment of needs, and export sales value. The Rapfish was analyzed using the coordination technique via the MDS method and obtained a sustainability status for the economic dimension, with a value of 72.67 (Fig. 5). The results of the analysis value are classified as good/ very sustainable. This value is in the range of 76- 100.

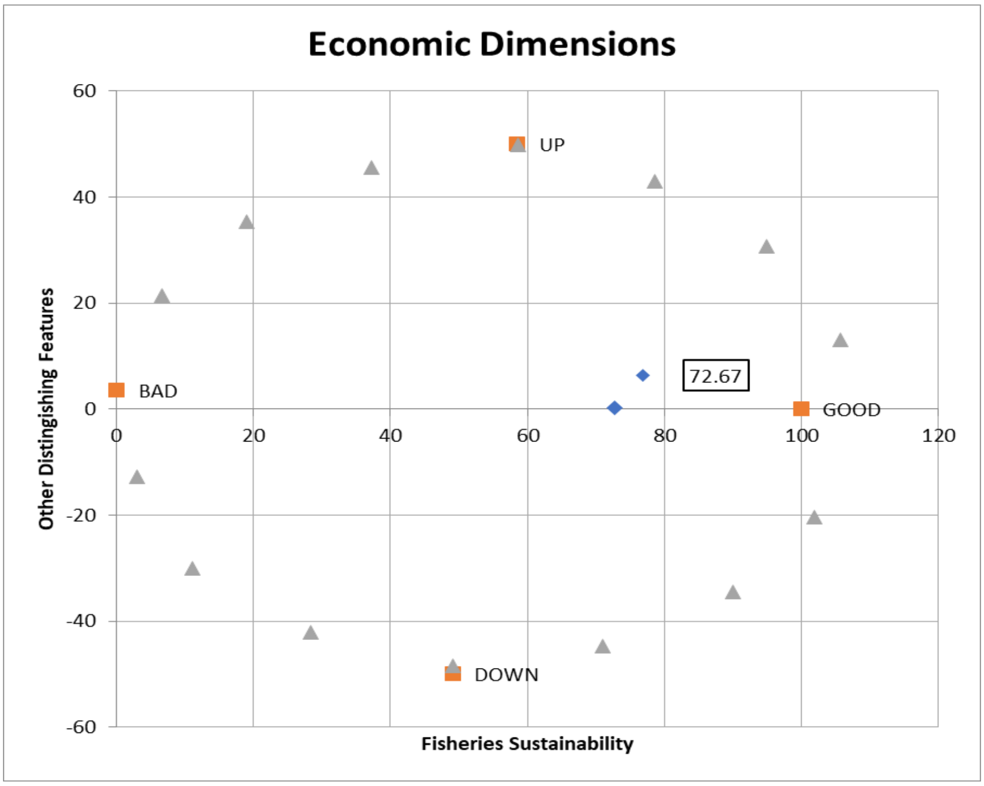

Fig. 5. Index analysis and sustainability status of economic dimensions

The Monte Carlo analysis was used to examine the dimensions of error factors in sustainability, which originated from differences in each respondent's assessment of attributes, errors in entered data, incomplete or missed data **(Kavanagh, 2001)**. The results of this analysis include a Monte Carlo sustainability index, as denoted in Table (3).

Table 3. Index values and sustainability status of yellowfin tuna for economic dimensions

Yellowfin tuna	SUSTAINABILITY	
	INDEX	**STATUS**
	72,67	Self Sustaining / Continuing
Stres : 0,14 R^2 : 0,948		

The results of the Monte Carlo analysis with a confidence interval of 95% indicated that, there were no differences in results where the value was less than 1 between the Monte Carlo and MDS analyses. The low difference in values proved that the influence of errors can be avoided. The results of the leverage analysis used to examine the impact on the sustainability score of the economic dimension (Fig. 6). There were several attributes that were sensitive and showed the value of the yellowfin tuna sustainability index. These attributes included regional economic growth, income level, and community growth rate.

The results of the economic dimension assessment through the leverage analysis process (Fig. 6) showed that of the 8 attributes analyzed, there were 3 attributes that were sensitive to influence, including regional economic growth, income level and community growth rate. These three attributes were closely interconnected.

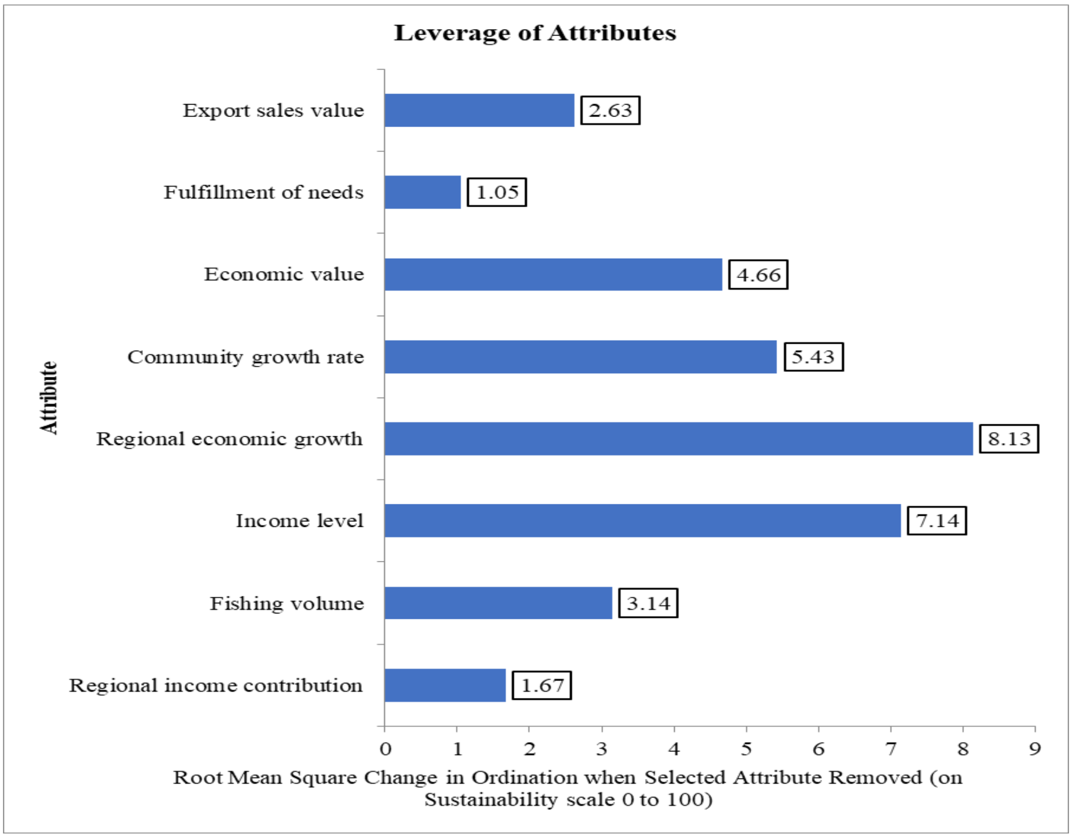

Fig. 6. Economic dimension leverage analysis

DISCUSSION

The results obtained from this research are not significantly different from the study conducted by **Burhanis *et al*. (2018)** who reported that in the Simeulue Sea, yellowfin tuna caught ranged in size from 35- 105cm. According to **Tumulyadi *et al.* (2019)**, the length of yellowfin tuna ranged from 22.4 to a maximum value of 175.2cm in the southern region of Malang Regency, with an average length of 42.60cm. The catch of yellowfin tuna had a standard length ranging from 30- 179cm in the Indian Ocean **(Wujdi *et al*., 2015)**. Fishermen of West Aceh and Simeulue generally catch fish in the Indian Ocean within the WPP 572. These results indicated that the caught fish belong to a single population, with yellowfin tuna being a migratory species with a wide distribution, and the fishing area serves as a migration zone for tuna in the waters of the Indian Ocean.

The spread and distribution of fish in the sea are influenced by metabolic activities, including feeding requirements, growth rate, body movement (swimming speed), and nerve stimulation influenced by water temperature **(Baskoro *et al*., 2004)**. The size structure of yellowfin tuna was divided into three groups. The first group consisted of larvae (< 40cm), then juveniles (> 40cm), and finally the larger group where fish had already spawned **(Kantun & Mallawa, 2016)**. According to **Nurdin (2017)**, the length standard of yellowfin tuna comprises two groups. Sizes ranging from 21- 70cm are considered immature (juvenile), and sizes between 81- 160cm are considered mature.

The tuna fish individual is a type of fish that undergoes extensive migration, constantly moving from one place to another. According to **Saputra *et al*. (2011)**, the waters of Indonesia represent a region for tuna fish migration, especially in the waters of the Indian Ocean and the Pacific Ocean. The fishing areas conducted by fishermen in West Aceh are located in the Indian Ocean waters, with catch sizes varying from juvenile to mature. The differences in the length of tuna are caused by genetic changes, as well as the migration process. They undertake to find food and reproduce **(Dhurmeea *et al*., 2016)**.

The results of the analysis of the sustainability of yellowfin tuna fisheries management from an institutional perspective reveal several challenges. One of the obstacles faced by fishermen is the limited knowledge and resources to determine the suitable and potential fishing areas in the Indian Ocean. According to **Siregar *et al*. (2018)**, the prediction of yellowfin tuna fishing areas is based on parameters, such as sea surface temperature, chlorophyll-a, and sea surface height in the Indian Ocean and the Pacific Ocean. The attributes need to be thoroughly studied and considered to improve their index values for the future.

Sustainability of the potential of marine and fisheries, from an ecosystem perspective, relies on maintaining the sustainability of the marine environment while optimizing the utilization of marine resources without waste. Environmental protection efforts are crucial for preserving the sustainability of marine resources and biodiversity. An integrated system is anticipated to have a positive impact on the utilization, optimization, and sustainability of fisheries and marine resources, making the country a global leader **(Burhanis *et al*., 2021)**.

The result of the economic dimension analysis showed that in the economic field, coastal communities often experience low income. According to **Fatmasari (2012)**, the majority of the social categories of Indonesian fishermen are classified as traditional and laborer fishermen. Their social position remains marginal in the economic transaction process. The deteriorated social welfare conditions among coastal fishermen are in areas/ waters that have experienced overfishing, which affects their income, leading to uncertainty **(Fatimah, 2012)**.

Coastal fishermen, in general, still live in economic, social, political, educational, and resource access dependency. The social dependency was realized through the lack of the coastal community's ability to engage in profitable market economic activities **(La Suhu, 2020; Putri *et al*., 2023)**. **Goso and Anwar (2017)** stated that, traditional fishermen in Indonesia are still considered poor, and their livelihoods depend on marine resources. To improve the economic sustainability of the community, policies are needed to create a trading system that is more focused and supportive for fishermen.

CONCLUSION

The research results lead to the conclusion that the catch of yellowfin tuna landing on PPI Ujong Baroh has a frequency of fork length ranging between 44- 95.2cm. Based on the results of the Rapfish analysis, the institutional dimension with a score of 76.02 is classified as good and sustainable (score 76- 100), while the results of the economic dimension analysis with a score of 72.67, falls into the quite sustainable category (score 51- 75).

Acknowledgements

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