SPATIAL CLUSTERING OF FISHING AREA IN BULU WATERS, TUBAN REGENCY

Wahida Kartika Sari[1*], Andre Laila Kusuma[1], Ledhyane Ika Harlyan[1], Abu Bakar Sambah[1], Wirastika Adhihapsari[1]

[1]Program Studi Pemanfaatan Sumberdaya Perikanan,
Fakultas Perikanan dan Ilmu Kelautan Universitas Brawijaya
* Email: wahidaks@ub.ac.id

ABSTRACT

The various characteristics of catches and fishing gear provide distinct advantages for fishermen, but these characteristics can cause other problems, namely pressure on stock availability caused by an increase in the number of catches and the use of various types of fishing gear and the efficiency provided. There needs to be good management to handle this. The purpose of this research is to find out the clustering of fishing areas based on the catch and fishing gear type. This study can be regarded as a reference in sustainable fisheries management. The research utilized descriptive methods and case studies at PPP Bulu. The analytical method used is the *Shannon-Wienner* index of diversity (*S-W,H'*), *Margalef* richness (R') and clusterization. Clustering analysis was performed by using Hierachical Cluster Analysis (HCA) method and Euclidean distance. The results showed that the value of diversity has a range of 0-2 and the value of wealth has a range of 1-10. The results of the clustering show that there were 3 clusters of fishing areas formed based on the catch, while no clusters of fishing areas are formed based on the type of fishing gear operated.

Keywords: *Multispecies & Multigear, DPI, Clusterization, HCA*

1. INTRODUCTION

Fisheries with various catch characteristics and types of fishing gear provide distinct advantages for fishermen, but these characteristics can cause other problems, namely pressure on stock availability caused by an increase in the number of catches and the use of various types of fishing gear and the efficiency. Overfishing is one that can occur due to an understanding that existing fish resources are *common property*, and can be used unlimitedly by anyone (*open access*) (Irianto & Soesilo, 2007). It can be said that fish resources have no regulation about what, who, when, where and how these resources are used.

Bulu waters is an area that has quite large fishery resource potential, where these waters are classified as one of the Wilayah Pengelolaan Perikanan Negara Republik Indonesia (WPPNRI; lit. Republic of Indonesia Fisheries Management Area) 712. Fishing activities in Bulu waters are supported by the Unit Pelaksana Teknis (UPT; lit. Technical Implementation Unit), Pelabuhan Perikanan Pantai (PPP; lit. Coastal Fishery Ports) Bulu, Tuban Regency. According to (Khatami *et al*., 2018) where the rate of fishing in the North Java Waters continues to increase, if this condition continues then at a certain level there can be overfishing of fish stocks. The importance of providing information regarding fishing grounds and more strategic potential in capturing fisheries control can be used to support capture fisheries management using a catch quota system.

The clusterization method is often used in grouping separate data into several groups with relatively similar resemblance (Fajriana, 2021). The relationship between the clusterization method and the context of capture fisheries management is that it can be used to identify and analyze the characteristics of fish species, fish populations, or fishing grounds that are similar to one another (Picaulima *et al.*, 2020). These characteristics can be used as a reference in developing management strategies that are more effective and in accordance with the conditions of each cluster. In clusterization, a spatial analysis is needed in mapping the habitats of fish species that includes targets and non-targets alike and can be used as information

on determining fishing grounds with the status of sustainable potential utilization levels in a waters (Harlyan *et al*., 2021) . Thus, capture fisheries in certain waters can be known both from developments and management taken according to water conditions, and existing resources can be utilized in a sustainable manner.

2. MATHEMATICS EQUATIONS

This research method uses several analyzes including species diversity analysis, clusterization analysis and spatial analysis. Species diversity analysis was performed using a richness index (*Margalef*) and a diversity index (*Shannon-Wienner*). Analysis of diversity is an indicator of the sustainability of an ecological system, so the purpose of this analysis is to determine habitat degradation, fragmentation and extinction in a waters (Irni, 2021). The equation formula to determine the *Shannon-Wienner* diversity index (*S-W,H'*) and *Margalef* richness (R'), as follows:

$$H' = -\sum_{i=1}^{s} pi \ln pi \quad (1)$$

Details:
H' = *Shannon-Wienner* Diversity Index
pi = Total amount of each species

$$R' = \sum \frac{s-1}{\ln N} \quad (2)$$

Details:
R' = *Margalef* Diversity Index
N = Total amount of marine population

$$S = \frac{s-1}{\ln N} \quad (3)$$

Details:
S = Diversity Index
s = Total amount of observed species
n = Total amount of observed individual species

Clusterization analysis is an analysis required to minimize the objective function and variation within a particular cluster. Clusterization analysis was carried out using the HCA (*Hierarchical Cluster Analysis*) method, the data used in this analysis is catch and gear data. The HCA method is carried out using the help of *R – Studio software*. The clusterizationanalysis formula used in this study is as follows:

$$d_{ij} = \sqrt{\sum_{k=1}^{p} = (X_{ik} - X_{jk})^2} \quad (4)$$

Details:
d_{ij}= Distance between object i and object j
X_{ik}= Object I value in variable k
X_{jk}= Object j value invariable k
ρ = amount of observed *variable*

Lastly, spatial analysis was carried out, with data in the form of clustering analysis results and fishing coordinate points obtained from *participatory mapping* activities of local fishermen. Mapping of fishing grounds is carried out to determine the location of species diversity, types of fishing gear and indications of competition between fishing gear in the waters. The *software* used in this analysis is *ArcGis 10.8 software*, by *plotting* which is then *overlayed* (overlapping technique), while the output obtained from this spatial analysis is a map of the distribution of fishing areas based on species diversity, types of fishing gear and competition between fishing gear.

3. RESULT

The fishing areas obtained during the study consisted of 117 fishing coordinate points, which can be seen in (Figure 1) where each circle diameter on the map indicates the type of fish and the number or kilograms of catch obtained by the fishing fleet in that area. In general, before carrying out fishing activities, local fishermen determine the fishing location in advance using traditional methods such as belief/instinct which is usually carried out by people who have been fishing for a long period of time, natural signs or weather conditions, areas that have has long been a location or point of regular fishing, and then fishermen's word-of-mouth.

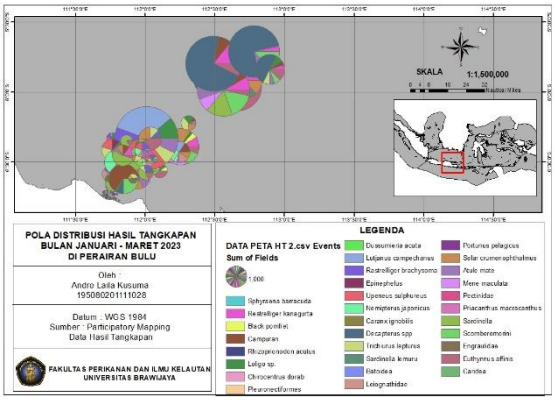

Figure 1. Map of Marine Catch in January - March 2023 in Bulu Waters

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Diversity Analysis

Species Diversity

Based on research that has been conducted in Bulu Waters, the results obtained from the calculation of the diversity index are as shown in (Figure 2), where darker colored dots indicate higher species diversity and there are several overlapping points. The distribution of species diversity found in Figure 2 among them has a diversity index with a value range of 0-2 spread across Bulu Waters, also obtained a fairly close range of values. Based on the results of digitization of the distribution of the species diversity index, it was found that the group with the highest value was in the waters with coordinate points (6º10'00" - 6º30'00" LS and 111º40'00" - 112º40'00" E).

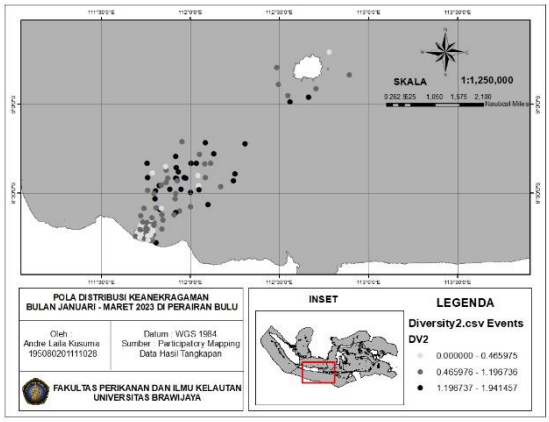

Figure 2. Distribution of Marine Species Diversity from January – March 2023 in Bulu Waters

Species Richness

Based on research that has been conducted in Bulu Waters, the results obtained from calculating the richness index are as shown in Figure 3, where the richness index in Bulu Waters is obtained with a value range of 1-10. Species richness results with darker colors indicate high levels of richness. Calculation of the species richness index in Bulu waters resulted in 3 categories. The value of the richness index in Bulu Waters has a fairly close range of values. The distribution of categories with species richness values contained in (Figure 3) also found several fishing points that overlapped. '00" South Latitude and 111º40'00" – 112º50'00" East Longitude).

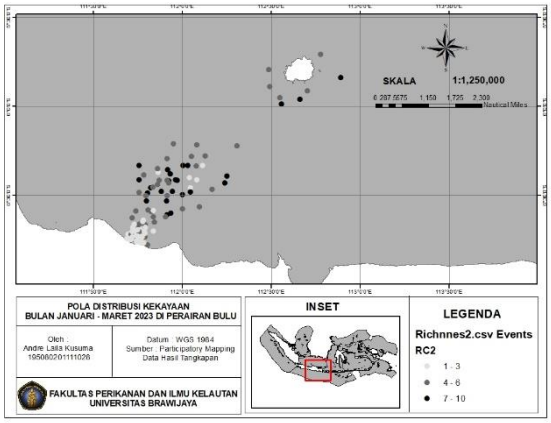

Figure 3. Distribution of Species Diversity within January – March 2023 in Bulu Waters

Fishing Gear Distributions

Based on the results of the digitization that has been done, it can be seen that (Figure 4) the distribution of fishing gear in Bulu Fisheries is divided into 3 locations including points with a circle shape indicating the use of purse seine fishing gear which are spread between a distance of 10-100 miles approaching Bawean Island, then the second location indicated by a square dot is the use of Payang fishing gear which is spread between 10-30 miles from the UPT PPP Bulu pier. The third location is indicated by a point in the form of a triangle, pentagon and octagon. These three forms represent the use of mini trawls, traps, and gillnets. All three have the same fishing area so that they are categorized into one location, the fishing area for the fishing gear has a distance of 1-13 miles from the UPT PPP Bulu pier.

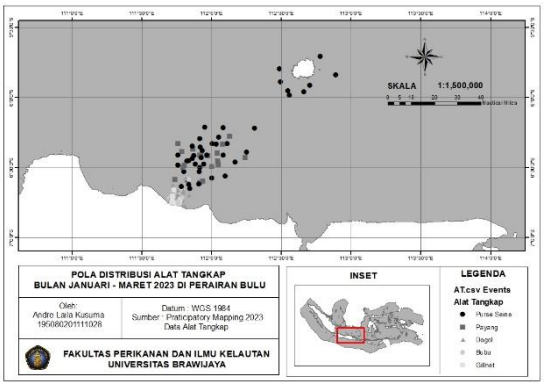

Figure 4. Fishing Gear Distribution from January – March 2023 in Bulu Waters

Area Clusterization According To Fishery Catch

This cluster shows that the fishing grounds are divided into 3 groups where the group with category 1 having a larger number of samples, namely around 108 samples from the total catch, category 2 showing the group with the least number of samples, namely 2 samples, while category 3 shows that the number of samples incorporated was slightly more than category 2 or as many as 7 samples.

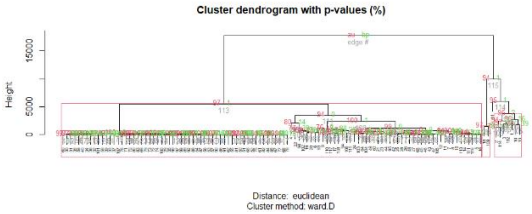

Figure 5. DPI Clusterization Dendogram Berdasarkan based on Catch from January - March 2023 in Bulu Waters

The distribution pattern of fishing areas formed in (Figure 6) shows the results of DPI clusterization based on catch. The location in cluster 1 is indicated by a red fishing point. Cluster 2 is marked with a yellow fishing area point. Cluster 3 is marked with a blue fishing area point. Based on the analysis that has been carried out, it can be seen that each cluster that is formed does not have overlapping fishing ground points.

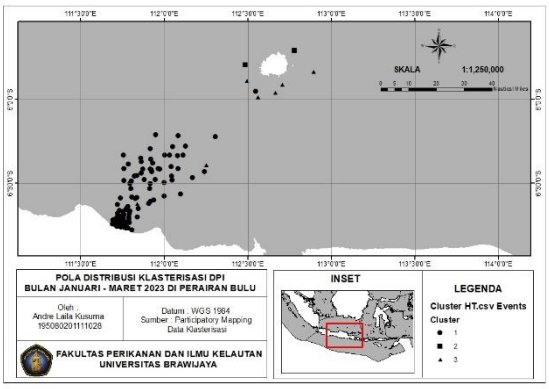

Figure 6. Distribution of DPI Clusterization DPI based on Catch from January – March2023 in Bulu Waters

The proportion of species obtained from the results of clustering analysis in Bulu Waters, Tuban Regency can be seen in (Figure 7), where the results formed into three adjacent clusters. Cluster I was obtained with a cumulative weight percentage of 52% of the total catch and is the cluster with the highest number of species, this cluster consists of all species caught in Bulu Waters. Cluster II was obtained with a cumulative weight percentage of 16% consisting of 6 species caught. Finally, cluster III was obtained with a cumulative weight percentage of 32% which consisted of 15 species of catch. among them are *Restrelliger kanagurta*, *Rhizoprionodon acutus, Decapterus spp*, *Atule mate*, *Scomberomorini*, *Euthynnus affinis*. Based on the acquisition of fish species in each cluster, the average fish species are included in the category of demersal and small pelagic fish.

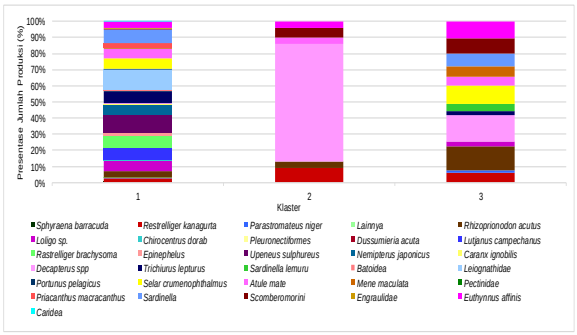

Figure 7. Species Proportion within Every Clusters in Bulu Waters

Fishing Gear Clusterization Based On Fishery Catch

Based on the results of the research that has been obtained, this research was conducted to determine the similarities between the characteristics possessed by fishing gear on the acquisition of catches. The clusterization carried out on the type of fishing gear is based on the similarity of the fishing gear used and the target catch(Sari *et al.*, 2015).

The results of the analysis that has been carried out can be seen that there are 2 clusters formed on the dendogram (Figure 8), where cluster I is indicated by two fishing gears that have close proximity, namely traps (4) and *gillnets* (5), while cluster II shows that there is closeness between fishing gear, namely purse seine (1), Payang (2), and Dogol / mini trawl (3). The components of cluster I proximity are found in other catches, these catches consist of various species that are not the main catch. Proximity to cluster II is composed of catches consisting of *Loligo sp*, *Rastrelliger brachysoma*, *Trichiurus lepturus*, *Selar*

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crumenophthalmus, *Sardinella*, *Scomberomorini*, *Engraulidae*, and mixed catches.

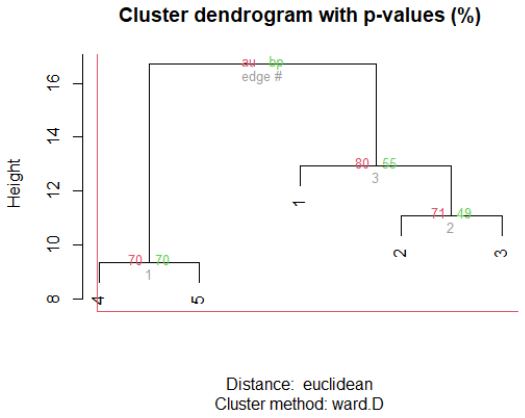

Figure 8. Fishing Gear Clusterization Dendogram based on catch from January - March 2023 in Bulu Waters

Obtained dendogram results are then reprocessed using spatial analysis to determine distribution patterns of fishing gear clusterization based on catches. In (Figure 9) cluster I is shown with a red dot, while cluster II is shown with a red dot.

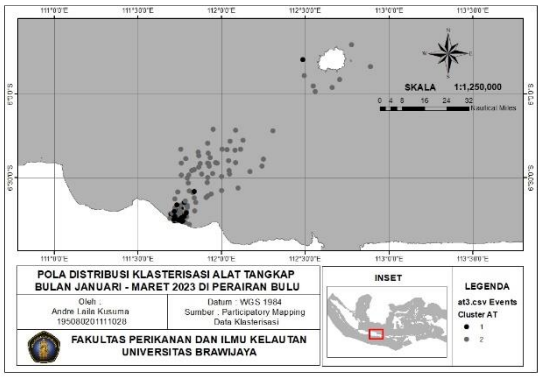

Figure 9. Distribution of Fishing Gear Clusterization based on catch from January - March 2023 in Bulu Waters

4. DISCUSSION

Fisheries in the tropics have elements of high complexity with characteristics such as variations in target species, fishing gear, catches and fishing techniques that are very dynamic, as well as changes depending on season and space (Sudarmo *et al.*, 2013). Bulu waters are included in the Wilayah Pengelolaan Perikanan Negara Republik Indonesia (WPPNRI; lit. Republic of Indonesia Fisheries Management Area) 712. North Java waters area of WPPNRI 712 has a level of utilization of small pelagic fish resources, most of which have been said to be over-exploited. In this situation the condition of the existing fisheries has entered a critical stage with extraction rates that exceed the ability of these resources to regenerate (Khatami *et al.*, 2019). The decrease in the ability of fish resources to regenerate will cause the number of fish stocks to decrease. Limitations that exist in environmental or market variability can also affect the way fishermen exploit these resources (Sudarmo *et al.*, 2013b). One of supports that can be given to fix the problems with fish resource stocks is by utilizing information about catches, types of fishing gear and fishing areas in these waters. The accuracy of the data obtained can be a basis for managing fishing activities in Indonesia, which has so far experienced improvements (Sari, 2021). This information can then be used as a reference for decision making, so that it can be used to determine better capture fisheries management policies.

There were 117 samples obtained from this study, the composition of the catch obtained during the study was dominated by *Decapterus spp*, *Sardinella* and other bycatch. The amount of catch is influenced by present natural factors including the weather and environmental conditions of the waters (Khatami *et al.*, 2019). Other factors are also found in coastal areas where problems often occur, such as environmental pollution which results in a decrease in the carrying capacity and living resources of the coast and sea (Shabrina *et al.*, 2021).

Research on species diversity has been carried out a lot, generally the selection of variable characteristics used still uses the same characteristics, namely the use of one type of species. In this study there are various species that can be studied to determine the level of species diversity. Thus, an analysis of species diversity was conducted to determine the structure and stability of a community. The results of this analysis are used to support the distribution and abundance of catches in these waters. Information about species composition and diversity is needed because by knowing the index of diversity, richness and balance of the species, so that the condition of the environmental community can be known

(Wahyunungsih *et al*., 2020). Based on the analysis of species diversity, specific information was obtained regarding the diversity and richness spread across Bulu Waters. Species diversity in Bulu waters has a value interval of 0 – 2, where it is known that the level of species diversity in Bulu waters is in the low category. This statement is supported by (Dimenta *et al.*, 2020) that the species diversity index with a value range of 0<H'<2.302 is included in the low diversity category. The results of the calculation of the species richness index in Bulu Waters have a value interval of 1 – 10, where this value indicates the category of species richness in the waters is classified as high. According to (Wahyunungsih *et al*., 2020) the species richness index with a value range of D > 4 is included in the high category. The diversity index value category can be influenced by several factors including habitat availability, human disturbance, genetic diversity, interactions between species, environmental factors, and so on (Wijana *et al.*, 2014). A low diversity index value indicates that the environment is experiencing disturbances and pressure on the structure of organisms in that environment (Shabrina *et al.*, 2021).

The distribution of existing fishing gear does not escape the habitat of each fish species. In general, the way fishing gear operates depends on the movement pattern of the fish that are traveling or from the movement of the water itself (Fatah & Makri, 2010). Species diversity in a waters is also an indicator for the distribution of fishing gear, because the operation of fishing gear does not escape information on the species caught in a waters. Even though the results of species diversity and distribution of fishing gear in Bulu waters show this, the accuracy of the information is still lacking, so other analyzes are needed to understand fisheries data more holistically and make more informed decisions.

The clustering method allows to identify different patterns and groups in fishery data, so it is very helpful for planning better resource management strategies. Based on research that has carried out clustering analysis of fishing grounds based on catch results, it was obtained 3 clusters with different fishing ground plots, but the three clusters had the same fish species acquisition including *Restrelliger kanagurta, Rhizoprionodon acutus, Decapterus spp, Atule mate, Scomberomorini, Euthynnus affinis* with the highest amount of production is in cluster 3. This species is mostly found in waters close to Bawean Island. The variability of several fish species is associated with changes in salinity, where pelagic fish are spatially spread eastward with concentrations of abundance in the eastern part of the Java Sea. Changes in environmental conditions affect certain types of fish to make migrations such as flying fish and banyar which migrate with changes in water salinity. Changes in fishing seasons can also lead to changes in fishing areas. During the eastern season, flying fish and tembang fish are often found in the waters of the South China Sea, Masalima, Makassar Strait and Bawean. (Umi & Tuti, 2010). Based on the information obtained, it can be said that during the east monsoon, fish species with the highest production are found in the waters near Bawean Island.

Specifically, the clustering of fishing gear based on the catch was obtained with the results that formed into 2 clusters, but in the HCA calculation it was not obtained with an AU <0.95. If the results of the HCA calculation find that the AU value is not met, which is less than 0.95, then it means that the grouping of data that is done can still be increased. The reason for this is because the number of observations used is too small (Kassambara, 2017). Based on the research that has been done, it is found that cluster 1 is obtained by fishing gear that has close proximity, namely traps and gillnets and cluster 2 is obtained by the closeness between purse seine, payang, and dogol. This closeness is supported by the presence of the same catch species, besides that the operation of the fishing gear used makes it possible to have the same catch. This is evidenced by the fact that bottom gillnets are widely used by East Java Pantura fishermen, especially to catch blue crabs and some are devoted to catching economically important demersal fish such as gulamah fish (Yulianto *et al.*, 2019). Production and productivity actually have a relationship that explains the level of effectiveness of fishing gear used (Yonvitner *et al.*, 2020). The mortality rate of the same species can have different values depending on the density of competitors, predation and environmental conditions. The fishing mortality rate varies greatly and can be affected by fishing intensity,

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boat engine power, fish behavior, and habitat conditions (Setyawan & Fitri, 2018).

The results obtained from the clusters formed can be used as information in the form of distribution patterns used by fishermen, in addition to information in this form these results can also be used to determine better capture fisheries management policies. Possible policies can be established in the form of a system of limiting catch quotas for fish species that may be vulnerable to over-exploitation, as well as minimizing competition between fishing gear in these waters. Therefore it is necessary to have further studies regarding clustering and a temporal study is needed by observing catch data which is complemented by fishing grounds and more diverse types of fishing gear.

5. CONCLUSION

1. There were 31 species caught in Airan Bulu during January - March 2023. The diversity was dominated by 3 types of catch, namely flying fish, tembang, and by-catch. Flying fish and tembang are often found in the operation of purse seine fishing gear, while bycatch can be found in all fishing gear. The diversity of species in Bulu Waters can be said to be in the low to high category, but this cannot be a benchmark for all waters because each waters has a different level of ecosystem fertility.
2. There are 5 types of fishing gear in Bulu Waters, including purse seine, payang, dogol / mini trawl, trap, and gillnet. The most dominant fishing gear in these waters are purse seine and payang. The dominance of fishing gear is influenced by the production of the catch obtained. The distribution of fishing gear in Bulu waters is inseparable from the movement of species that are the main catch.
3. From the clusters formed, it can be seen that the distribution of the diversity of catches has differences. The cluster with the most types of species was obtained with a yield of 52% as many as 31 species were caught. The difference in the three clusters lies in the composition of the number and types of fish from each cluster, while the similarity of the three clusters is that they have the same 6 species of catch. The formation of existing clusters can be used as a reference in making decisions in determining the management of capture fisheries in Bulu waters.
4. From the formed clusters, it can be seen that traps and gillnets have the most dominant affinity. This statement is supported by the same species caught, namely bycatch, but the results obtained from the HCA calculation do not meet the criteria for AU > 0.95.

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