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Competition Pattern of Small-Scale Cluster-Based Capture Fisheries in Each Season in the Small Island Park Conservation Area of Southeast Maluku Regency, Indonesia

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ABSTRACT

Efforts to improve the welfare of small fishermen in the conservation area of small Kei Kecil Island Park by increasing the number of small-scale fishing fleets from year to year without effective and efficient management of fisheries managers have led to competition between fishery fleets, leading to overcapacity. This study aimed to determine the competition pattern of small-scale fishing fleets in the conservation area of small Kei Island Park every season based on clustering. This study used a survey method, selecting respondents by purposive sampling techniques. Data were analyzed using descriptive and cluster analysis of the square Euclidean distance method. In this study, the fishing grounds of small-scale fishing fleets each season were concentrated in the waters of ten islands. The dendrogram described the small-scale fishing fleets operating in the conservation area of small Kei Island Park, which were competed widely and fiercely in each season. Competition among the small-scale fishing fleet was intense during the western season in Cluster 1, the first transition season in Clusters 1 and 3, the eastern season in Clusters 1 and 3, and the second transition season in Clusters 1 and 3. Catches, revenues, and operating costs influenced the competition that occured in each season.

INTRODUCTION

Small Island Park (TPK) conservation area is one of four conservation areas included in the park category and managed by the Ministry of Marine Fisheries (MMAF); this conservation area is designated for the protection, preservation, and utilization of biodiversity and fish resources, and serves to maintain and improve the quality of biodiversity **(KKP Indonesia, 2020)**. One of the TPK conservation areas in the Maluku Islands is the small TPK Kei conservation area in Southeast Maluku Regency, which was reserved in 2012 by the Regent of Southeast Maluku and determined by the MMAF through the Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia Number 6 / Kepmen-KP / 2016. The management of the area is currently under the authority of the Maluku Provincial government by Law No. 23 of 2014. This small TPK Kei conservation area has an

area of 150,000 Ha and has three limited utilization zones: the cultivation zone, tourism zone, and capture fisheries zone. TPK Kei Kecil Conservation Area is administratively located in four sub-districts: Kei Kecil, Manyeuw, Hoat Sorbay, and Kei Kecil Barat. The small TPK Kei conservation area is a potential fishing area for small fishermen in the four sub-districts every season.

The strategy to be achieved by the Ministry of Marine Fisheries as conservation area management is to make conservation areas an economic driver as a form of social responsibility to improve the welfare of coastal communities **(Bahtiar, 2012; KKP Indonesia, 2013)**. Therefore, one of the efforts made by the government to improve the welfare of coastal communities in the small TPK Kei conservation area is to increase production and income by increasing the number of small-scale fishing gear from year to year. The number of fishing gear operating in the small TPK Kei conservation area until 2022, according to the sub-district, is small Kei sub-district with 1,966 fishing gear, Manyeuw with 1,599 fishing gear, Hoat Sorbay with 1,272 fishing gear and West Kei small with 1,168 fishing gear **(DKP Southeast Maluku Regency, 2022)**.

The increase in the number of small-scale fishing gear as a form of increasing fishing efforts in the small TPK Kei conservation area, which is multi-gear and multi-species, and the regulation of fishing efforts that have not been effective and efficient by fisheries managers make fisheries production tend to decrease, in 2021 the amount of small fishermen's production from four sub-districts around the small TPK Kei conservation area amounted to 53,577.4 tons but in 2022 decreased by 53,404.7 ton **(DKP Southeast Maluku Regency, 2022)**. Increasing fishing efforts amid declining fish resources in a fishing ground can cause competition between capture fisheries equipment in the fishing ground **(Budiarti *et al*., 2015)**. Small-scale fishing fleet competition is a technical interaction between fishing gear in seizing fishing grounds **(Boncoeur *et al*., 1998; Rijnsdorp *et al*., 2000)** and similar fish resource targets **(Ulrich *et al*., 2001)**. Therefore, tight fishing gear competition in each season and fishing grounds show symptoms of overcapacity **(Hufiadi & Wiyono, 2009)**.

Overcapacity indicates the technical, biological, and economic fishing pressure on fish resources that can reduce catch and ecological fishing grounds in the small TPK Kei conservation area. Therefore, to realize effective and efficient small-scale fisheries in the small TPK Kei conservation area, it is necessary to cluster small-scale fisheries fleets in each season based on the function of small-scale fishing fleets, catch, income, and operational costs **(Picaulima *et al*., 2020)**. Small-scale fishing fleet clustering is used to identify the relationship of fishing gear proximity based on the similarity of catches and numbers **(Wiyono, 2012)**. By clustering several small-scale fishing fleets into one cluster, several fishing fleets are suspected to have close relationships and compete **(Sari *et al*., 2015)**. The cluster's distance is far from the zero point, and the fishing fleet does not compete with each other; on the contrary, the cluster distance close to the zero point shows that the fishing fleet is competing fiercely **(Hakim *et al*., 2018)**. Therefore, it was essential to study the clustering of small-scale fishery fleets in the small TPK Kei conservation area to obtain information on competing small-scale fishery fleets so that they can obtain the optimal number and type of inputs in the small TPK Kei conservation area. This study is helpful for small TPK Kei conservation area managers to be more effective and efficient in making policies for the

sustainability of fish resources and improving the welfare of small fishermen in small TPK Kei conservation areas.

MATERIALS AND METHODS

This research was conducted from May to October 2023 on 13 Ohoi coastal areas of western Kei Kecil and small islands that utilize the small TPK Kei conservation area as a fishing ground (Fig. 1). The data used in this study included data, fishing grounds, operational costs, income, and catch in each season. The data collection method involved a survey using interviews, questionnaires, and observation techniques. Respondents were determined based on purposive sampling techniques provided that small fishermen have experience in fishing operations for more than five years and fishing grounds in each season in small TPK Kei conservation areas, vessel capacity of less than 10 GT **(DKP Indonesia, 2016)**, and operate one or two dominant fishing gear in small TPK Kei conservation areas, lift net, purse seine, long line, gillnet, harpoon and hand line. The number of respondents obtained in this study was 130 units.

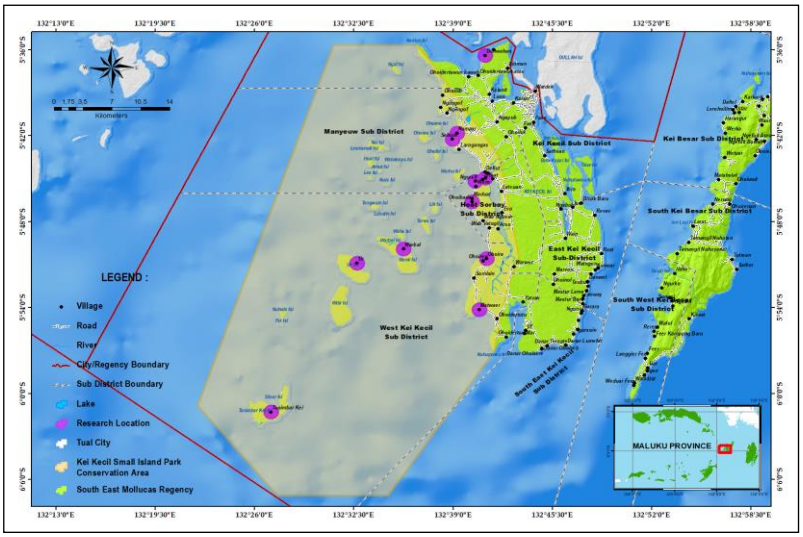

Fig 1. Map of the study in conservation areas TPK Kei is a small of Southeast Maluku Regency, Indonesia

1. Identification of the fishing ground

Identification of fishing ground was carried out to determine the fishing ground of small fishermen from lift net, purse seine, long line, gillnet, harpoon, and hand line operating in each season in the small TPK Kei conservation area. The fishing grounds of small fishermen in the small TPK Kei area always vary every season, variations in fishing grounds are a form of increased fishing effort in obtaining catches **(Nelwan *et al.*, 2011)**. Identifying fishing grounds begins with submitting a grid map measuring 1 x 1km to small fishermen to mark fishing grounds each season. Then, it was transformed into the Google Earth program to find out latitude and longitude, then tabulated into a Microsoft Excel spreadsheet and processed with Arc Map software to produce a map of the location of the fishing ground of each small-scale fishing fleet in each season.

2. Clustering

Clustering was carried out to determine the competition pattern of small-scale fishery fleets in the small TPK Kei conservation area in each season. Clustering was based on operating costs, catches, and revenue variables. The characteristics of small fishermen drive the competition of fishing fleets that occur in each season, as they consistently seek fishing grounds with high catches, provide a decent income and low operational costs **(Sudarmo *et al*., 2013)**, and less effective and efficient fishing efforts by fisheries managers **(Budiarti *et al*., 2015)**. Clustering begins with an analysis of operational costs, revenues, and catches.

The results of the analysis of operational costs, revenues, and catches based on fleet type in each season were then grouped based on similar characteristics using cluster analysis through SPSS 23 software. In SPSS 23, Hierarchical Clustering Analysis (HCA) analysis with agglomerative type was visualized with a dendrogram, where each object or observation was considered a separate cluster. In the next stage, two similar clusters were combined into a new cluster. The clustering of small-scale fishing fleets based on variable operational costs, catches, and revenues into one cluster with a cluster distance close to zero indicated that competition between small-scale fishing fleets was getting tighter **(Picaulima *et al.*, 2020)**. Cluster analysis was carried out using the squared Euclidian distance method to measure the distance of the similarities between the objects being tested. Matrix proximities was used to show matrix distances between one variable and another. The smaller the space, the more similar the two variables will be so that they will form a group (cluster). The squared Euclidean distance formula was used **(Yulianto & Hidayatulah, 2014)** as follows:

$$(x, y) = \sqrt{(\sum_{i=1}^{d} (x_1 - y_1)^2}$$

Where, $x = (x_1, x_2, x_3, \ldots\ldots x_d)$, $y = (y_1, y_2, y_3, \ldots\ldots y_d)$ is with two data objects with d-attributes. Clusters are formed using the agglomerative method (between group linkage), where each object or observation is considered a separate cluster. The agglomeration process will eventually unite all objects into one cluster interpretation of cluster analysis results that have been carried out using dendrogram visualization. Dendrograms are helpful to make it easier to provide a visual picture of small-scale fishing fleet competition according to existing clusters as desired by the number of clusters formed. Determination of the number of clusters in the study was based on distance and usability **(Simamora, 2005; Ramadhani *et al*., 2018)**. The last stage of interpretation of cluster results aimed to describe the contents and to find out the competency profile of each cluster formed from the average of each cluster on each object.

RESULTS AND DISCUSSION

Fishing ground

A fishing ground (DPI) is an area that is a habitat for fish and a potential target for fishing, and there are schools of fish with high economic value in the area. Therefore, the characteristics of a fishing ground are that the fishing ground must be easily visited by fish groups and a good habitat for fish, the area is easy to operate fishing ground, and is

economically valuable **(Tadjuddah, 2017)**. The small Kei TPK conservation area is located in the waters of western Kei Kecil Island. The fishing ground of small-scale fishing fleets in the area is close to the coast **(Sudarmo *et al.*, 2015)**. Moreover, its existence is highly dependent on fish resources and the environment **(McClanahan *et al.*, 2009)**. Fishing ground located in the small TPK Kei conservation area is generally within the utilization zone in the waters of Ngaf and Ohoiew Islands, Sepuluh Islands (Warhu, Tanwala, Lea, Nuhura, Amut, Nuhikaha, Nai, Hoat, Ohoiwa, and Ohoitir), Lima Island (Manir, Warbal, Tarwa, Lik, and Labulin), Tanimbar Kei Island (Tanimbar Kei and Nuhuta). The fishing grounds always vary in each season and tend to be the same yearly. This condition has become a habit and experience for generations for small fishermen. Fishermen in Indonesia tend to rely on intuition or instincts passed down from generation to generation by their ancestors when choosing fishing grounds **(Prayanda *et al.*, 2018)**.

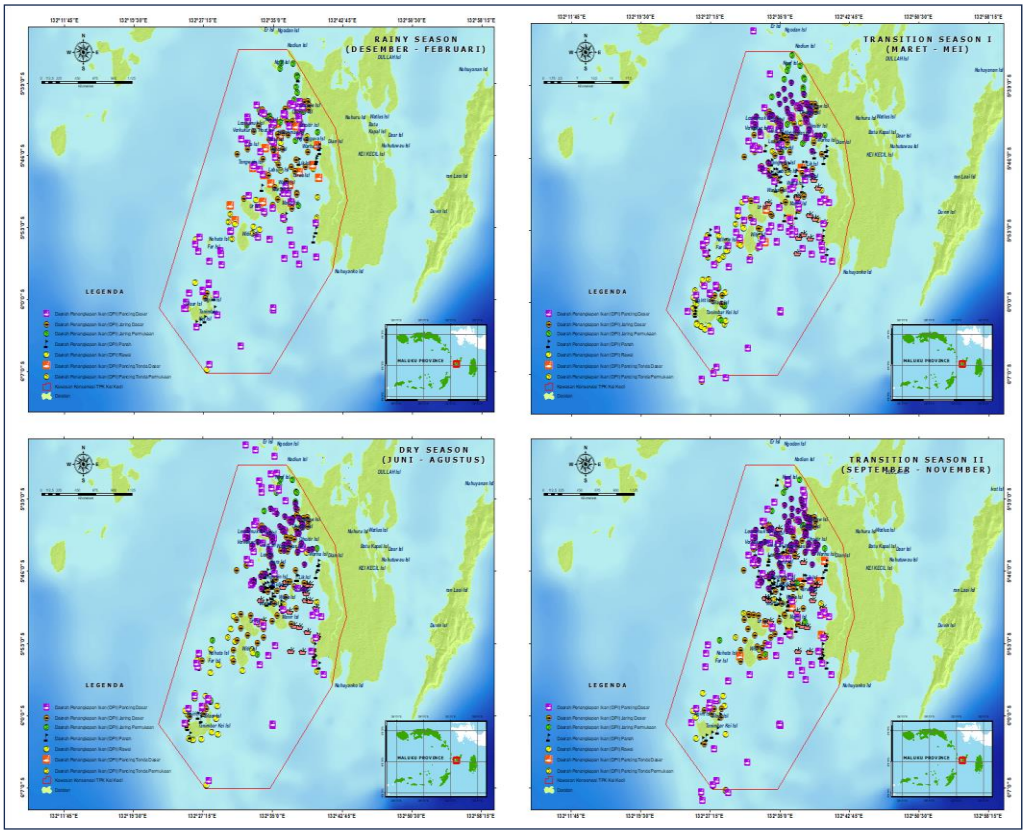

Fig 2. Small-scale fishing fleet fishing grounds in conservation areas, the small TPK Kei in every season

The potential small-scale fishing fleet fishing ground in the TPK Kei small area in the rainy season, transition season I, dry season, and transition season II were found to be concentrated in the waters of Sepuluh Island, with the highest fishing fleet intensity occurring in the transition season II season while the lowest intensity in the rainy season. In the fishing grounds in Lima Island and Tanimbar Kei, the fishing fleet spreads evenly, with high intensity occurring in transition season I and transition season II. In contrast, the lowest

fishing fleet intensity occurs in the rainy season. In the dry season, there is a dominance of specific fishing fleets on fishing grounds (Fig. 2).

The low intensity of fishing fleets operating in the rainy season in the fishing grounds of Sepuluh Island, Lima Island, and Tanimbar Kei, especially Ngaf and Ohoiew islands, due to the rainy season, the wind blows from the north-northwest to the east southeast with an average wind speed of 4.73m/ s and an average rainfall of 13.07mm. As a result, the sea conditions in the small TPK Kei conservation area are very bumpy. Therefore, the fishing grounds of small fishermen in the western season are in coastal areas included in the cultivation zone and tourism zone as well as the core zone **(Makalaipessy *et al*., 2018)**. According to **Harahap *et al*. (2019)**, the sea is surging with high currents in fishing grounds, hence fishermen tend to carry out fishing operations near the coast.

The dominant small-scale fishing fleets carrying out fishing operations this season are generally passive, gillnets, hand line, and harpoon with catches of reef fish, demersal, and pelagic with high economic value and their habitat in coastal waters. The fishing fleets are evenly distributed, and there is a high intensity of fishing fleets in the four fishing grounds because in transition season I, the wind speed is 4.03m/ s, and rainfall is 16.19mm. In contrast, the transition season 2 wind speed is 4.57m/ s, and rainfall is 11.73mm. This shows that the wind speed in transition season II is higher than in transition season I and vice versa. The rainfall in transition season 1 is higher than in transition 2, but the direction of the wind blowing in both seasons is not one direction or back and forth. This condition makes the waters in the small TPK Kei conservation area smoother. Thus, the fishing ground of small-scale fishing fleets in conservation areas began to shift towards the deep sea and spread to the south but still within the utilization zone.

The operating fishing fleet is generally passive and active, with catches being demersal and pelagic fish. In the dry season, the fishing grounds of Sepuluh Island, Lima Island, Tanimbar Kei, Ngaf Island, and Ohoiew are dominated by specific fishing fleets because, in the dry season, the wind blows from the east-southeast to the north-northwest at a speed of 4.87m/ s and rainfall of 14.73mm, high wind speed causes upwelling in the coastal area of the small TPK Kei conservation area. This makes the fishing grounds in the conservation area very fertile and very economical for pelagic fishing fleets such as purse seine and bagan. Fishing grounds are economical since they provide large catches and fish resources that have high economic value **(Ayodhyoa, 1981)**.

Small-scale fishing fleet competition

Small-scale fishing fleet competition can occur because the fishing ground is not too far away due to the wind season, fish season, fishing technology, fish resource conditions, as well as fleet capacity, and similar catch composition **(Sari *et al*., 2015; Hakim *et al*., 2018)**. Fishing fleet competition is always dynamic in each season because the distribution of fishing gear in fishing grounds varies in each season, which aims to catch as many fish as possible so that the income obtained is higher than operational costs **(Sudarmo *et al*., 2013)**. Clustering is carried out based on catches, income, and operational costs in small-scale fishing fleets that have rowing propulsion, 6 Horsepower or Paardenkracht (PK), 6.5 PK, and 15 PK in small-scale fishing fleets operating in small TPK Kei conservation areas, showing that in the rainy

season, transition season I, and transition season II form three clusters and dry season form four clusters. The complete number of clusters is shown in Table (1).

Table 1. Grouping three and four small-scale fishing fleet clusters in the small TPK Kei area each season using average linkage

Cluster	Reany season	Transit season I	Dry season	Transit season II
	Small-scale fishing fleet	Small-scale fishing fleet	Small-scale fishing fleet	Small-scale fishing fleet
Cluster 1	Bottom gillnet rowing, Bottom gillnet 6 PK, Bottom gillnet 15 PK, Surface gillnet 6 PK, Surface gillnet 15 PK, Harpoon rowing, Harpoon 6 PK, Harpoon 15 PK, Hand line rowing, Hand line 6.5 PK, Hand line 15 PK.	Raft lift net, Bottom gillnet 15 PK, Bottom troll line 15 PK, Surface troll line 15 PK	Raft lift net, Longline 15 PK, Surface troll line 15 PK	Raft lift net, Purse seine 15 PK, Surface troll line 15 PK
Cluster 2	Long line 6.5 PK, Bottom troll line 15 PK	Boat lift net	Boat lift net	Boat lift net
Cluster 3	Longline15 PK, Surface troll line 6.5 PK, Surface troll line 15 PK.	Bottom gillnet rowing, Bottom gillnet 6 PK, Surface gillnet 6 PK, Surface gillnet 15 PK, Harpoon rowing, Harpoon 6 PK, Harpoon 15 PK, Hand line rowing, Hand line 6.5 PK, Hand line 15 PK, Purse seine 15 PK, Longline 6.5 PK, Longline 15 PK, Surface troll line 6.5 PK.	Bottom gillnet rowing, Bottom gillnet 6 PK, Bottom gillnet 15 PK, Surface gillnet 6 PK, Surface 15 PK, Harpoon rowing, Harpoon 6 PK, Harpoon 15 PK, Hand line rowing, Hand line 6.5 PK, Handl ine15 PK, Longline 6.5 PK, Surface troll line 6.5 PK	Longline 15 PK, Bottom gillnet rowing, Bottom gillnet 6 PK, Bottom gillnet 15 PK, Surface gillnet 6 PK, Surface gillnet 15 PK, Harpoon rowing, Harpoon 6 PK, Harpoon 15 PK, Hand line rowing, Hand line 6.5 PK, Hand line15 PK, Longline 6.5 PK, Bottom troll line 15 PK, Surface troll line 6.5 PK
Cluster 4	-	-	Purse seine 15 PK	-

Based on the number of clusters determined each season, a dendrogram describing the level of competition of small-scale fishing fleets each season in the small Kei TPK conservation area can be seen in full in Fig. (3). The results of the dendrogram analysis in Fig. (3) show that, in the rainy season, competition is tight in cluster 1. The competition that occurred in cluster 1 consisted of two groups, namely the first group, competition occurred between the bottom gillnet rowing fishing fleet, harpoon 6 PK, hand line rowing, and the second group among the bottom gillnet fishing fleet 16 PK, surface gillnet 6 PK, bottom gillnet 15 Pk hand line 6.5 PK. In the transition season I, competition was tight in clusters 1 and 3. The first cluster of competition occurred between the bottom gillnet fishing fleet 15 PK, bottom troll line 15 PK, surface troll line 15 PK and cluster 3 among the fishing fleets bottom gillnet rowing, bottom gillnet 6 PK, surface gillnet 6 PK, surface gillnet 15 PK, harpoon rowing, harpoon 6 PK, harpoon 15 PK, hand line rowing, hand line 6.5 PK, hand line 15 PK, purse seine 15 PK, long line 6.5 PK, long line 15 PK, surface troll line 6.5 PK. In the dry season, tight competition occurs in cluster 1 between the long line 15 PK fishery fleet and the 15 PK surface troll line. Cluster 3 tight competition occurs in two groups, namely the first group among the bottom gillnet rowing fishing fleet, bottom gillnet 6 PK, surface gillnet 6 PK, surface gillnet 15 PK, harpoon rowing, harpoon 6 PK, harpoon 15 PK, hand line

rowing, hand line 6.5 PK, hand line15 PK. The second group is bottom gillnet 15 PK, surface troll line 6.5 PK, long line 6.5 PK.

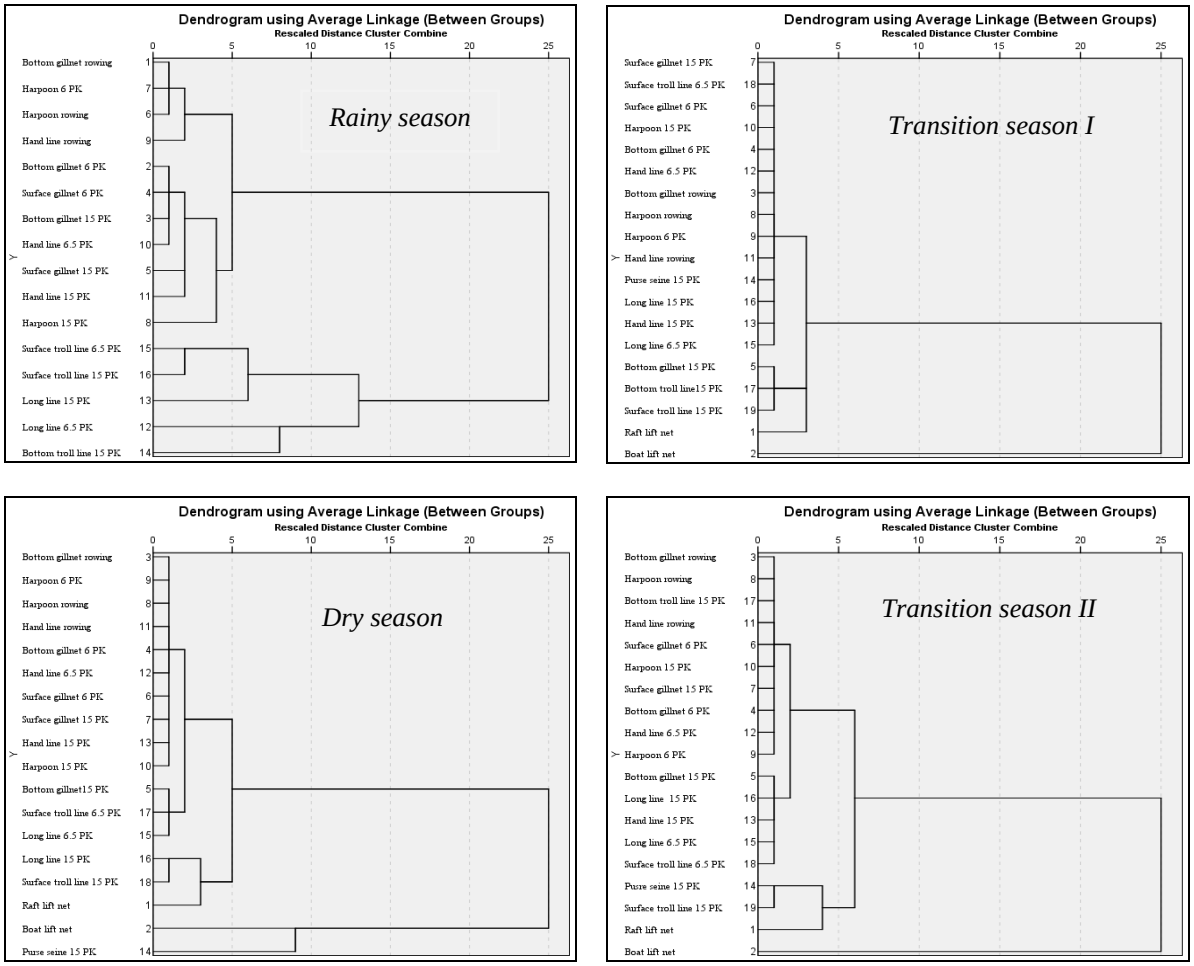

Fig. 3. Dendrogram clustering of small-scale fishery fleets in conservation areas, TPK Kei is small in every season

In transition season II, intense competition occurred in cluster 1 among the purse seine fishing fleet 15 PK and surface tonda 15 PK, and cluster 3 consisted of two groups. The first group occurred between bottom gillnet rowing, 6 PK bottom gillnet, 6 PK surface gillnet, 15 PK surface gillnet, rowing harpoon, 6 PK harpoon, 15 PK harpoon, hand line rowing, 6.5 PK hand line, 15 PK bottom troll line, and the second group occurred between the fleet of 15 PK longline, 15 PK bottom gillnet, 15 PK hand line, 6.5 PK longline, 6.5 PK surface troll line.

The competition of fishing fleets is strictly shown by the clustering of small-scale fishing fleets in one cluster, having the same distance and approaching the zero point. The distance formed shows the inequality of catch, income, and operational costs between clusters in each season's fishing operations. Therefore, the level of competition that occurs strictly in each cluster and season based on fleet functions, namely catches, revenues, and operational costs, can be seen in Fig. (4).

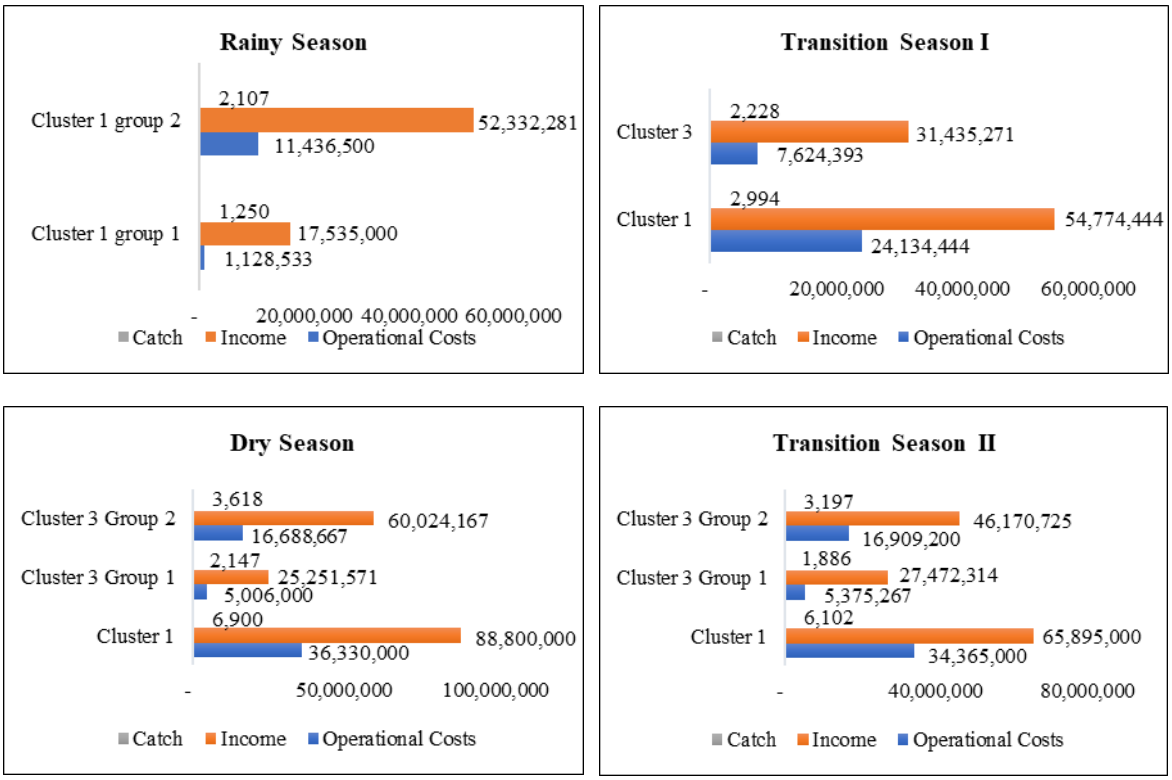

Fig. 4. The level of competence that occurs is strictly based on the average operational costs, income, and catch in each cluster and season of small-scale fishing fleets in the small TPK Kei conservation area

Fig. (4) shows that the highest level of competition among small-scale fishing fleets occurs during the dry season, particularly in Cluster 1 among pelagic fishing fleets such as the 15 PK longline and the 15 PK surface troll line. This intense competition is associated with the highest average operational costs, income, and catch. Conversely, the lowest level of competition, marked by lower operational costs, revenue, and catch, occurs during the rainy season, especially in Cluster 1, Group 1, among demersal fishing fleets, including bottom gillnet rowing, 6 PK harpoon, and handline rowing.

Competition is tight among small-scale fishing fleets because the fishing ground each season is in a small TPK Kei conservation area low distance from the home base. The fleet capacity is generally less than 2 Gross Tonnage (GT) using rowing and 6, 6.5, and 15 PK outboard motors. This condition causes the operational costs used in each fishing operation to be manageable. The monsoon that occurs in the TPK Kei conservation area with ever-changing speed and direction makes the fishing ground of small-scale fishing fleets always vary. The small TPK Kei conservation area is located in the waters of the western part of Kei Kecil Island. Therefore, during the rainy season, the

waters are very bumpy, so the fishing ground of small-scale fishing fleets is on the coast of small islands. This condition makes the fishing fleet compete fiercely and highest in the demersal fishery fleet operating in the coastal areas of small islands against *Lethrinus lentjan* fish resources, *Carangoides bajad, Siganus lineatus, Skarus dimidiatus,* and *Parupeneus indikus*. The habitat of these fish resources is close to the coast in coral and seagrass areas at a depth of < 15m with a sandy substrate type **(Sudarmintha *et al*., 2018)**. In the dry season, high wind speeds from the east make upwelling occur in the coastal areas of the small TPK Kei conservation area. Hence, the fishing area in the conservation area is very productive, and competition is tight in pelagic and demersal fishing fleets. However, the highest level of intense competition occurs in pelagic fishing fleets. In transition season I, the wind speed began to increase with the entry of the dry season. In transition season II, the wind speed began to decrease after the dry season with erratic wind direction, causing the waters of the TPK Kei conservation area to be small in both seasons and less bumpy so that competition occurred strictly in the demersal and pelagic fishing fleets. However, the highest level of intense competition occurred in the demersal fishing fleet during the first transition season due to the lingering influence of the western season, and in the pelagic fishing fleet during the second transition season due to the ongoing influence of the eastern season. This condition indicates that competition among small-scale fishing fleets in the small TPK Kei conservation area is intense as they strive to maximize their catches, which hold significant economic value, each season to increase their income. During the transition season I, dry season, and transition season II, pelagic fishing fleets, such as the boat lift net and raft lift net fleets, experience a low level of competition within a single cluster compared to other small-scale fishing fleets. This is because these fleets have large capacities and target species like *Stolephorus indicus* and *Stolephorus commersonnii* during the dry season, and *Decapterus ruselli* during transition season I, operating primarily at night. On the other hand, the purse seine 15 PK fishing fleet, despite having smaller capacity and operating twice a day, focuses on *Auxis thazard* during the dry season, which is the peak season for this species.

CONCLUSION

Intense competition in the fishing grounds of the small TPK Kei conservation area, with varying levels each season, is driven by similar high catches, efforts to increase fleet revenues, and low operational costs. This competition significantly impacts the ecological conditions and the potential of specific fish resources in the conservation area. Therefore, information about the close competition among small-scale fishing fleets can serve as a reference for the Maluku Provincial Government to develop policies aimed at limiting the use of competing fishing gear. These policies could help maintain fish resource stocks and provide alternatives for fishermen to choose more practical and sustainable fishing gear.

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