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CLUSTERING CHARACTERISTICS OF SMALL-SCALE CAPTURE FISHERIES IN PRIGI, EAST JAVA

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ABSTRACT

Small-scale capture fisheries condition is multi gear and multispecies has an impact on increasing the pressure of fish condition. The information related to fisheries resource status is very essential in order to build sustainable fisheries management planning. This study aims to analyze the level of fishing gear productivity, clustering of fishing gear based on the number of catch fish in Prigi, East Java. These study results are expected as sustainable small-scale fisheries management recommendations. This research methods were used the analyzed of diversity by Shannon-Wiener index, catch per unit effort (CPUE) and clustering of fishing gear based on a combination between principal component analysis (PCA) and hierarchical cluster. The results showed that the composition of the catch in each fishing gear was varied. The highest diversity of fish used gillnet as fishing gear. In general, the type of fishing gear with the most catches in AFP Prigi is handline, meanwhile scoop net became the highest CPUE of fishing. Clustering of fishing gear tends to be the same with varying proximity and gillnet fishing gear is a fishing gear that tends not to group with other tools. This study resulted that the clustering of fishing gear tends not to change in the last 10 years, however the correlation between groups are dynamic and this case has an impact on the variations of catch fish and fishing gear productivity.

Keywords: Diversity of fish species; catch per unit effort; principle component analysis; hierarchy of cluster

INTRODUCTION

Indonesia has a high potency of multi species of catch fish (CF) due to abundant of fish resource. Indonesia is divided into 11 Fishery Management Areas (FMA), and Prigi is located in FMA573. Muripto & Ripai (2015) stated that Prigi coastal area is located in the northern part of the Indian Ocean, traversed by water masses known as the South Java Current, has a high abundant fishery resources and important economic value such as tuna, skipjack, tuna, milk shark and mackerel. Prigi's fishermen commonly catch pelagic fish are using nets (purse seine, gillnet), fishing rods (handline, troll line), and fish aggregating device (FAD). (Nurani et al., 2014). Most of the Prigi's fishermen used small-scale fishing gear such as gillnet, handline, '*jaring klitik*', and scoop net. The diversity of types and economics status of Prigi's fishermen, these small-scale fisheries tools are characterized by multi species and multi gear thus impacting on the difficulties and complexities management (Pauly, 1979).

Indonesia as developing country face overcapacity problems in small-scale fisheries (Nikijuluw, 2002). Small-scale fisheries that multispecies and multi gears also cause other problems such as pressure on the availability of fish stocks due to the increase in the number of fishing gear with various types and sizes and varying efficiency. Multi gears in fishery conditions allow fishermen to increase their catch (Fauziyah et al., 2018), however it can also lead to a decrease in fish abundance and ecology in an area (Berkes et al., 2001).

Basic information related to utilization of fish resource including the number of catches of a fishing gear, composition of catches, competition for fishing gear, and the level of resource utilization. Those information are expected to be useful as a reference and consideration on the management of fish resources. However, there is limited data and information about small-scale fisheries with multispecies and multi gears. This study aimed to analyse the diversity of the catch fish, fishing gear productivity level, and fishing gear clustering based on catch in archipelagic fishing port (AFP) of Prigi. This study results are expected to be used as recommendations for sustainable small-scale fisheries management.

RESEARCH METHODS

Material

This research was conducted at AFP Prigi, Tasikmadu village, Watulimo district, Trenggalek, East Java (Figure 1). This research started from June until September 2021. Data were collected, including number of fishing gear, fish species and the number of catches. The data were obtained from annual reports of fish landings at AFP Prigi from 2010-2014. The definition of small-scale fisheries is very diverse, and there is no definite limit on it (Panayotou, 1982). Food and Agriculture Organization (FAO) stated that small-scale fisheries have the purpose of fulfilling the daily needs, small capital, and operating around the coast with short trip times (FAO, 2015). In this study, the limitation of small-scale fisheries based on fishing fleet which has ≤5GT of weight. Types of fishing gear operated by the fleet ≤5GT include: a) gill net, b) handline, and c) '*jaring klitik*'. The information from annual reports of the landing of the fish thus divided based on the type of fishing gear and the number of catches (kg/year and kg/trip). This classification methods were chosen due to overlapping catches between fishing gears, the grouping of fishing gear was not based on fish groups (demersal or pelagic), but based on all catches.

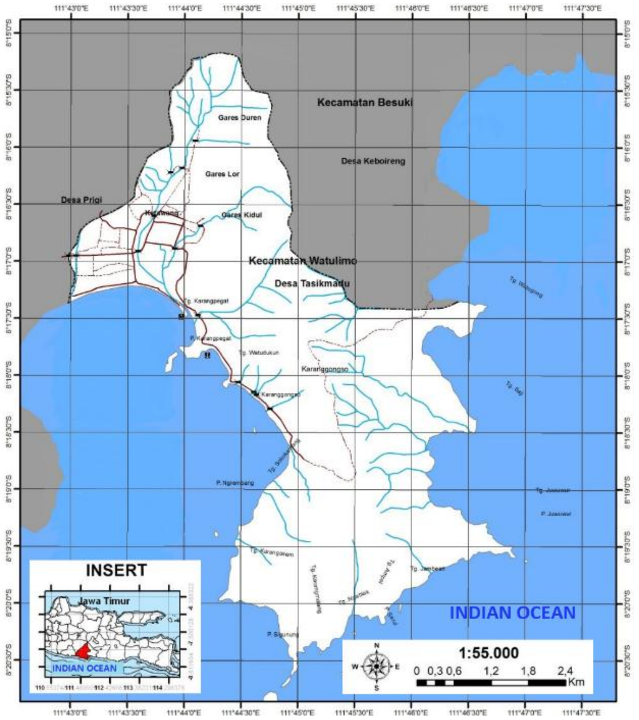

Figure 1. Location of AFP Prigi

Methods

Diversity of Catch Fish

Catch diversity of a fishing gear was calculated using the Shannon Wiener diversity index (Mwagi et al., 2012; Wiyono, 2010; Zhang et al., 2009) with following equations:

$$H' = -\sum Pi \ln Pi \quad \ldots\ldots (1)$$

$$H' = -\sum \left(\frac{ni}{N}\right) \ln \left(\frac{ni}{N}\right) \quad \ldots\ldots (2)$$

Where: H' = Diversity index of Shannon Wiener; ni = the number of species i; N = the total number of all species. If the H' value close to 0 means low diversity of fish caught, and the H' value close to 1 means high diversity of fish caught.

Fishing Gears Productivity

Productivity of fishing gears calculated based on *catch per-unit effort* (CPUE). CPUE can be used to analyze the productivity of waters (Wiyono, 2010). Badrudin (2013) stated that CPUE measured the relative abundance which could be as an indicator of the abundance of fish resources; while the CPUE trend is up thus indicates the level of exploitation of fish resources is growing, meanwhile when the CPUE trend is declining and it shows the efforts led to overfishing. CPUE calculation following the equations:

$$CPUE = \frac{c}{f} \quad \ldots\ldots (3)$$

Where: CPUE = catch per-unit effort; c = catch; f = effort.

Clustering of Fishing Gears

The clustering of fishing gear was analysed using Principal Component Analysis (PCA). To avoid large deviation, the data is standardized first. Standardization used the scoring method (Haluan & Nurani, 1988) with following this scoring equation :

$$NS_{ij} = \frac{X_{ij} - X_{0j}}{X_{1j} - X_{0j}} \quad \ldots\ldots (4)$$

Where: NS = score; J = *j* criteria; I = *i* alternative; Ij = *j* criteria in *i* alternative; X_{ij} = score of *j* criteria in *i* alternative; X_{0j} = minimum score in *j* criteria; X_{1j} = minimum score in *j* criteria.

The PCA analysis results were combined with cluster analysis by Hierarchical Cluster Analysis (HCA) methods in this research. The clustering groups are based on fishing gear and fishing targets (Leleu et al., 2014). Furthermore, cluster analysis was calculated based on the composition of each fishing gear (Tzanatos et al., 2005). The PCA and cluster analysis results were then used to determine the relationship between fishing gears (Wiyono, 2012).

RESULT AND DISCUSSION

Results

Diversity of Catch Fish

The composition of catch fish in each fishing gear was very diverse. Furthermore, there are 20 dominant fish species caught by small-scale fishing gear in Prigi (Table 1). The most caught fish in 2011-2020 were *Scyphozoa* (jellyfish). Even though Scyphozoa were only found in 2011-2015, the number caught greatly exceeds the number of other fish caught. The dominant catch of gillnet fishing gear was *Katsuwonus pelamis* and followed by *Sardinella gibbose*. Further, the dominant handline catch was Scyphozo followed by *Trichiurus lepturus*. The dominant catch of '*jaring klitik'* fishing gear was *Sardinella lemuru* followed by *Sardinella gibbose* and the most caught scoop net only *Scyphozoa*.

If examined based on fishing gear, the diversity of fishing gear varies over years (Figure 2). In 2011-2020 the fishing gear with the highest average of diversity is gillnet. In 2011 the diversity of gillnets was lower than that of *'jaring klitik'* and handline, however the diversity of gillnets continued to increase in 2012 which the peak in 2015 reached up to 2,53. Over the time, the diversity of gillnets continues to decline until this day. In the other hand, the diversity of handlines changes every year, the highest diversity occurred in 2018, which reached up to 2,16. Whereas, the diversity of *'jaring klitik'* fishing gear continued to decline from 2011 to 2013, which the value was worth 0 due to no fishing activities starting in April 2013. Scoop net diversity is worth 0 due to its function to catch Scyphozoa only, moreover the scoop net only operates in July-August 2011 and November 2012 only.

Productivity of Fishing Gears

The type of fishing gear generally which obtained most catches in AFP Prigi was handline (7.895.396 kg), followed by scoop net (1.899.191 kg) (Table 2). The most widely used fishing attempts were handline (2.566,112 trips) and gillnet (353.008 trips). The highest gillnet catch was 253.037 kg and it occurred in 2011 with the highest fishing effort occurring in 2013 which was 54.346 trips. The highest handline catch was 3.882.619 kg in 2013and followed with in

2011 (6,85) but then decreased and increased slightly in 2019 and 2020. The CPUE handline value was very dynamic with the highest value occurring in 2015 (15,50) and the lowest in 2018 (0,26). The highest value of CPUE in *'jaring klitik'* appeared in 2013 at 1,06 and the lowest was 0 due to absence of fishing activity. The highest scoop net CPUE value was in 2011 with the value 26,47 and then continued to decrease drastically until 0 in 2013-2020. This case also caused by no fishing activity.

Table 1. Total Catch of Fish Landed at AFP Prigi By Species of Fish and Fishing Gear Since 2011 Until 2020

Species	Gillnet (kg)	Handline (kg)	Jaring Klitik (kg)	Scoop Net (kg)	Total (kg)
Scyphozoa	0	3886972	0	1899191	5786163
Trichiurus lepturus	4808	3292859	3423	0	3301090
Katsuwonus pelamis	557003	18478	0	0	575481
Sardinella gibbosa	195748	120	106096	0	301964
Selar crumenophthalmus	22475	238481	24616	0	285572
Sardinella lemuru	42000	0	178958	0	220958
Thunnus albacares	146944	4759	0	0	151703
Decapterus russelli	279	136270	0	0	136549
Scomber australicus	555	126741	95	0	127391
Argyrosomus amoyensis	4148	92452	2490	0	99090
Rastrelliger sp	39177	18373	38592	0	96142
Auxis tharzad	81437	5080	3351	0	89868
Caranx sp	165	71522	3046	0	74733
Euthynnus affinis	32431	24545	85	0	57061
Auxis rochei	46879	1102	0	0	47981
Scomberomorini	985	40594	0	0	41579
Neotrygon kuhlii	17633	20721	42	0	38396
Decapterus kurroides	5476	21156	0	0	26632
Carcharhinus obscurus	1302	21629	0	0	22931
Priacanthus tayenus	13636	6288	2049	0	21973

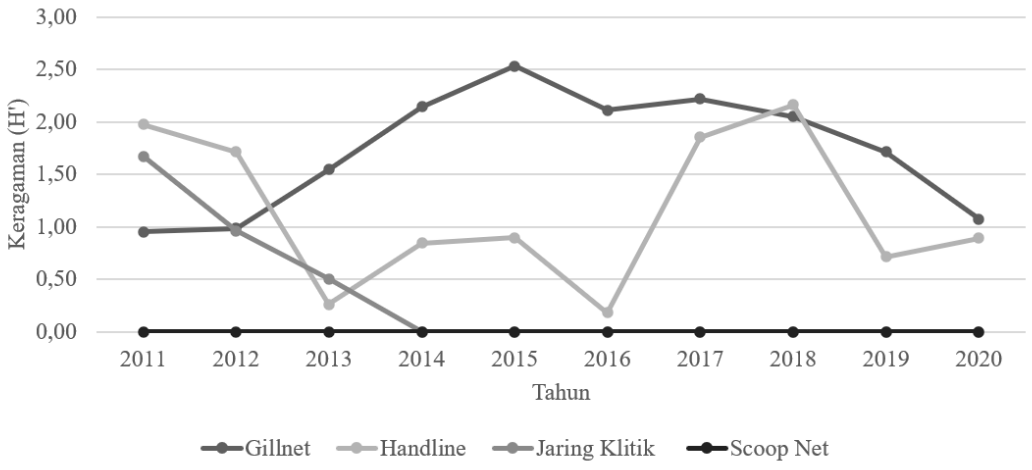

Figure 2. Diversity Index (H') of Catches by Fishing Gear on AFP Prigi

Table 2. Total Catch And Fishing Trips In Prigi In Since 2011 until 2020

Year	Gillnet		Handline		*Jaring Klitik*		Scoop Net	
	CF (kg)	trip	CF (kg)	trip	CF (kg)	trip	CF (kg)	trip
2011	253037	36946	160880	196446	76772	99006	1830040	69136
2012	166486	28942	257997	262798	87589	105560	69151	20126
2013	176228	54346	3882619	451878	41172	38976	0	0
2014	51554	20416	186513	150452	0	0	0	0
2015	75864	21286	797172	51446	0	0	0	0
2016	28146	28768	1128162	425952	0	0	0	0
2017	47061	35612	154323	157934	0	0	0	0
2018	25125	34858	44924	173438	0	0	0	0
2019	106900	48024	284057	231884	0	0	0	0
2020	112726	43810	998749	463884	0	0	0	0
Total	1043127	353008	7895396	2566112	205533	243542	1899191	89262

The highest number of trips was up to 451.878 trips at the same year. The large number of catch fish was due to increasing the *Trichiurus lepturus* catch in 2013. The most catches using *'jaring klitik'* occurred in 2012 with the amount of fish catching up to 87.589 kg and the highest number of fish catching attempts in 2011 reached up to 105.560 trips. In the other hand, the highest number of catch fish using scoop net occurred in 2011 which reached to 1.830.040 kg with the number of catching attempts was 69.136 trips.

Based on CPUE analysis described the increasing and decreasing of catch productivity generally. The CPUE of small-scale fishing gear in AFP Prigi was quite dynamic over the years (Figure 3). The highest gillnet CPUE value occurred in 2011 (6,85) but then decreased and increased slightly in 2019 and 2020. The CPUE handline value was very dynamic with the highest value occurring in 2015 (15,50) and the lowest in 2018 (0,26). The highest value of CPUE in *'jaring klitik'* appeared in 2013 at 1,06 and the lowest was 0 due to absence of fishing activity. The highest scoop net CPUE value was in 2011 with the value 26,47 and then continued to decrease drastically until 0 in 2013-2020. This case also caused by no fishing activity.

Clustering of Fishing Gears

Clustering of fishing gear was examined by grouping fishing gear based on the catch fish. Based on the results, the pattern of clustering according to the structure of the grouping of fishing gear resulted almost similar over the years, but the proximity value of each fishing gear changes every year. The fishing gears which clustered in one group were *'jaring klitik'* and scoop nets. Gillnets was unable to grouping with the other fishing gears except in 2011, 2012, and 2018. In 2011 the handlines were close to gillnet and scoopnet groups with a proximity value of 9 (Figure 4a). In 2012, gillnets, scoop nets and *'jaring klitik'* were joining into a group with proximity 1 (Figure 4b). In 2013 the *'jaring klitik'* were in the same group

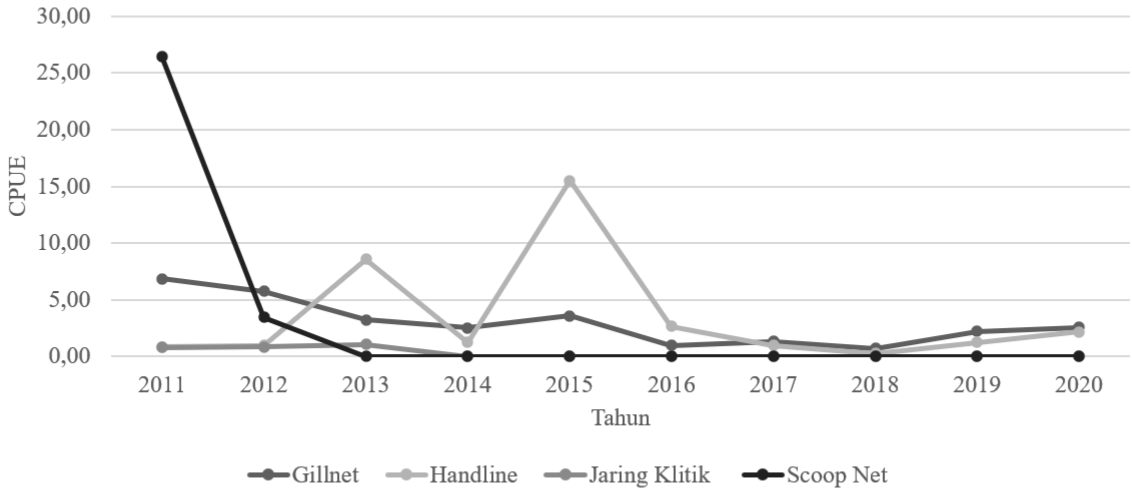

Figure 3. CPUE Value Fluctuations by Type Of Fishing Gears Since 2011 until 2020

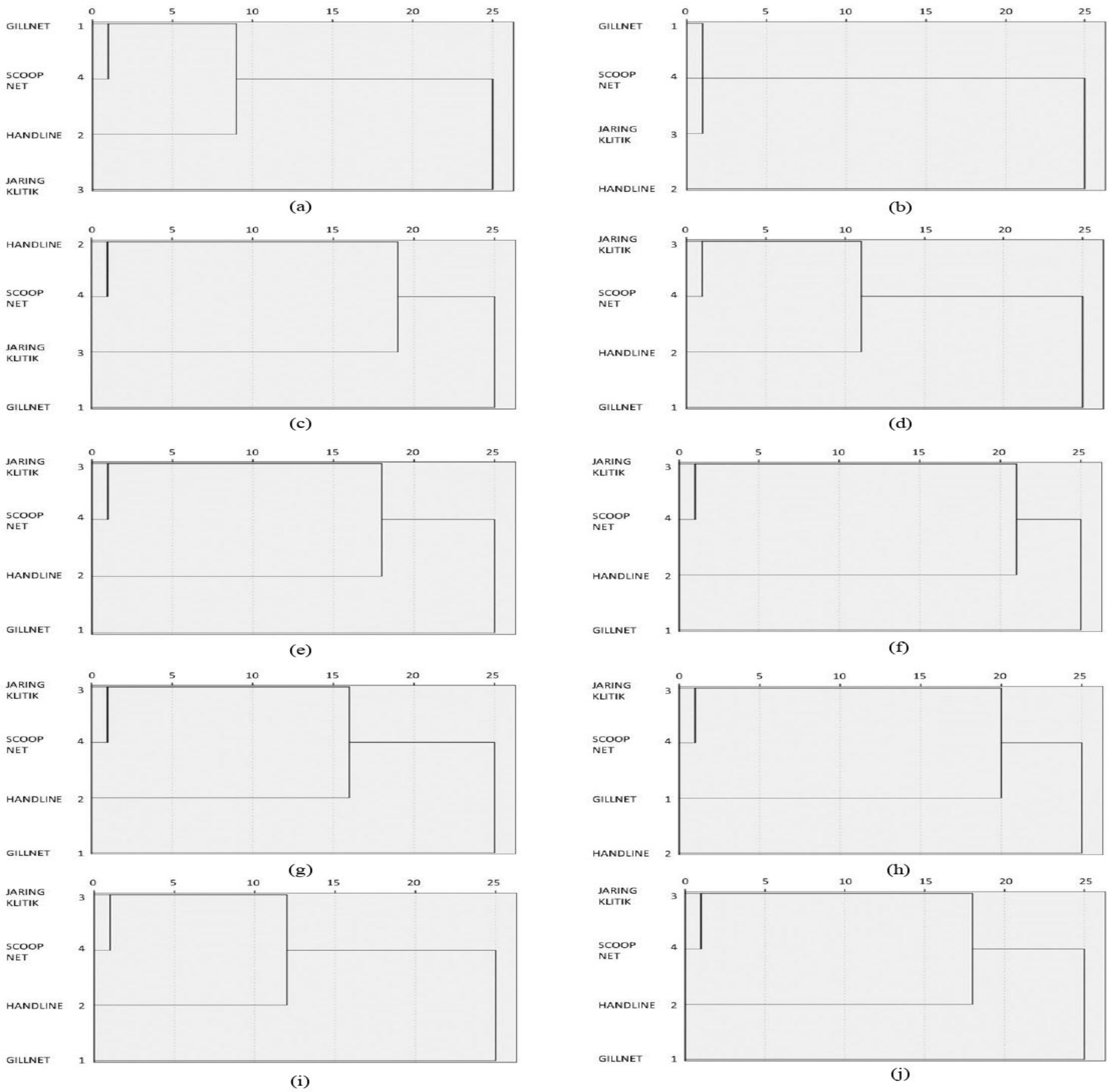

Figure 4 Clustering of fishing gears in: a) 2011; b) 2012; c) 2013; d) 2014; e) 2015; f) 2016; g) 2017; h) 2018); i) 2019; j) 2020

Discussion

The results of this study indicated that the clustering of fishing gear during the last 10 years has changed. These changes might cause by changes in the composition and diversity of catches fish landed in AFP Prigi. Clustering of fishing gear can occur due to the similar composition and diversity of catches. Fishing gear which in the same group tends to compete in catching the same fish (Sari et al., 2015). Gillnets tend to be at a long distance compared with the other fishing gear due to the greatest diversity of gillnet catches compared to other fishing gear. These mechanisms resulted on the competition in catching similar fish became very small. The results of this study were similar with research conducted by Wiyono (2010) in Pelabuhanratu which reported that gillnet fishing gear was in a different group with handlines. However, the study results were contrary wit by Forcada et al. (2010) in the Mediterranean reported that gillnets and handlines were in the same group. That result means that the two fishing gears compete with each other while *'jaring klitik'* was in different groups.

The dynamic condition of fishing gear impacts community structure and the dominance of a species in an area. Community structure and dominance change caused alteration on the composition and diversity of catches. This finding also supported by Wiyono (2010) stated that the diversity of catches indicates the dominance of fish species in an area. The alteration on diversity in AFP Prigi were suspected caused by changes in the structure of the gillnet catch. The large gillnet catch affects the catch of other fishing gear. Gillnet utilization also affects the diversity of catches of all fishing gears. The results of the diversity analysis showed that the diversity of the catches of *'jaring klitik'* decreased while the gillnets catch increased. These results also show that the diversity of catch fish using gillnet is greater than the diversity of other fishing gears. Stergiou et al. (2002) reported in the waters of the Cyclades (Seagen sea) has the diversity of gillnet catches greater than the diversity of handlines. Wiyono et al. (2006) also stated that gillnet fishing gear has a large variation in catch diversity compared to other fishing gear (H' > 0.1).

On the other hand, changes in the proximity of fishing gear groups impact catch fish productivity. Based on the results of the CPUE analysis, the productivity of all fishing gear has changed. This occured as a result of shifting catches. In 2016, the CPUE of handline fishing gear decreased to 2.65 kg/trip and continued to decline in the following years. The value of gillnet CPUE gradually reduced from 2011 until 2018 and only increased slightly in 2015 at 3.56 kg/trip and according to the next 2 years. The decrease in CPUE indicated that the condition of fish resources was biologically overfishing (Harjanti et al., 2012).

CONCLUSION

The results of study showed that the clustering of fishing gear tends not to change in the last 10 years, but the closeness between groups is dynamic. This affects the diversity of catches and also the productivity of fishing gear.

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