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The Dynamics of Fishing Ground and Catches Diversity of Small-Scale Fisheries in Southern Java Waters, Indonesia

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Abstract

Study on the diversity of fish catches and fishing seasons is extremely essential for fishermen in order to engage in more efficient fishing operations; however, researches in this area are still limited. The purpose of this study was to determine the diversity of fish catches and to assess the dynamics of changes of the fishing grounds. The study was conducted in Southern Java waters in Gunungkidul Regency from September 2012 to January 2013. The diversity of the fish catches was analyzed using the Shannon-Wiener index, while the fishing season patterns were analyzed using a moving average. The result of shannon-wiener index has shown that most of the waters of Gunungkidul Regency is at a low level of diversity (less than 2) except for the fishing ground of the waters of Ngandong (2.085). In general, pattern of fishing season is differentiated in four categorized by location. Little tuna and eagle rays fishing seasons are occurred in all Gunungkidul coastal. Octopuses fishing season is found in Drini, Ngandong, Siung, Nampu and Sadeng, while sharks, hair tails, pomflert, and giant catfish fishing seasons are occurred in several locations. Particularly, tuna and skipjack fishing seasons are in Sadeng's fishing ground. The dynamics of fishing seasons of each fish have differences in both time and place, and this condition can be used as a reference for fishermen in performing their activities in the fishing operations in Gunungkidul.

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1. Introduction

Fishing activities in Gunungkidul Regency are dominated by traditional fishermen as most of them still use outboard boat motors. The DKP Statistics of Yogyakarta Province in 2011 reported that of the total fishery households (as many as 771 households), as much as 94% did not have a boat or used outboard boat motors, and only a few possessed a motor boat [13]. Small-scale fisheries have a characteristic of relatively small capital, limited facilities and limited understanding of the coastal environment [14]. This group also has limited technological means such as boats and fishing gear, thus limiting the space for fishermen to develop their businesses and access to other works. This condition leads low income levels. This condition also causes the small-scale fisheries to have a very high dependence on fish resources which are entirely based on the coastal areas as the main sources of their livelihood; therefore, the presence of fish resources will greatly affect their level of earnings [17].

One of the major obstacles in the utilization of fish resources is the limited knowledge of fishermen on fishing operations. The Indonesian fishermen generally perform their catching activities based on their experience or ancestral traditions, resulting in less efficient fishing operations [10]. To perform efficient catching operations requires precise information including fishing seasons. Basically, the fishermen always pay attention to the weather and related factors associated with the presence of fish in one location and particular depth of the waters; however, most of them still perform the catching activities based on their experience and tradition of their predecessors [19].

A number of studies on the diversity and patterns of fishing seasons have been conducted in a number of locations in the waters of Indonesia i.e. the abundance of demersal fish stocks in the highest deep sea in the waters of Indian Ocean of South Java is found at the depth of 700 to 1,100 m with the stock density ranging from 0.8 to 39.9 tons per km^2 [7]. The lobster fishing season with the highest production in the waters of southern Yogyakarta occurs at the end of the year up to the beginning of the year [2]. This leads to the great exploitation of shrimps (shrimp endeavor) in this fishing ground [5]. Moreover research on pelagic fishing seasons in the waters of Apar Bay, East Kalimantan shows that there are three patterns of fishing seasons of pelagic fish species [19].

Efforts to provide information on diversity of catches and fishing seasons are extremely essential for the fishermen in an endeavor to engage in more efficient fishing operations. The purposes of this study were to determine the species composition of the fish catches and level of diversity and to study the dynamics of changes in the fishing grounds.

2. Methods

This study was conducted in South Java waters in the region of Gunungkidul Regency for 5 months from September 2012 to January 2013. The primary data obtained from the interviews with the fishermen contained locations of the fishing grounds carried out from September 2012 to January 2013,

and purposive sampling technique was used to determine the respondents. The secondary data were obtained from the Statistics of Gunungkidul Regency, fishery statistics of Gunungkidul Regency, UPT Arthamina, Department of Marine and Fisheries of Gunungkidul containing reports on the production of fish catches for 2 years (from January 2011 to in December 2012) and the number of trips of each PPP/PPI (Coastal Fishing Port/Fish Landing Center) for 2 years in Gunungkidul Regency (from January 2011 to December 2012).

The analysis used in this study included:

2.1. Diversity Index

Calculation of the diversity index value was conducted to obtain a picture of species richness and their similarity in a single value from each fish landing port. According to C.I.Zhang *et al*. [11] and Mwangi *et al*. [9], the modification diversity index of Shannon-Wiener was formulated as follows:

$$H = \sum_{i=1}^{N} [\frac{ni}{N} Ln \frac{ni}{N}] \quad (1)$$

Notes:

H = Diversity index

n_i = Species number i (kg), i = 1, 2, 3,...10

N = total species number (kg)

2.2. ***Moving Average***

Determining the dynamics of the major fishing catch seasons on the basis of each fish landing with the ratio method of moving average by referring to A. Dajan [1] as follows:

a) Arranging the Catch per Unit Effort (CPUE) time series data from January 2011 to December 2012:

   Yi = CPUEi (2)

   Notes:

   i = 1, 2, 3,....., n

   Yi = CPUE ke-i

b) Arranging the CPUE moving average of the 12 months (RG) :

$$RG_i = \frac{1}{12}\sum_{i=1-6}^{i+5} Y_i \quad (3)$$

Note:

i = 3, 4,....., n-5

c) Arranging the centralized CPUE moving average (RGP)

$$RGP_i = \frac{1}{2}\sum_{i=1-6}^{i+5} RG_i \quad (4)$$

Note:

i = 3, 4,....., *n*-5

d) Calculating the monthly average ratio (*Rb*)

$$Rbi = \frac{Y_i}{RGP_i} \quad (5)$$

Note:

i= month 1,2,3...12

e) Arranging the average value in a matrix with the size of j x i for every month starting from i + 6, calculating the average or seasonal variations, and then calculating the index of fishing seasons.

(i) Average ratio of -i month (*RRB*)

$$RRB_i = \frac{1}{n}\sum_{j=1}^{n} Rb_{ij} \quad (6)$$

Note:

j = 1, 2, 3,.....,*n*

(ii) Total of monthly average ratio (JRRB)

$$JRRB = \sum_{i=1}^{12} RRB_i \quad (7)$$

Note:

i = 1, 2, 3...12

(iii) Fishing Season Index

The season index total for one year on monthly basis is 1,200 or an average which equals to 100. The total of monthly average ratio (JRRB) is not always 1,200; therefore, the monthly average value should be corrected by a correction factor (FK):

$$FK = \frac{1200}{JRRB} \quad (8)$$

Furthermore, fishing season index (IMP) was calculated by the following equation:

$$IMPi = RRBi \times FK \quad (9)$$

3. Results and Discussions

3.1. Results

3.1.1. Fishing Grounds

Southern Java waters in Gunungkidul Regency has a coastline of 70 km which stretches from Purwosari sub district to Girisubo sub district, and this area has been used for fishing activities, tourism and trade. When the area is calculated as far as 4 miles from the shoreline area, the width of the waters of Gunungkidul Regency is approximately 129.64 km2, with a rocky beach condition [10]. The fishermen of Gunungkidul Regency are artisanal concentrated in 8 fish landing ports for their activities, namely, Sadeng PPP, Nampu PPI, Siung, Ngandong, Drini, Baron, Ngrenehan and Gesing (Figure 1).

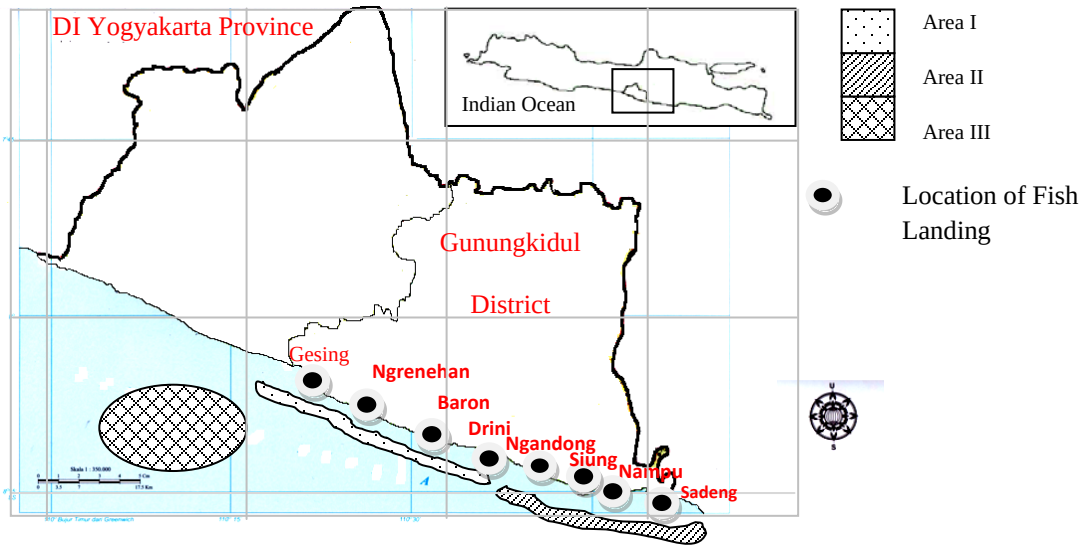

Fig. 1. Location of Fish Landings and Fishing Grounds of Fishermen in Gunungkidul Regency

Based on the information from the fishermen of each PPP/PPI, the locations of the fishing grounds are divided into several locations in the waters of the southern coast of Java. The fishing grounds in Gunungkidul Regency (Figure 1) are as follows:

- Region I which is the fishing ground for the fishermen of Drini, Baron, Ngrenehan, Gesing includes the waters surrounding Drini, Baron, Ngrenehan, and Gesing and the mouth of Progo River.
- Region II which is the fishing ground for the fishermen from Ngandong, Siung and Nampu and for some of the fishermen of Sadeng includes the waters around Ngandong, Siung, Nampu, and Sadeng.
- Region III which is the fishing ground for the Sadeng fishermen using motorboat includes the waters around Parangtritis (about 20-40 miles from Sadeng PPP) and Line III of the ZEEI waters based on the Ministry Regulation KP PER.05/MEN/2012.

3.1.2. Fish Production and Composition of the Fish Catches

From January 2011 to December 2012, more than 37 kinds of fishes can be caught by the fishermen of Gunungkidul starting from tuna, skipjack, little tuna, hairtail, and eaglerays which are the dominant types of fish caught. The types and production of dominant fishes caught in Gunungkidul are presented in detail in Table 1[12].

Table 1. Main Catch Fishes Production in Gunungkidul Regency

Kinds of Fishes	weight (kg)		
	2011	2012	Total
Tuna	92 920.30	172 620.50	265 540.80
Skipjack	120 932.00	134 045.50	254 977.50
Little Tuna	118 308.00	98 995.00	217 303.00
Hairtail	40 245.50	32 287.70	72 533.20
Eaglerays	24 549.00	29 144.20	53 693.20
Pomfret	7 692.00	40 204.35	47 896.35
Octopus	35 808.80	5 858.50	41 667.30
Lobster	5 024.90	31 904.04	36 928.94
Snail	2 294.00	26 776.50	29 070.50
Shark	17 473.00	8 575.41	26 048.41
Giant catfish	10 712.60	6 502.50	17 215.10
Mackerel	10 975.20	3 117.30	14 092.50

3.1.3. Analysis on Catching Season

Based on the result of the analysis of IMP value above 100%, the dominant fishing seasons in each of the PPP/PPI is presented in Table 2, and based on the distribution of the locations, the fishing seasons can be categorized into 4 groups, namely: (1) little tuna and eaglerays fishing seasons occurring in all

locations, (2) octopus fishing season occurring in most locations including Drini, Ngandong, Siung, Nampu and Sadeng, (3) sharks, hairtails, pomflert, and giant catfish fishing seasons occurring in several locations, (4) tuna and skipjack fishing season occurring only in Sadeng.

Table 2. Pattern of Seasonal index of main catches in Gunungkidul Regency

Kind of Fishes	January	February	March	April	May	June	July
Little Tuna		8 7 4	5 2	5 4 3	7 5 3	2 5 3 2	1 8 7 5
Eaglerays		6 5	1 8 7 6 5	8 4	3 1 4 3 2	1 7 4 3	8 7 6 5 4 1
Octopus	5 4 2 1	5 4 3 2	5 2				
Shark		5	5 1	3	4 3 1	3	4
Hairtails	8 7	8 7 5	8 7			5	
Pomfret	7	8 7 6	8 7 5	5	5		
Giantcatfish		8 5	8 6 5	6 3		3	5
Mackerel			4		4		
Tuna		1	1	1		1	1
Skipjack		1					1

Kind of Fishes	August	September	October	November	Desember
Little Tuna	8 2	6 2	8 7 6 5 4 3 1	4 2 1	1
Eaglerays	7 4	8 5			
Octopus		6	6	4 3 2 1	5 2 3 2 1
Shark	4	5	5		4
Hairtails				6	6 5
Pomfret		7	6 5		6
Giantcatfish	6 5				
Mackerel	5 4 2	5 4 2 5 4			
Tuna	1	1			
Skipjack	1	1	1		

Sources: Data Analyzed (2013)

Information:

IMP >100 s/d 150
IMP >150 s/d 200
IMP >200

1 = PPP Sadeng
2 = PPI Nampu
3 = PPI Siung
4= PPI Ngandong
5= PPI Drini
6= PPI Baron
7= PPI Ngrenehan
8= PPI Gesing

3.2. Discussions

Based on the types of fish catches which are dominant in each PPP/PPI, analysis on the diversity index of each PPP/PPI in Gunungkidul was conducted to determine the diversity of the fishes catches. Based on analysis of the diversity index shown in Figure 2, it can be explained that the diversity index of fish catches in the waters of Gunungkidul ranges from 1.3086 to 2.085. The lowest index of 1.3086 occurred in Sadeng PPP where the fishing ground is located in the waters of Sadeng, 20-40 miles in the waters of Parangtritis and on the catching track III (ZEEI) and the highest index was obtained in Ngandong PPI where the fishermen usually catch fishes in the coastal waters of Ngandong and Sadeng beach. Nampu had the second highest index which was equal to 1.866, followed by Drini, Baron, Siung, Ngrenehan, and Gesing. If the diversity index value (H) is less than 2, the area is classified as an area with low-level diversity, if it is between 2 to 3, it is classified as an area with medium-level of diversity, and if it is above 3, it is classified as an area with high level of diversity [4]. The level of diversity of the fish catches in the waters of Gunungkidul Regency is generally at a low level (less than 2), and only the fishing ground of Ngandong PPI has a moderate level of diversity. Based on the fishing ground, the diversity level of catches in the fishing grounds of Region III in Sadeng in which motor boats are used is the lowest i.e. 1.3086. Meanwhile, Region II has the highest diversity level of catches ranging from 1.8089 to 2.0582 whereas Region I has the diversity level between 1.5712 and 1.8156. This condition requires attention in regards to the utilization of fish resources in Gunungkidul Regency especially in Regions III and I whose level of diversity is low.

The analysis on the fishing seasons was carried out to determine the fishing season patterns of each type of fish in a location based on the fishing season index (IMP). The index value of the fishing season can be used in determining the appropriate time to conduct fishing operations [19]. The criterion used in determining the fishing season is if the IMP value is equal to or greater than 100%, it is said to be the fishing season; however, if the IMP value is less than 100%, it is not a fishing season.

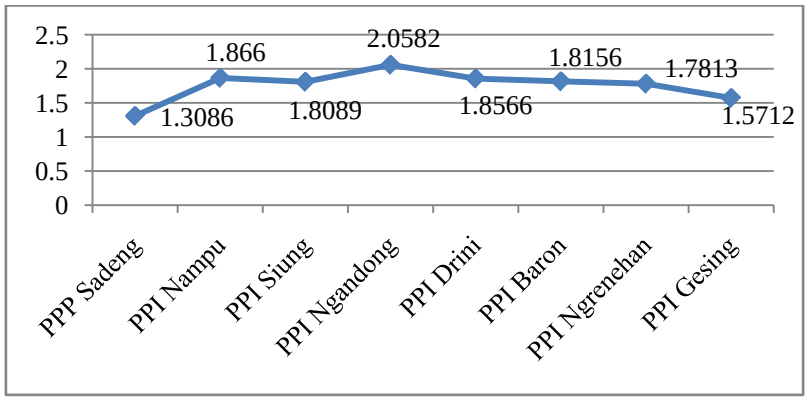

Fig. 2. Result of index Diversity of Catches in PPP/PPI Gunungkidul Regency.

The dynamics of fishing season in Southern Java waters has differences in types of fishes. Based on the analysis of tuna fishing season in this area, the seasons generally occur throughout the year except in

January. Moreover, southern Java water of Yogyakarta is a fishing ground of this kind of fish [18]. However, the peak season of tuna fishing in the Indian Ocean region occurs from August to September [16]. Tuna fishing season starts from Gesing in February and ends in December in Sadeng (Table 2) based on the dynamics/movement of the fishing seasons. The dynamics of tuna fishing ground are directly influenced by oceanographic factors, fertility waters and food availability [18]. Tuna fish often follows the distribution or circulation of the currents [18]. February is the starting month of the west season where the currents that occur in Southern Java move from west to east [3]. This is also thought to influence the movement of the little tuna in the area.

Hairtails fishing season occurs from January to March, in June, and from August to October and later in December. The peak fishing seasons occur in February and in December, and hairtails fishing seasons in the waters of the Indian Ocean reach a peak in May, June and July [8]. Based on Table 2, it can be seen that hairtails fish is only caught by the fishermen of Drini, Ngrenehan and Gesing the area where they conduct the fishing operations in Region I. It is thought that Region I is the fishing ground of this type of fish since hairtails fish belongs to demersal fishes whose habitat is in shallow coastal areas [18].

Eaglerays fishing season occurs in Sadeng in February, and it starts again from April to September. Distribution of the highest Eaglerays fishing season occurs in June. There is no eaglerays fishing season in all locations in January, February, October, November and December. Shark fishing season occurs in Drini from February to October and in Ngrenehan in December. Distribution of the locations of highest shark fishing season occurs in May. Shark is one of the predators for tuna, skipjack, and others [18]. It is suspected that the existence of such fishes cause the presence of sharks in this area.

Tuna fishing season occurs from February to April and from June to September. In line with previous studies, a large quantity of tuna catches in the waters of the Indian Ocean can be obtained from March to June and from September to October with a peak in October, and it allegedly becomes the fishing season [16]. Mackerel fishing season occurs in February and from July to October. Previous studies inform that mackerel fishing season in the Indian Ocean takes place from June to October [16]. Tuna and mackerel can only be found in Sadeng PPP since the fishermen in this area use a larger motor boat so that the range of fishing grounds is greatly different from that of the fishing grounds in Regions I and II.

In reference to the results of the above discussion, in general, the patterns of the fishing seasons in the waters of Gunungkidul for each fish species are quite diverse both spatially and temporally. Fishing season in each of the locations has different patterns in species of fish, time and location. This is a characteristic that characterizes a fishing ground. Fishing season is also highly dependent on the existing oceanographic and meteorological conditions. This is presumably to be strongly associated with comfort and safety in the operations of ships [14]. The dynamics of the fishing season occurring in each of the fish types mentioned above can certainly be used as a reference in an effort to perform

activities of the fishermen in fishing operations in the South Java waters especially in the area of Gunungkidul.

4. Conclusions

1. The diversity level of fish catches caught by the fishermen in the waters of south coast of Java, Gunungkidul Regency, is low (the diversity index value is less than 2), except for the waters of the fishing ground of Ngandong whose index value is moderate (value of 2.084). Region I is a fishing ground with the highest catch diversity level whereas Region III has the lowest. It is an indicator of the need for attention in the utilization of fish resources in Regions III and I.
2. The fishing season is divided into four distribution locations, namely: (1) tuna and pari fishing seasons occurring in all locations, (2) octopus fishing seasons occurring in most locations i.e. Drini, Ngandong, Siung, Nampu and Sadeng; (3) shark, hairtails, pomfret, mackerel, giant catfish fishing seasons occurring in several locations: (4) tuna and skipjack fishing seasons occurring only in Sadeng.
3. The dynamics of the fishing seasons of each fish have differences in both time and place. These conditions can be used as references for fishermen in performing their activities in the fishing operations in Gunungkidul.

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