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IMPACT OF SEASONS ON THE SUSTAINABILITY OF CATCH COMPOSITION IN GILI SULAT-GILI LAWANG, INDONESIA

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Abstract: The fish caught by fishermen vary depending on the season. Seasonal changes are associated with shifting monsoon patterns and unpredictable marine conditions, resulting in uncertain numbers of fishing days and possibly affecting fishermen's catch. To address this issue, this study examined how the seasons influence catch composition among the fishermen in Gili Sulat-Gili Lawang, Indonesia. Data were obtained through face-to-face interviews with 85 respondents in four villages around Gili Sulat-Gili Lawang: Sugian, Dadap, Belanting, and Labuhan Pandan. Descriptive analysis was used to analyse the data. The result showed the species that fishermen caught the most during the west monsoon season was mackerel tuna (4,975 kg), followed by sardine (2,922 kg) and bigeye tuna (2,775 kg). During the east monsoon season, the species that fishermen caught the most was mackerel tuna (2,847 kg), followed by bigeye tuna (1,800 kg) and mackerel (690 kg). This study's findings show that seasons play a vital role in influencing fish abundance in Gili Sulat-Gili Lawang. Thus, the government should monitor fishermen's catch and the use of fishing gear to ensure the sustainability of fisheries, prevent the capture of protected fish, and ensure stable income for fishermen.

Keywords: Catch composition, fish abundance, season, fishermen, Gili Sulat-Gili Lawang.

Introduction

Generally, Indonesia has two seasons based on the fluctuation of evapotranspiration and rainfall patterns, namely dry and wet seasons. The wet season occurs when the rates of the rainfall are higher than evapotranspiration over successive days, resulting in a surplus of rainwater. Conversely, the dry season occurs when the rates of rainfall are lower than evapotranspiration over successive days, resulting in a deficit of rainwater (Setiawan, 2020). The wet season in Indonesia (west monsoon) usually occurs from October to March and the dry season (east monsoon) occurs from April to September (Dida *et al.*, 2016).

The fish catch tends to be different between the seasons, probably due to the difference in fish diversity during each season. For example, Anggara and Rudin (2020) showed that diversity of fish species was different during rainy and dry seasons at Baron Beach, Gunung Kidul, Indonesia with the dominance of *Pampus argenteus* during the rainy season and *Stolephorus* sp., *Elagatis bipinnulata*, and *Auxis rochei* during the dry season. However, many studies have indicated that the diversity of fish species is higher during the rainy season than the dry season. Corpuz *et al.* (2016) found the abundance of freshwater fish in Lake Taal River systems, Philippines was higher during the rainy season than the dry season as the rainy season was a reproductive season for some species. Furthermore, Setyaningrum *et al.* (2020) found the fish diversity in River Sapuregel of Segaran Anakan Eastern Area, Cilacap was higher during the rainy season than the dry season due to the tides that carried some fish into the river.

In contrast, Melaku *et al.* (2017) and Mekonen and Hailu (2021) reported higher diversities of fish species during the dry season than the rainy season in Geba and Sor Rivers, Ethiopia, East Africa, and Southern Ethiopia, respectively. DeGraaf (2003) and Tesfaye and

Wolff (2014) said that this phenomenon could be explained by the high turbidity, speedy run-off, and low temperature during the rainy season. The higher water discharge during the wet season also resulted in a higher dispersion of fish in the large volume of water, making it difficult to catch them. Generally, the differences in fish diversity may be due to environmental conditions such as pH, food availability, temperature, dissolved oxygen (DO), and other reasons. For example, a study by Chankaew *et al.* (2022) found that *C. limbata* (Chal) was commonly found in places with high temperatures and *Phenacostethus smithi* was found in areas where pH was the lowest.

Difference in fish diversity results in different compositions of fish caught by the fishermen during the seasons. Previous research has reported the effect of seasons on fishermen's catch compositions. Velip and Rivonker (2015) found that catch compositions in Goa, west coast of India were different across the seasons due to the roles of temperature, salinity, and DO in determining species occurrence. Tyabji *et al.* (2020) found that catch compositions in the Andaman and Nicobar Islands, India were different between the west and the east monsoon seasons because of the absence of landings during the west monsoon as the weather was too risky for fishermen to go out to sea. The same situation may also occur in Gili Sulat-Gili Lawang.

Several studies have also examined the fish species in Gili Sulat-Gili Lawang. For example, Gelis *et al.* (2021) studied the community structure of coral fish using eDNA metabarcoding during the east monsoon in Gili Sulat-Gili Lawang. The study found the community structure of fish in the area was composed of cardinal fish (*Apogonichthyoides nigripinnis*), redbelly yellowtail fusilier (*Caesio cuning*), yellow-edged lyretail (*Variola louti*), whale shark (*Rhincodon typus*), grey sharpnose shark (*Rhyzoprionodon oligolinx*), spotted-belly catshark (*Atelomycterus erdmanni*), silky shark (*Carcharhius falciformis*), coral grouper (*Plectropomus*), and blackspine unicornfish (*Naso minor*). Accordingly, this study aims to analyse the impact of seasons on fish catch composition in Gili Sulat-Gili Lawang, Indonesia, based on fishermen's catch.

Materials and Methods

The data on catch composition among fishermen were collected from June to September 2023 in four villages around Gili Sulat-Gili Lawang, Sambelia, East Lombok, West Nusa Tenggara. The four villages are Sugian (8°21'01" S 116°41'18" E), Dadap (8°21'21" S 116°42'59" E), Belanting (8°18'58" S 116°35'48" E), and Labuhan Pandan (8°24'42" S 116°40'00" E). Data were obtained from primary sources through face-to-face interviews and field observations with 85 respondents. The number of respondents was determined based on Slovin's formula with a 10% margin of error. The population size of fishermen (426) used in this formula was obtained from data on the jobs of the communities available on the website of each village (Sugian village government, 2023; Dadap village government, 2023; Belanting village government, 2023) and Labuan Pandan fishermen group profile (Ministry of Marine Affairs and Fisheries of Indonesia, 2020).

The type of fishing gear and the type and volume of fish caught by the fishermen were also included in the recorded data. Volume refers to the average volume of fish that the fishermen caught daily during each season. To analyse the data, this study used descriptive analysis. According to Thompson (2009), descriptive statistics can be used to summarise data in order to describe what occurred in the sample, determine whether there are differences between two or more samples, and whether these differences are likely to be present in the population of interest, and compare samples from one study with another. This method has been used in several studies. For example, Suharyanto *et al*. (2020) described the volume of catch in Fisheries Management Area (FMA) 716, Indonesia and Aprilla *et al*. (2021) analysed the catch composition in Gampong Deah Raya, Syiah Kuala, Banda Aceh.

Before conducting the descriptive analysis, the relative abundance of catch composition was calculated based on Krebs (1989). The relative abundance formula is:

$$\text{Relative abundance } \% = \left(\frac{ni}{N}\right).100 \qquad (1)$$

where:
ni = number of individuals of the species
N = total number of individuals of fish caught

Results

From the total of 85 respondents in Gili Sulat-Gili Lawang, this study identified eight types of fishing gear. Handline was the most commonly used among the fishermen, followed by the gill net, longline, cast net, trolling line, speargun, scoop net, and fishing rod (Table 1). The average hook size of the longlines, trolling lines, and handlines used by the fishermen was No. 20 and below. The average mesh size of the cast nets, gill nets, scoop nets, and spearguns used by the fishermen was 2 inches and below (1 inch, 1.25 inches, 1.5 inches, and 2 inches). Most of the cast nets, gill nets, handlines, longlines, and trolling lines used by the fishermen were longer than 50 m. All the scoop nets and spearguns used by the fishermen were shorter than 50 m.

Catch Composition and Abundance of Fish

A total of 30 species were recorded during the study period in Gili Sulat-Gili Lawang, as shown in Table 2. The total weights were 17,617 kg during the west monsoon and 9,586 kg during the east monsoon. The results also show that the most abundant species caught during the west monsoon was mackerel tuna (4,975 kg), followed by sardine (2,922 kg) and bigeye tuna (2,775 kg). Meanwhile, the most abundant species caught during the east monsoon was mackerel tuna (2,847 kg), followed by bigeye tuna (1,800 kg) and mackerel fish (690 kg). Overall, the total weight of the fish caught was higher during the west monsoon than the east monsoon.

Discussion

The results reveal differences in catch composition between the west monsoon and the east monsoon seasons. During the west monsoon, winds blow from the west to the east, causing currents to move from the Java Sea (west) to the Flores Sea (east or north Gili Sulat-Gili Lawang), the Banda Sea, and the Arafura Sea (Assir *et al.*, 2017). On the other hand, during the east monsoon, water masses are brought from the Arafura Sea to the Java Sea through the Banda Sea and the Flores Sea. As a result, the types of fish in the sea during the west monsoon are different from those during the the east monsoon. This is because the fish in the Java Sea follow the currents, migrating eastward during the west monsoon and vice versa. Likewise, the fish from the Banda Sea and surrounding areas migrate westward through the Flores Sea during the east monsoon.

The results also show that the number of mackerel tuna and bigeye tuna caught by fishermen in Gili Sulat-Gili Lawang during the west monsoon was higher than during the east monsoon. This phenomenon could be due to the migration of fish from the west to the east during the west monsoon. According to Safruddin *et al.* (2020), the seasonal and annual movements of water masses in Indonesian waters influence the migration patterns of migratory fish (high migratory species) such as tuna (*Thunnus* sp.). During the west monsoon, Indonesia's water current exhibits the pattern of moving from the South China Sea to the Java Sea. From the Java Sea, the current moves to the Flores Sea until it reaches the Banda Sea in the east (Wyrtki, 1961). Priatna and Natsir (2017) also revealed that the distribution pattern of small pelagic fish follows the direction of the current movement. The distribution pattern of pelagic fish is also supported by the presence of plankton and fish larvae, which move in the direction of the current.

The high number of fish caught in the Gili Sulat-Gili Lawang area is also caused

Table 1: Types and characteristics of the fishing gear used in Gili Sulat-Gili Lawang, Indonesia

Characteristic			Type of Fishing Gear															
			Cast net		Fishing Rod		Gill net		Handline		Longline		Scoop Net		Speargun		Trolling Line	
			n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Total length (m)		≤ 50	1	6	1	50	4	14	1	2	0	0	3	100	4	100	0	0
		> 50	15	94	1	50	25	86	56	98	27	100	0	0	0	0	10	100
		Total	16	100	2	100	29	100	57	100	27	200	3	100	4	100	10	100
Size	Mesh	≤ 2 inch	15	94	-	-	25	86	-	-	-	-	2	67	4	100	-	-
		> 2 inch	1	6	-	-	4	14	-	-	-	-	1	33	0	0	-	-
		Total	16	100	-	-	29	100	-	-	-	-	3	100	4	100	-	-
	Hooks	≤ No. 20	-	-	2	100	-	-	57	100	27	100	-	-	-	-	10	100
		> No. 20	-	-	0	0	-	-	0	0	0	0	-	-	-	-	0	0
		Total	-	-	2	100	-	-	57	100	27	100	-	-	-	-	10	100

Note: *n* = Frequency, % = Percentage

Table 2: Catch composition and relative abundance by season in Gili Sulat-Gili Lawang, Indonesia

Species	West Monsoon		East Monsoon	
	Volume of Catch (kg)	Relative Abundance (%)	Volume of Catch (kg)	Relative Abundance (%)
Grouper	339	1.92	197	2.06
Nemipterus sp.	44	0.25	72	0.75
Emperor fish	690	3.92	494	5.15
Red snapper	31	0.18	20	0.21
Pompano	10	0.06	0	-
Barracuda	122	0.69	78	0.81
Stingrays	395	2.24	147	1.53
Mackarel scad	955	5.42	657	6.85
Snapper	20	0.11	60	0.63
Mackarel fish	795	4.51	690	7.20
Blackspot snapper	6	0.03	5	0.05
Sardine	2922	16.59	655	6.83
Bigeye tuna	2,775	15.75	1,800	18.78
Marlin	181	1.03	170	1.77
Squid	147	0.83	75	0.78
Rabbitfish	81	0.46	35	0.37
Skipjack tuna	497	2.82	566	5.90
Shark	1,870	10.61	400	4.17
Octopus	90	0.51	47	0.49
Anchovy	50	0.28	40	0.42
Mackerel tuna	4,975	28.24	2,847	29.70
Giant travally	224	1.27	76	0.79
Ambligaster sirm	280	1.59	80	0.83
Parrot fish	20	0.11	10	0.10
Mahi	37	0.21	0	-
Silver Pomfret	0	-	15	0.16
Yellowfin tuna	46	0.26	213	2.22
Wolf herring	10	0.06	120	1.25
Argyrosomus	5	0.03	12	0.13
Largehead hairtail	0	-	5	0.05
Total	**17,617**	**100**	**9,586**	**100**

by the movement of fish to areas nearer to land during the rainy season. According to Priatna and Natsir (2017), during the west monsoon, the density of pelagic fish is higher in shallower areas, especially at depths lower than 40 m. Meanwhile, according to Adnan (2010), mackerel tuna is mostly caught at low temperatures. Warmer water may cause the fish to migrate into deeper locations where the fishing gear used by fishermen would be unable to reach them, resulting in lower catches.

The Gili Sulat-Gili Lawang is also a potential location for fish spawning, as the area has extensive mangroves and coral reefs. Wahyudewantoro and Haryono (2011) found that anchovies generally live in groups and use coastal areas to spawn and raise their young during the rainy season. This is reflected in the result of this study, which showed the volume of anchovies caught during the west monsoon was higher than during the east monsoon. Interestingly, a study by Binsasi (2020) reported that the main food for mackerel tuna is anchovy. This may explain the high number of mackerel tuna caught during the west monsoon. Furthermore, the environment of Gili Sulat-Gili Lawang is suitable for mackerel tuna. Based on Shabrina *et al.* (2017), mackerel tuna live in water temperatures ranging from 28°C to 29°C. According to Arifin and Yulianda (2003), the temperatures in Gili Sulat and Gili Lawang are 28°C and 28.5°C, respectively.

Overall, this study found that the total weight of fish caught during the west monsoon was higher than during the east monsoon, possibly due to food availability. Based on Ginzel (2021), during the west monsoon season, high rainfall affects water temperatures and food availability. Moreover, during the rainy season, fish can obtain additional food such as protein-rich insects from the land, which are good for their growth (Sulistiyarto, 2012).

Researchers have found that some fish species are abundant during the west monsoon season. Rahadian *et al.* (2019) found that sardine catches in Bali Strait waters were the highest during the west monsoon and the lowest during the east monsoon, especially in July. Ridho *et al.* (2019) found that the number of fish in Lebak Jungkal waters was much greater during the rainy season than the dry season. According to Simbolon (2011), the population of fish in Indonesian waters is dynamic, as the fish move according to changes in environmental conditions, which naturally cause them to go to places that are more suitable for living.

An optimum temperature and high chlorophyll-a content or food resources are the characteristics of an area with the potential to have large numbers of fish. Based on the research by Adnan (2010), the highest concentration of chlorophyll-a occurs in February (west monsoon), especially in coastal areas due to the supply of nutrients through run-off from land. Since the Gili Sulat-Gili Lawang waters are quite close to the mainland, the chlorophyll levels in the water are probably high during the rainy season. In addition, Adnan (2010) also revealed that decrease in sea surface temperature results in an increase in fish catch and vice versa.

Conclusions

Gili Sulat-Gili Lawang has huge potential to become a major fishery. In this study, a total of eight types of fishing gear were identified, resulting in high diversities of catch composition among fishermen. A total of 30 species were found, in which the most abundant species during the west monsoon was mackerel tuna (4,975 kg), followed by sardine (2,922 kg) and bigeye tuna (2,775 kg). The most abundant species during the east monsoon was mackerel tuna (2,847 kg), followed by bigeye tuna (1,800 kg) and mackerel (690 kg). Overall, the total weight of fish caught during the west monsoon was higher than during the east monsoon. In addition, the government and other stakeholders need to tighten laws and policies on fishing and establish an action plan to prevent unethical catches of protected fish such as sharks. Monitoring and evaluation of fish landing around the Gili Sulat-Gili Lawang by the fisheries department is crucial to ensure the sustainability of fishing activities in this area.

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Conflict of Interest Statement

The authors declare that they have no conflict of interest.

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