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Response of Indian Mackerel (*Rastrelliger kanagurta*) Biomass Size-Spectra Towards Moon Phase

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ABSTRACT

Lift net is one of light fishing which is occupied to catch small pelagic species. Plenty of studies on lift net have been presented but very view has explored at the biomass size spectrum of Indian Mackerel as a description of fishing intensity and selectivity. Indian Mackerel (*Rastrelliger kanagurta*) is among other small pelagic species captured by lift net. Observation of biomass size spectrum under different environmental factors aims to describe the selectivity of Indian Mackerel towards lift nets operated at Waralohi waters, Western Seram Regency. Length (cm) and weight (gr) of fish were used to calculate biomass size spectrum. Length of fish ranged from 16.5 cm to 22.5 cm with mean 18.2 cm, median and modus of 18.5 cm. The weight ranged from 16 gr to 149 gr, with mean and median 80 gr and modus 89 gr. Succeed of lift net operation to catch Indian Mackerel occurred during last quarter moon phase. The catch of Indian Mackerel is categorised as juveniles and undersized catch. Biomass size spectra identified that less fishing intensity during full moon affect less vulnerability of small fish being caught. This result should be concerned otherwise growth overfishing could not be avoided.

INTRODUCTION

Lift net is one fishing gears used by fishers in coastal area to catch small pelagic fish. It was initially introduced by Bugis-Makassar fishers around the 1950s (Genisa, 1998) and in a relatively short time, the gear has been well-known throughout Indonesia. Through many changes in shapes and sizes, modified lift nets can be operated according to the water condition and to limit uncertainty of catch (Oostenbrugge *et al*., 2001). This fishing gear is included as light fishing since lights were functioned as fish attractors, but it is also classified as lift net due to the sunken net was lifted to reach water surface after fish gathered under the lights (Mulyawan *et al*., 2015). It produces important economic small pelagic fishes

(Notanubun & Patty, 2010; Dwipayana *et al*., 2018; Triyono *et al*., 2020) other nocturnal marine biota such as squids (Tirtana, 2016; Sulaiman *et al*., 2015; Syahputra *et al*, 2016; Chaidir *et al*., 2019) and large predator species i.e trevallies, mackerels, tunas, and barracudas (Tirtana 2016; Chaidir *et al*., 2019; Limbong *et al*., 2020). Small pelagic fish contribute and play a very important role in Indonesian's fisheries development.

Indian mackerel (*Rastrelliger kanagurta*) is one of small pelagic species caught by light fishing including lift nets. This fish is always in groups, forming large groups in deep waters and small groups in shallow waters (Prahadina *et al*., 2016). Even more by its nature positive phototaxic (Azhari *et al*., 2017) makes this fish very easily captured under the light attractors. Response of mackerel towards light was categorized as species preferring low light illumination (Sudirman *et al*., 2003). This is because the fish has biological interaction with the environment of fishing ground (Bubun *et al*., 2015) such as primary production, surface water temperature, Chlorophyll-a, and depth. Variation of those environmental factors preferred by Indian Mackerel were 0.38 to 9.8mg/m^3/d^1 primary production, 23.1 to 29.6° of temperature, and 1.2 to 9.8 mg/m^3 Chlorophyll-a (Chl-a) (Das *et al*., 2017). Food intake of Indian mackerel consists of phytoplankton Bacillarophyceae, zooplankton, fish, shrimp and crustacean (Utami *et al*., 2017; Nath *et al*., 2015; Salsabila & Affandi, 2019). High chlorophyll-a content in the water will influence abundance of those foods (Salsabila and Affandi 2019). Preference of a targeted species should be understood once intending to study the impact of fishing.

Since all fishing gears are selective in size, effect of fishing was commonly traced from size distribution of marine populations and assemblages (Y. J. Shin *et al*., 2005). Size is acknowledged as a crucial component of marine biological processes. Theory of size-spectrum has been developed for particular marine ecosystems (Andersen & Beyer, 2006). The models of body size classes describe the biomass size spectrum and the distribution of biomass across body size classes of each individual species that triggered by the process of ecology. In the process of ecology, there is transfer of energy established from size-dependent predation that regulates the mortality of prey and growth of predator, controls prey mortality and predator growth. Unfished size spectra have two classes: a stable spectrum and waves progress from small to large body size over time (Law *et al*., 2009). How does fishing impact these dynamics is the question. It is well known that fishing intensity can affect the structure of the size spectrum (Y.-J. Shin & Cury, 2004). Selective fishing makes intuitive sense since it could create gaps that disrupt the current of biomass and possibly favor oscillatory dynamics, resulting biomass and catch changes in time. It is obvious that the interaction between fishing intensity and selectivity determines how fishing affects size-spectrum dynamics.

In this study, we concentrate on a single species, separate the size-spectrum effects from the multi-species effect. We tried to include lunar phase as a factor to find out how does fishing simply impact the single-species size-spectrum dynamics although it never done before. The aims of this study are 1) to describe the selectivity of Indian Mackerel towards lift nets operated at Waralohi waters, Western Seram Regency and 2) to track fishing effect by comparing the slopes of size-spectra. The introduction contains the research background, literature review, and aim of the research. The writing of the background and problems is presented in the form of a description which is chronologically directed from the general to go straight to the problem formulation. In the background and problems, several brief descriptions of previous research can be included which can strengthen the reasons why this research was conducted. If necessary, this section may contain general hypotheses/conjectures.

METHODS

Sampling Site

Waralohi suburb is located at the coast of Kamarian Village, Western Seram Regency (Figure 1). This coastal area inhabited by fishers who fully operate lift nets every day during the night. In one boat, required number of crew is at least 7 fishers. One acts as a fishing master who notices the availability of fish under the light, commands to immerse and lift the net and sells the catch. The rest of the crews lift the net following fishing masters and sort the catch by species.

Lift net fishing process was started by activating 48 LED (light emitting diode), 24 watt each. Left and right-side light attractors were set by 24 lights on lift net boat. Then net was submerged about 10 m depth. When fish was gathered in the catchability area, all lights were off except one light with red reflector. Red light has long wave length and attract fish from short distance to swim closed to the light (Fitria et al., 2015). These efforts were made to increase catches.

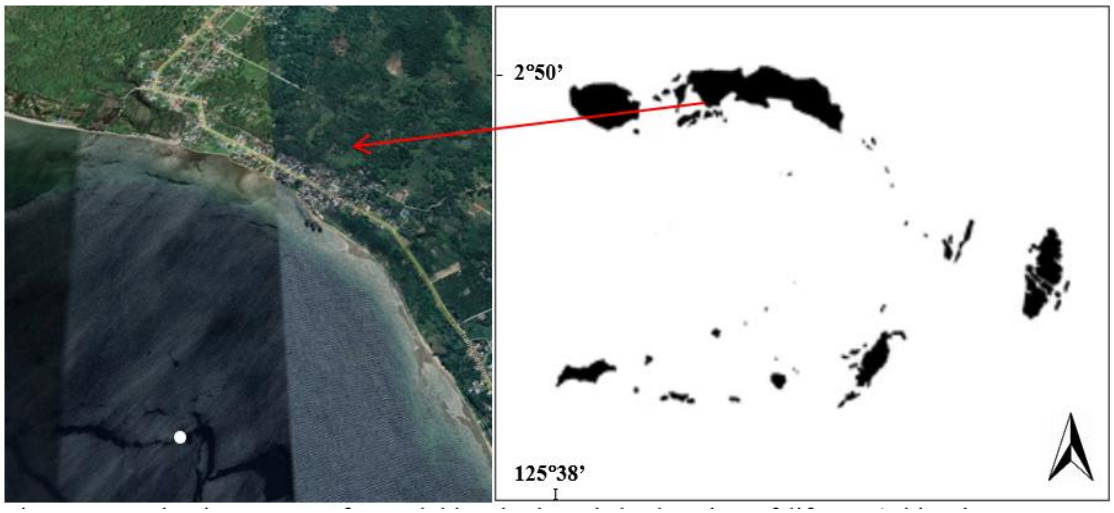

Figure 1. Study Site. Image of Waralohi Suburb and The Location of Lift Net (White Dot: 3°25.75'S 128°23.78'E). Right Map is Maluku Archipelago.

Data Collection

Data was collected from April to May 2022 from a lift net located about 1.12 km from Waralohi suburb. Preparation fishing operation started from 7 pm by turning on all lights consisted. Fishing finished in 6am with 1 to 2 times of net hauling, depends on fish gathering.

Indian mackerel (*Rastrelliger kanagurta*) is the main species measured during this study. Thirty samples were randomly taken from each hauling and measured its total length (cm) and weight in gram. Data of lunar cycles was taken from Nautide application which provides data according to the date of sampling.

Data Analysing

The biomass size spectrum for a single species is a valuable tool for understanding the distribution of biomass across different size classes within a population. This spectrum provides insights into the relative abundance and contribution of individuals of varying sizes to the overall biomass of the species. The slopes of size spectra were estimated from linear regression of log10 biomass per size class on the log10 minimum point of length class (Sweeting et al., 2009). Each length class was 0.5 cm interval. The general formula for this log-linear relationship between size (x) and biomass (y) within the catch is:

$$\text{Log10 (y)} = a + b * \text{Log10 (x)}$$

Where:
a = intercept
b = slope of the model

Length distribution at different lunar phase was analysed using nonparametric Kruskal-Wallis (H). General linear model was occupied for testing the slopes of size-spectra for each moon period. Statistics application used for data analyzing was SPSS 25 (IBM corp.). Relationship between size-spectra parameters (slopes and intercepts) and fishing intensity was analysed descriptively. This section presents information about the place and time of research, tools and materials, research design or hypothesis if any, research procedures, and data analysis used.

RESULTS

The length and weight of 1183 individual Indian Mackerel samples ranged from 16.5-22.5cm and 16-149g, respectively. The mean length of Indian Mackerel captured by lift nets had a mean was 18.2 cm, a modus of 18.5 cm, and 18.5cm of median (Figure 2). According to the statistics, when 96.9% of fish length fell within ± standard deviation of the mean, they are normally distributed and the fish are considered as juveniles.

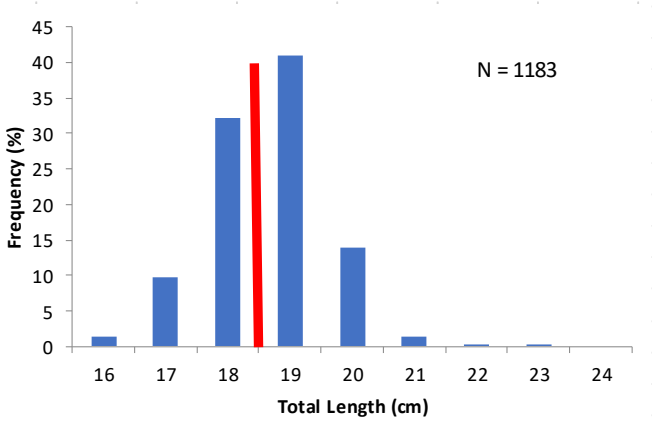

Figure 2. Length Distribution of Indian Mackerel Caught by Lift Net. Red Line Showed Median and Modes.

Four moon phases were passed during this study. The last quarter moon period (a 100% chance of catching Indian Mackerel had the highest fishing success, followed by the new moon period (90%) and the first quarter moon period (86.7%) (Table 1). Size distribution of Indian mackerel at different lunar phases was not significant (H=1.76; df=3; p=0.674). This result showed that selectivity of lift net to catch Indian mackerel was not influenced by moon phases. However, the slope of biomass size spectrum was significantly different among moon period (F=5.54; df=25; p=0.005). Visualised slopes representing lunar phases crossed and overlapped each other (Figure 3), which means there was a discrepancy between slopes. More hauling during the operation of lift net, the slopes of size-spectra were steeper. More fishing intensity, more young fish captured.

Table 1. Lift Net Fishing Intensity and The Parameters of Biomass Size-Spectra

Lunar Phase	Hauling			Biomass spectra	
	Total	Success	Failed	Slope	Intercepts
First Quarter	15	13	2	-11.59	15.06
Last Quarter	11	11	0	-7.06	9.29
New Moon	10	9	1	-4.56	8.07
Full Moon	12	7	5	-2.68	4.68

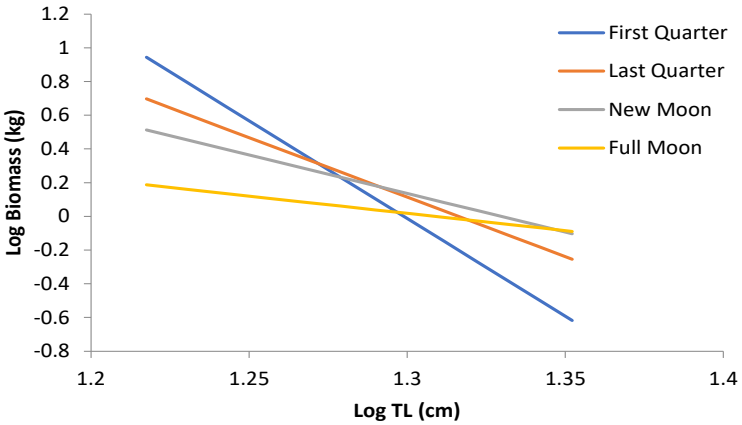

Figure 3. Slopes of Biomass Size-Spectrum of Indian Mackerel (*Rastrelliger kanagurta*) at Different Lunar Phases

DISCUSSION

Most Indian Mackerel captured during this study are young fish, weight no more than 149g. This means that during this fishing season, the waters of Kamarian Village composed by juvenile fish. On the other words, Kamarian waters might be a nursery area for Indian Mackerel. Local name of young Indian Mackerel is tatari and the adult is lema. If tatari is commonly captured by lift net in this area, the fisheries decrease number of reproductive fish and lead to recruitment overfishing (Froese, 2004; Froese & Proelss, 2013).Other studies on lift net also reported young fish as the catch (Chaidir *et al*., 2019; Botu *et al*., 2021). Therefore, lift nets should be considered in the scenario to maintain the Indian Mackerel population since the practise is vulnerable for young fish (Mosse & Hutubessy, 1996; Kantun *et al*., 2018; Widiyastuti *et al*., 2020; Gondhalli *et al*., 2013).

The occurrence of Indian mackerel as the catch of lift net varied among sites of fishing. There was no Indian mackerel among the lift net catches in the seas of Pelabuhan Ratu Bay (Ta'alidin, 2004) or in the waters of Ohoi Namar, Southeast Maluku, from September to April of the following year, which were dominated by small pelagic fish. (Rudin *et al*., 2017) and (Botu *et al*., 2021) did not report catch of Indian mackerel in waters of Pangkajebe (South Sulawesi) and Getting (East Timor). There were catch of Indian mackerel but as a by-catch in the waters of Krueng Raya, Aceh Besar (Ikramullah *et al*., 2018) and in Lasolo Bay (Chaidir *et al*., 2019). As the dominant species in the composition of lift net catches in the Flores Sea, *Rastrelliger kanagurta* is widely utilized (Assir *et al*., 2017). According to this study, lift nets can effectively collect the resources found in water. It is believed that Kamarian waters serve as a nursery region for juvenile mackerel, *Rastrelliger kanagurta*, during period of April to May.

The use of biomass size-spectra to calculate the impact of fishing on fish populations of a single species has not been widely implemented. The selectivity of fishing gear can be determined using biomass size-spectra (Breen *et al*., 2016), while length frequencies are more frequently employed in this capacity. The study's findings demonstrate that length frequency is no longer a sensitive variable to determine if a lift net is more selective for catching Indian mackerel during different moon phases. The biomass size-spectra, on the other hand, revealed notable variations. Accordingly, fish weight is a crucial variable to indicate the state of the fish that was captured. Going back to the length-weight relationship in fish, seasonal variations in the parameters (De Giosa *et al*., 2014) can be induced by the fullness of stomach contents and the maturity stages of the gonads (Flura *et al*., 2015). Therefore, biomass size-spectra are a more sensitive apparatus for measuring the fishing impact on target fish populations.

High failure of Indian mackerel fishing occurs on the full moon period similar to other species such as anchovies (Karuwal & Bagafih, 2016) and shrimp (Dwipayana *et al*., 2018), or other light fishing such as mini lift net (Sihotang, 2018) and barrier net (Mambrasar *et al*., 2014) and gillnet (Libini & Khan, 2012). Several studies have explored the impact of lunar cycles on fish behavior and fishing success. While specific research on light fishing and full moons may be limited, the broader body of research on lunar effects on fish activity strongly supports this observation. For example, studies have shown that fish exhibit altered feeding patterns and activity levels in relation to the moon's phases, with reduced activity often observed during full moon periods (Poisson *et al*., 2010). This reduced activity, coupled with the masking effect of moonlight on artificial lights, directly contributes to the poor performance of light fishing during this time. The increased light may also alter the behavior of the fish's prey, making them less readily available to the fish, thus further reducing the chances of a successful catch. This highlights the complex interplay between lunar cycles, fish behavior, and the effectiveness of fishing techniques. Therefore, experienced light fishers often adjust their strategies or avoid fishing altogether during full moon periods (Sulaiman, 2018).

As previously stated, the Kamarian waters serve as an Indian mackerel nursery area where young fish are harvested. Lift net, a fishing gear helps local fishers make a living. Meanwhile, recruitment overfishing is the result of intensifying fishing for juvenile fish. Compared to other lunar phases, the capture success rate during a full moon is low. Smaller fish are caught less frequent when fishing intensity is reduced because the slope becomes flatter (Table 1 and Figure 3) (Sweeting et al., 2009). The catch of juveniles Indian Mackerel is lower during the full moon phase. From ecological point of view, the prey of Indian Mackerel moved to the deeper part the sea which then followed by the predator during full moon period (Andrzejaczek *et al*., 2024). We believe that this period is a pausing time for juveniles Indian Mackerel to be captured and consider on the natural process of maintaining the balance of fish populations and community structures.

CONCLUSION

When examining how fishing affects fish populations and ecosystems, length-based analysis is insufficient; biomass size-spectra are required to produce more precise results. More young fish are exploited in relation to the intensity of fishing. There is a real impact of the lunar phase on fishing. Variations amount of moonlight are a natural mechanism to preserve the balance of the population being targeted and the equilibrium of community structure.

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