The Impact of Bottom Gillnet Construction on Lobster Catch Quality in Segara Bay District, Bengkulu City, Indonesia

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ABSTRACT

Lobster represents one of the most valuable non-fish species with significant economic potential in Bengkulu City, with the first lobster fishermen's association being established in Segara Bay District. This research aims to identify the construction of bottom gillnets used by fishermen, assess their compliance with the Indonesian National Standards (SNI), and evaluate their impact on lobster catches in the waters of Segara Bay, Bengkulu City. The study was conducted from April to June 2020 using a survey method that directly observed and measured bottom gillnets, fishing activities, and catch characteristics across 42 fishing operations. Results indicated that the identified bottom gillnets did not meet SNI specifications. Consequently, the primary lobster catches, dominated by scalloped spiny lobster (*Panulirus homarus*), accounted for only 31% of the total catch, while by-catch constituted a significantly high proportion at 69%. Additionally, the catch exhibited uneven size distributions with a high proportion of undersized lobster (62%), and the estimated first catch size (7.8 cm) was smaller than the size at first maturity. These findings highlight the urgent need for comprehensive improvements in the bottom gillnet dimension standards in Indonesia.

Keywords: Bengkulu, Bottom gillnet, Length at first maturity, Lobster

INTRODUCTION

Lobster is a non-fish species that is quite popular in Indonesia and ranked fourth among export crustaceans, after shrimp of the genera *Penaeus, Metapenaeus,* and *Macrobrachium* (KKP, 2012). Demand for lobsters from the U.S. and Japan has increased every year since the 1980s, according to FAO and GLOBEFISH fisheries statistics, further indicating the expansion of the global lobster industry (Boesono *et al*., 2011; WWF-Indonesia, 2015). As a result, efforts to catch lobster species in Indonesia have become more intensive, supported by the high selling price of lobsters (Saputra, 2009). There are several types of lobster in Indonesia, namely, scalloped spiny lobster (*Panulirus homarus*), long-legged spiny lobster (*Panulirus longipes*), ornamental spiny lobster (*Panulirus ornatus*), pronghorn spiny lobster (*Panulirus penicillatus*), mud spiny lobster (*Panulirus polyphagus*), and painted spiny lobster (*Panulirus versicolor*) (Dall, 1974; Chang *et al*., 2007; Yusnaini *et al*., 2009; Ikhwanuddin *et al*., 2014; Kembaren and Nurdin, 2015; Khikmawati *et al*., 2017).

Bengkulu City, Indonesia has a sea area of 387.6 km^2, located at 102º14'42"–102º22'45" East Longitude and 3º43'49"– 4º01'00" South Latitude DKP Bengkulu, 2012). It is a significant marine production area, particularly for lobster, which is highly favored. The first lobster fishermen's association was established in the Segara Bay District which is one of the lobster fishing bases in Bengkulu City.

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Received 15 March 2024 / Accepted 27 November 2024

Lobster fishermen in the area primarily use bottom gillnets, which are known for high catch efficiency (Febriani *et al*., 2014). Gillnet specifications vary across Indonesia (Kholis *et al*., 2018), and while the Ministry of Maritime Affairs has standardized bottom gillnets under the Indonesian National Standard (SNI) Code 01–7214–2006, many constructions still do not meet these standards.

The impact of SNI or not SNI gillnets on lobster resources is significant. While the effects of fishing gear operations have been studied (Font and Lloret, 2014; Grabowski *et al*., 2014; Lewin *et al*., 2019), the specific influence of gillnet dimensions on lobster biology remains under-researched. This study aims to examine the construction of bottom gillnets used by fishermen in Segara Bay, assess their compliance with SNI, and analyze their impact on lobster biology in Segara Bay.

MATERIALS AND METHODS

This study used a survey method, by conducting direct observations and measurements of bottom gill nets, conducting direct fishing activities, and observing the characteristics of the catch. Primary data including net dimensions, types, and lobster size, were the main data sources. The study was conducted at Malabero Beach and Zakat Beach (Segara Bay District) Bengkulu City, Bengkulu Province (Figure 1). Surveys and fishing activities took place over 42 trips from April to June 2020, using a 3 GT boat operating at 0–12 miles of the coastline at fishing grounds with depths of 15–18 m. Each fishing trip lasted one day, from 5:00 a.m. to 6:00 p.m. The study focused on using bottom gill nets and the fish caught during the research period. The tools used included stationery, measuring tapes, calipers, and digital cameras.

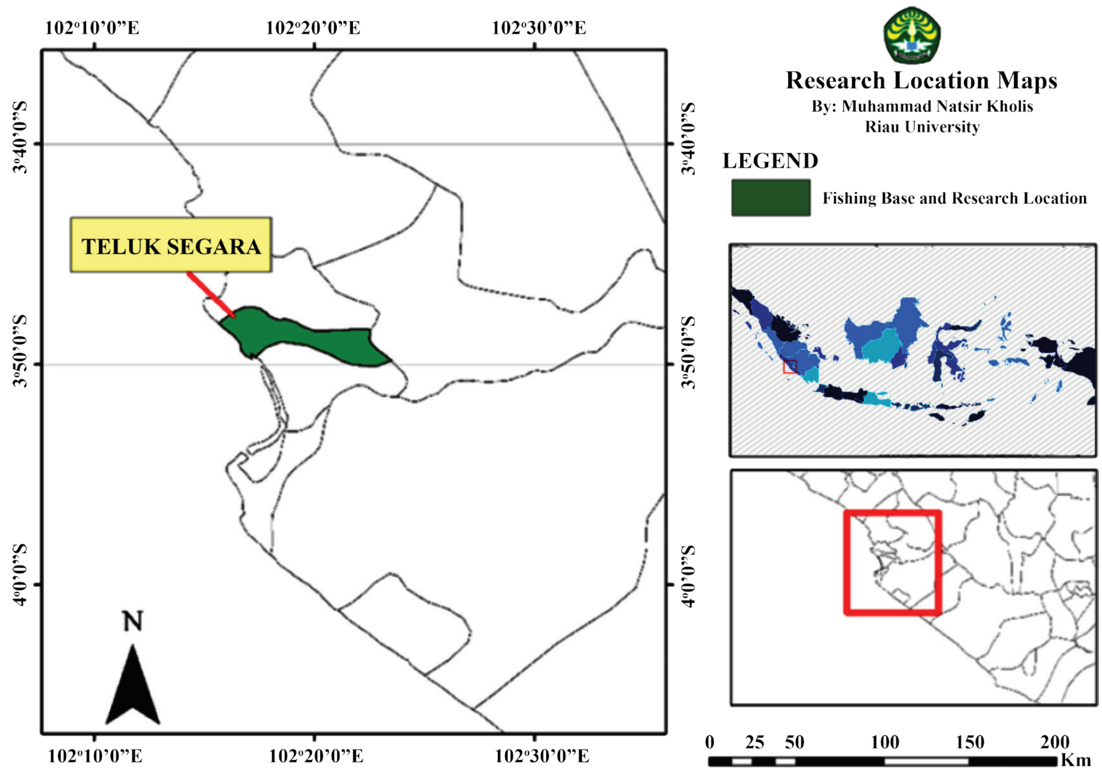

Figure 1. Map of research location showing Segara Bay District (Teluk Segara) Bengkulu City, Indonesia.

Fishing gear analysis

The analysis of bottom gillnet construction was performed through direct measurement and observation. The collected data were tabulated using data sheets and drawings. The final results would be compared with the Indonesian National Standard (SNI) 01–7214–2006, which outlines the standard form of monofilament bottom gillnet construction. The specific component standards for bottom gillnet construction are presented in Table 1.

Analysis of catch characteristics catch composition

The catch composition was analyzed using a descriptive-tabular approach. All lobster and bycatch were presented as catch composition diagrams following the method described by Wahju and Riyanto (2017).

First caught size

The size of the first lobster caught was determined through length frequency distribution analysis, utilizing a normal equation approach (Myers and Mertz, 1998). The length class with the highest carapace length value was identified as the size of the first lobster caught (Lc). The mathematical model used for this analysis is as follows:

$$F(c) = (ndL/s\sqrt{2\pi})\times e\{-(L''-L)2\ /2s^2\}$$ (Panda *et al*., 2012)

where:

F(c) = fish frequency in long class
n = number of samples in sampling
dL = interval in long class
s = standard deviation
π = constant 3.14
L” = mean of long class
L = average length of one lobster cohort

Furthermore, the estimation of the mean and standard deviation of lobster length in each sample was carried out by changing the equation in linear form as follows:

$$\Delta \ln Fc\ (z) = a-bx\ (L+dL/2)$$ (Cervigón *et al*., 1993)

where:

ΔlnFc (z) = the logarithm difference of two long classes

Table 1. Bottom gillnet construction components based on the Indonesian National Standard (SNI 01–7214–2006).

No	Assessment component	Description	SNI standard value
1	E1	Hanging ratio	0.65–0.80
2	Lgr/Lhr	Comparison of the length of the bottom riser rope and the length of the top riser rope	1.00–1.20
3	L/h	Comparison of the length of the installed net and the height of the installed net	20.00–30.00
4	dt/mo	Comparison of thread diameter and stretched mesh size	0.00650–0.00850
5	B/Lhr	Comparison of buoyancy and length of the top rope	110–135 grf
6	S/Lgr	Comparison of sinking force and the length of the bottom riser rope	235–290 grf
7	S/B	Comparison of sinking and buoyancy	2.00–2.45
8	Sf/h	Comparison of float distance and net height	22.50–30.00 %
9	Ss/h	Comparison of ballast distance and net height	6.00–8.50 %
10	Sf/Lhr	Comparison of buoy spacing and top rope length	0.80–1.20 %
11	Ss/Lgr	Comparison of ballast spacing and length of the bottom rope	0.20–0.30 %

Note: grf = $g\cdot force^{-1}$

L + dL/2 = upper limit of each class length
a, b = constants

The mean value and standard deviation of the length of each particular age group were estimated by the formula Lc = a/b dan s^2 = -dL/b.

Catchable size

The analysis of catchable size was carried out using descriptive analysis, referencing the Lm value (length at first maturity) as outlined in PERMEN-KP No. 56 of 2016 Article 2 (b). According to this regulation, lobster (*Panulirus* spp.) with a carapace length greater than 8 cm are eligible for capture. The percentage of eligible catches was calculated by comparing the carapace length (Lm) of lobsters caught by fishermen with the Lm value set by the regulation. The results were presented in the form of a diagram, showing the proportion of lobsters meeting the catchable size criteria.

RESULTS AND DISCUSSION

Bottom gillnet

The bottom gillnet, commonly referred to as a lobster net by fishermen in Segara Bay, is primarily used for catching lobsters. Its general construction consists of several components, including the net body (webbing), rigging ropes, float rope, top rigging rope, bottom rigging rope, webbing buoys, buoys, lead weights, and rock weights. These components are illustrated in Figure 2. A datasheet was prepared to detail the bottom gillnet design, with codes in the datasheet corresponding to those in the construction drawing (Figure 2).

According to the datasheet (Table 2), the bottom gillnet measured 1,200 m in length and 5 m in height. It is equipped with 150 PP-based floats and 500 Pb (tin) ballast units. The mesh size is 4 inches (10.16 cm), with a mesh length (ML) of

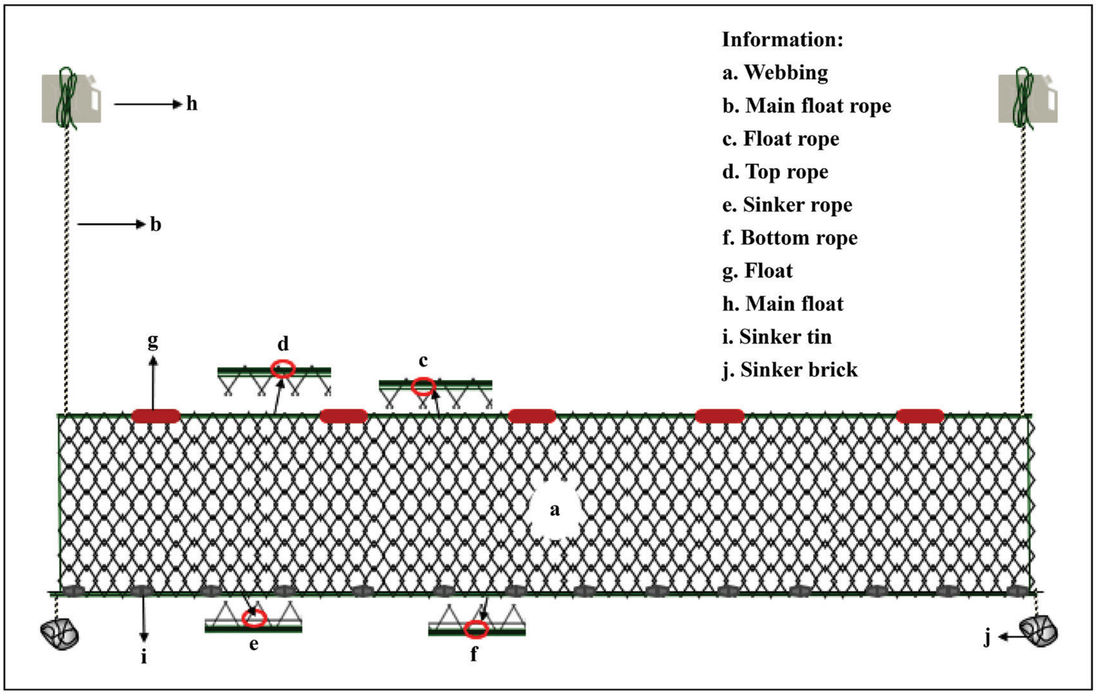

Figure 2. Schematic diagram of the bottom gillnet design.

Table 2. Bottom gillnet datasheet.

Data sheet			
Name of gear	: Gillnet	Main species caught:	Vessel: INA
Type	: Bottom gillnet	Lobster (*Panulirus* sp)	LOA: 6–7 m
Country	: Indonesia	Fishing condition: Bottom	Gross tonnage: 2–3 GT
Locality	: Bengkulu city		Horse power: 6.5 PK
			Crew: 2 men

Webbing	**a**				
Material	PA Monofilament				
Type of knot	Double English knot				
Preservation	-				
Color	Transparent				
Twine size	-				
Breaking strength (kg)	-				
Stretched mesh (mm)	101.6 (4 inch)				
Upper edge	-				
Lower edge	-				
Length (mesh/m)	7,100/1,200				
Depth (mesh/m)	70/5				
Baiting rate	-				
Take up	-				
Selvage	-				
Hanging ratio	29%				
Lines, rope	**b**	**c**	**d**	**e**	**f**
Material	PE	PE	PE	PE	PE
Preservation	-	-	-	-	-
Circum reference	-	-	-	-	-
Diameter (mm)	152.4	76.2	76.2	63.5	63.5
Breaking strength (kg)	-	-	-	-	-
Construction	Z	Z	Z	Z	Z
Lay	-	-	-	-	-
Length (m)	23	1,200	1,200	1,100	1,100
Float, singker	**g**	**h**	**i**	**j**	
Number	-	-	-	-	Reference and
Material	Plastic	PP	Pb	Stone	Collection:
Shape	dirigent	cylinder	cylinder	-	Muh. Natsir
Diameter (mm)	-	10	100	-	Kholis
Length (m)	0.4	0.15	0.05	-	Faculty of Fisheries
Static buoyancy (kgf)	-	-	-	-	and Marine Science
Weight on air (gf)	-	-	-	-	Riau University
Weight submerged	-	-	-	-	2024

Note: The alphabetic codes a, b, c, d, e, f, g, h, i, j are the construction section codes in Figure 2; Z code is the direction of the rope twist; PE, PP, Pb, etc are the materials used

7,100 and a mesh depth of 70. The total number of meshes is 1,001,029, and the net is made of 0.35 mm PA monofilament. The bottom gillnet is operated using a small 2–3 GT vessel, which has a length overall (LOA) of 6–7 m, a 6.5 PK engine, and a crew of two. Based on the construction drawing and datasheet, a detailed bottom gillnet design was created, as shown in Figure 3.

This design provides comprehensive information about the dimensions of the fishing gear and structure. However, when compared to the Indonesian National Standard (SNI) 01-7214-2006 for bottom gillnets, several parts of the design fall outside the specified lower and upper limit values. These discrepancies are highlighted in Figure 4.

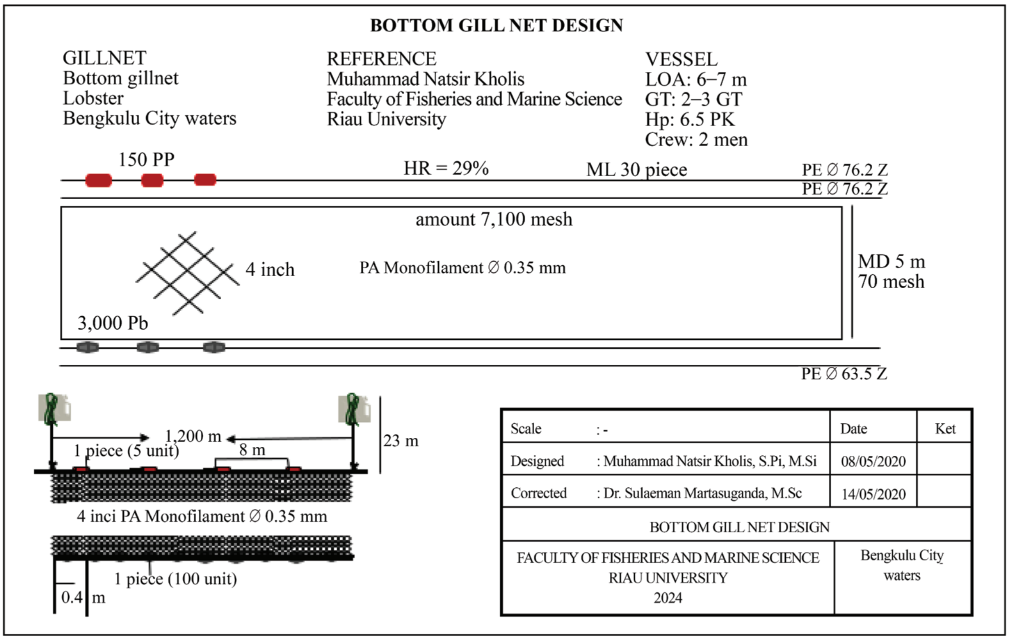

Figure 3. Detailed design of the bottom gillnet used for lobster fishing in Bengkulu City waters.

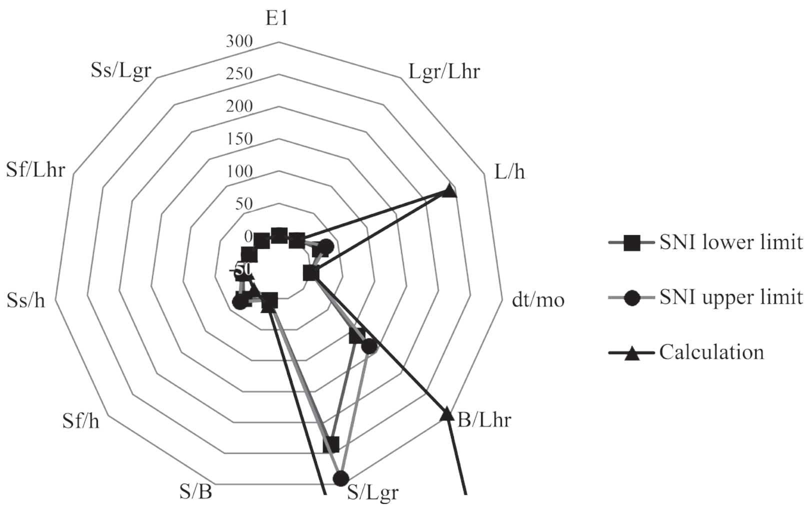

Figure 4. Performance of bottom gillnet standard form based on SNI 01–7214–2006.

Figure 4 illustrates that the components of the bottom gillnet fall below the SNI limit values for Sf/h, Ss/h, Sf/Lhr, and Ss/Lgr. Conversely, components exceeding the SNI limits include L/h, B/Lhr, S/Lgr, and S/B. The standard construction forms according to SNI standards are E1, Lgr/Lhr, and dt/mo. The variations in construction sizes among the bottom gillnet components can be attributed to fishermen's lack of awareness regarding proper design calculation and their adaptation to the specific characteristics of their fishing grounds and target species.

Catch characteristics

The composition of the catch from bottom gillnets was dominated by lobsters, accounting for 31% of the total catch, followed by crabs (Suborder Brachyura) at 20%, Sagor catfish (*Hexanematichthys sagor*) at 17%, threadfins (Family Polynemidae) at 11%, tongue fish (Family Cynoglossidae) at 9%, and other species at 12% (Figure 5).

While the primary target for Segara Bay fishermen using bottom gillnets was lobster, the catch data indicated a significant amount of bycatch (69%) (Figure 5). Several types of commodities likely share similar habitat characteristics with lobsters. Lisdawati *et al*., (2017) noted identical bycatch incidents in Selayar, South Sulawesi, where bottom gillnets captured white pomfret (*Pampus argenteus*) and various cartilaginous fish (Superorder Batoidea). In West Pasaman, West Sumatra, bycatch from bottom gillnets included 24 species (Fisabillilah *et al*., 2022), while in Palabuhanratu waters in West Java recorded bycatch of 31 species (Khikmawati *et al*., 2017).

The lobster fishing area in Segara Bay, Bengkulu City, extends from 0 to 12 miles from the fishing base, predominantly in rocky zones with depths averaging ±18 m (Lisdawati *et al*., 2017). Estuaries, characterized by fluctuating salinity and temperature, attract lobsters (Watson III *et al*., 1999). These lobsters exhibit various survival strategies, including behavioral adaptations (behavioral thermoregulation) and physiological ones (osmoregulatory adjustments) (Crossin *et al*., 1998; Charmantier *et al*., 2001). They also migrate through locomotor movements to different environmental conditions (Herrnkind, 1980). Estuaries provide essential habitats for lobsters, offering warmer water temperatures during summer as a place for growth, maturation, or reproduction, thereby facilitating their migration and protection (Maynard *et al*., 1999).

The primary species of lobster caught in Segara Bay was the scalloped spiny lobster, characterized by its rough, toothed cephalothorax, two-branched antennae, eight walking legs, six swimming legs, and five caudal fins (telson). This species typically has a dark green to slightly blackish coloration, consistent with the FAO's identification (Bianchi, 1985).

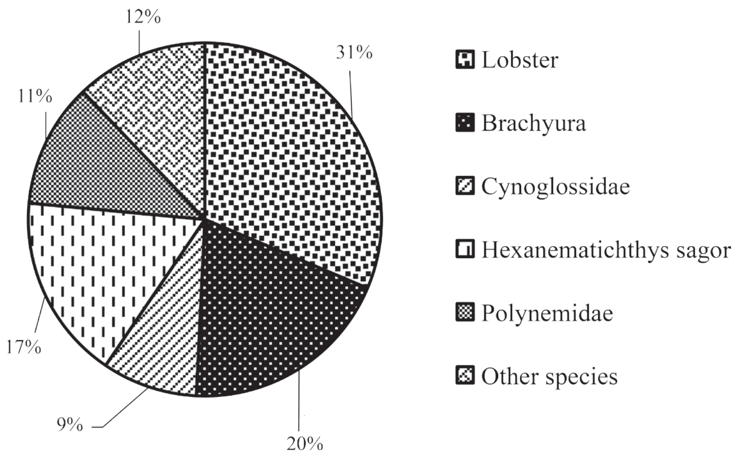

Figure 5. Composition of bottom gillnet catches in Bengkulu City waters April-June 2020.

First catching size and eligible catching size

Between April and June 2020, a total of 338 scalloped spiny lobsters were caught, with the highest carapace length recorded at 8.5 cm (85 mm) and the lowest at 5 cm (50 mm). The majority of the carapace lengths ranged from 78–81 mm. Catch numbers were 58 in April, 38 in May, and 72 in June. However, lobsters with lengths between 54–57 mm, 58–61 mm, 62–65 mm, and 62–69 mm were not caught during the study, possibly due to construction collisions. Factors such as mesh size, hanging ratio, and looseness can contribute to this uneven size distribution. Internal biological factors or environmental influences may also play a role in the lack of certain sizes in the catch. The distribution of carapace lengths of scalloped spiny lobsters caught with bottom gill nets is depicted in Figure 6.

The first catching size of the scalloped spiny lobster in Segara Bay was estimated at an Lc value of 78.15 mm (7.8 cm). The size is still below the Lm value (length at first maturity) as per PERMEN-KP No. 56 of 2016. The analysis revealed that only 38% of the lobsters caught from April to June 2020 were of legal size, while 62% were undersized, as shown in Figure 7.

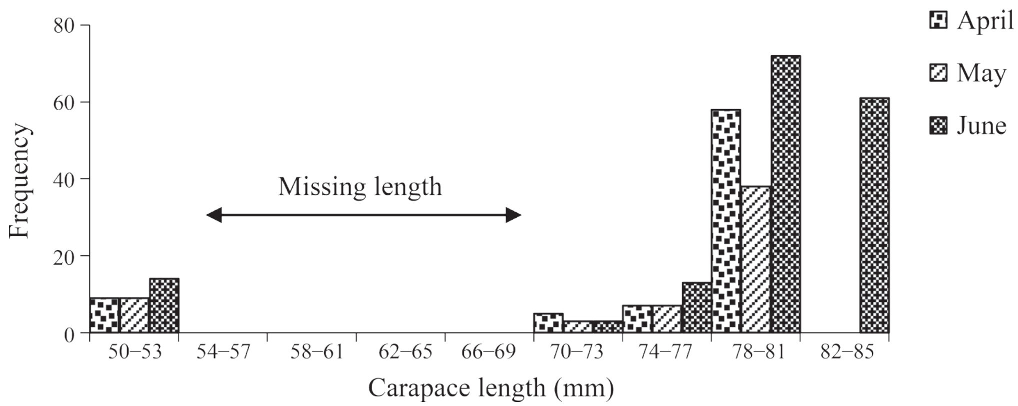

Figure 6. Distribution of carapace length of scalloped spiny lobster (*Panulirus homarus*) in Segara Bay waters, Bengkulu City.

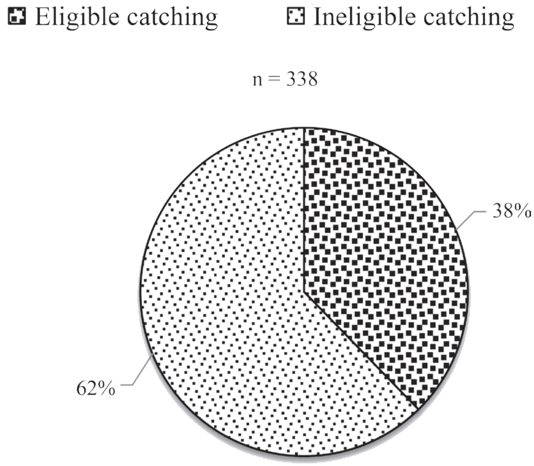

Figure 7. Percentage of scalloped spiny lobster (*Panulirus homarus*) eligible to catch in Bengkulu City waters.

The majority of scalloped spiny lobsters caught in Segara Bay were undersized. In contrast, research by Wahju and Riyanto (2017) reported that the proportion of lobsters caught in Aceh Jaya that fell within the legal-size requirement ranged between 60% and 90%. This discrepancy suggests that fishing practices in Segara Bay may not comply with legal regulations, potentially influenced due to the construction of the bottom gillnets. Observations indicated a low level of oversight and engagement from the local government concerning fishermen's practices, leading to inadequate recording of catch sizes and numbers. Furthermore, stakeholder participation in the development and management of sustainable fisheries remains relatively low. Current regulations from the central government, which apply uniform eligible sizes across all lobster species, have generated some debate. It is essential to establish catchable sizes specific to each lobster species to ensure appropriate management. For example, the blunthorn lobster (*P. waguensis*) has an Lm of 96.9 mm exceeding the standards set by PERMEN-KP No. 56 of 2016 (Chakraborty *et al*., 2021). Measurement of Lm for each lobster is crucial for their sustainability.

Impact of bottom gillnet construction on lobster

All commercial fishing gears affect fish resources, both directly and indirectly. Recent data show that recreational fisheries also impact fish populations and coastal environments (Lewin *et al*., 2019). In Segara Bay, several noteworthy observations emerge regarding bottom gillnets. Firstly, the identified bottom gillnets do not meet the Indonesian National Standard (SNI) requirements, with only three out of 11 sizes falling within the acceptable SNI range. Secondly, the impact on lobster catches is concerning, with a significant portion being undersized (mature burnt length < 8 cm), a bycatch rate of 69%, and 62% of lobsters being unsuitable for retention. Khikmawati *et al*. (2017) noted that improper construction can also result in lobsters being ineligible for export due to incomplete body parts. The wide class interval indicates an uneven size distribution among captured lobsters, influenced by fishing grounds and lobster seasons, as well as gear construction.

Finally, improper construction can also result in increased bycatch and negatively impact the environment (Kumar *et al*., 2015; Fisabillilah *et al*., 2021). Variations in gear construction also affect the efficiency of bottom gillnet catches (Fitri *et al*., 2019). The mesh size also affects the diversity of fish species caught (Rahantan and Puspito, 2012). Therefore, improvements in the construction of bottom gillnets are necessary to enhance lobster fishing effectiveness and compliance with standards. Key factors such as hanging ratio, slack, and mesh size should be carefully redesigned (Mardiah *et al*., 2016; Puspito *et al*., 2019). Neglecting these construction improvements may lead to unsatisfactory outcomes. Lobster fisheries management needs to be regulated in such a way that it is measurable and sustainable. For example, the application of EAFM-based lobster fisheries management patterns, centralized fisheries management (top-down), community-based management (bottom-up), joint management, and others (Munandar *et al*., 2018). Several other ways can be done to minimize the side impacts of fishing on the habitat, namely: closing areas, modifying fishing gear, and reducing fishing effort (Board and NRC, 2002; Grabowski *et al*., 2014).

CONCLUSIONS

The bottom gillnets were found not to comply with the Indonesian National Standard (SNI), resulting in a high proportion of bycatch (69%), an estimated first catch size (7.8 cm) below the size at first maturity, and a high proportion of undersize individuals (62%) relative to the legal catchable size. The bottom gill net dimension standards need comprehensive improvement. Government supervision plays a crucial role in managing lobster resources, and regulations can be established through intensive dialogue with relevant stakeholders.

ACKNOWLEDGEMENTS

The authors would like to thank Mr. Abu Bakar, the head of the bottom gill net fishermen group (lobster net) in Segara Bay District, Bengkulu City. The author also extends gratitude to all stakeholders who assisted during the research and to the sponsors who provided funding for the project.

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