Estimation of fishing boats operational waste and its management strategy at Nizam Zachman Ocean Fishing Port

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Abstract. Pollution from the operational waste of fishing boats remains a problem in Indonesia, owing to insufficient regulations and a lack of discipline among fishers in disposing of waste to the sea. This research aims to determine the categorization and amount of waste, to identify factors that influence handling, and to develop strategies for dealing with waste pollution. The study was carried out at Nizam Zachman Ocean Fishing Port, Jakarta, Indonesia from January to March 2021. The data was collected through interviews with the captain of the boats. There were 60 boukeami, 12 squid jigging, 9 line haulers, 4 gillnets, and 4 purse seines among the respondents. Descriptive and SWOT analyses were used in this study. The waste generated by fishing boats was classified into three broad categories: consumption, machinery, and fishing waste. On every fishing trip, vessels produce an average of 107.53 kg. Internal factors that influence waste management include fishing vessel storage facilities, waste profit value, crew awareness, and external factors are regulation, deposit system, recycling facilities, and socialization. The primary strategy consists of optimizing socialization aimed at fishing vessel captains and owners and providing facilities for depositing recyclable waste, which can be converted into profit value for fishing vessel.

Key Words: operational, pollution, recyclable, socialization.

Introduction. Marine debris can originate from distant regions, where it is either intentionally dumped into the sea or rivers, left lying on the beach or coast, washed away indirectly into the sea through rivers or sewers, carried by the wind, or lost accidentally, such as fishing equipment or supplies (Djaguna et al 2019). Ocean Conservancy (2015) also found that 75% of garbage leaks into the sea were caused by inadequate urban slide management systems and lack of collection. Even though 80% of land-based waste disposal into the ocean comes from land, the remaining 20% comes from maritime activities, particularly ship activities, such as fishing vessels (Chen & Liu 2013).

MARPOL 73/78 Attachment V, adopted by Indonesia and contained in the Regulation of the Minister of Transportation of the Republic of Indonesia Regulation No. 29 of 2014, regulates waste management and handling to prevent pollution by ships, including fishing vessels. However, the Minister of Transportation Regulation No. 29 of 2014 is regarded as lacking in its application to Indonesian fishing vessels. This is because 100 GT fishing vessels dominate the entire fleet of Indonesian fishing vessels. In contrast, 100 GT-sized vessels must comply with Paragraph 5 of Minister of Transportation Regulation No. 29 of 2014 regarding the construction of shelters, handling systems, and waste logbooks. The only requirement in the regulation to prevent the pollution of 100 GT fishing vessel waste is to have a garbage collection location. This indicates that the legislation does not regulate waste management from fishing vessels larger than 100 GT.

In addition to regulations, fishers' behavior involving the disposal of trash in the ocean is essential in preventing the pollution of fishing boat waste. Multiple instances of fishers disposing of waste into the ocean, demonstrate that the behavior of fishing vessel waste management has not been properly implemented. Inadequate ship and port waste storage facilities are also suspected to be a factor in the ineffective management of fishing vessel waste. Moreover, the fishing port environment in Indonesia, particularly in port ponds that are considered slums and polluted according to Wahyudi et al (2017), indicates that the behavior of fishers in handling waste is still poorly educated and does not rule out the possibility of similar pollution actions occurring during fishing operations at sea.

To unravel the problem of fishing ship waste pollution, basic information regarding the amount and types of fishing vessel operational waste, as well as several motivating factors and barriers for fishers in preventing pollution and fishing vessel waste, is required. As a preliminary step, this study focuses on a fleet of fishing vessels based at the Nizam Zachman Ocean Fishing Port (PPS Nizam Zachman), the largest fishing port in Jakarta, Indonesia. It serves as a model for the growth of capture fisheries in other ports in Indonesia (Sam 2012). This research aims to determine the classification and quantity of waste, to identify factors that affect its management, and to develop strategies for combating waste pollution. The research is anticipated to yield information regarding strategies to combat pollution caused by fishing vessel waste.

Material and Method

Description of the study sites. This study was was carried out at the PPS Nizam Zachman in North Jakarta from January to March 2021 (Figure 1). Writing instruments, smartphones, and laptop computers were used in this study. Data and interview results were recorded on paper, while interview results and documentation were recorded on smartphones. In the meantime, laptops store data and support software, such as Microsoft Excel and Microsoft Word, that is used to process research data. The case study method was applied in the study.

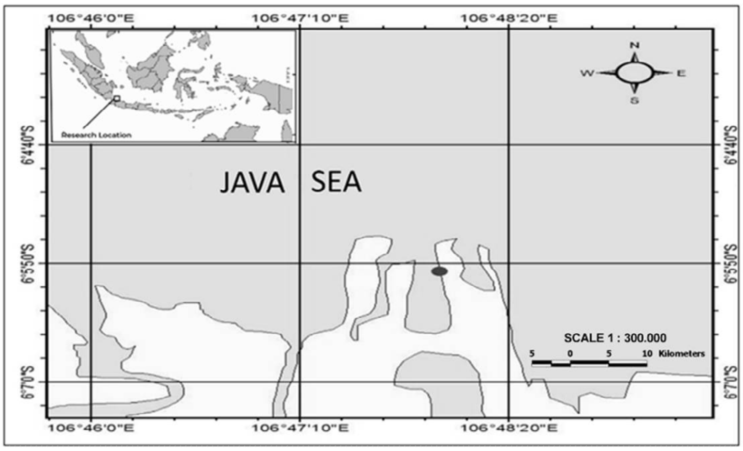


Figure 1. The location of the PPS Nizam Zachman Fishing Port, North Jakarta.

Collecting data and observations. This was done to gain a concrete understanding of something interesting or to observe a social process (Prihatsanti et al 2018). The investigation, in this case, is centered on the waste management practices of a fishing boat fleet of 30-100 GT based at the PPS Nizam Zachman. The data was gathered through interviews with questions provided by the researcher. This interview's questions are open-ended. Almost all of the data in this study came from primary sources. Secondary and primary data are required to develop strategies for preventing pollution from fishing vessel waste. The respondents in this study were determined by using the purposive sampling technique, which aims to intentionally determine the sample, where the selected class has the same initial ability not based on random or strata. The resource persons, who are also the sample in this study, amounted to 89 fishers or administrators who work on fishing vessels of different sizes 30-100 GT (consisting of 60 boukeami boats, 12 squid jigging vessels, 9 line haulers, 4 gillnet boats, and 4 purse seine vessels) with a total fishing vessel population of 754 vessels. Respondents were selected based on their ability and involvement in handling waste and loading fishing vessels. The determination of the number of samples refers to the sampling formula as follows Scheaffer et al (2011):

$$n = \frac{Npq}{(n-1)^2 + pq}$$
$$q = 1 - p$$

where: n = number of ships sampled;
N = total number of ships of size 30-100 GT based in PPS Nizam Zachman;
p = probability of ships disposing of garbage into the sea (0.5);
q = probability of ships that do not dispose garbage in the sea;
B = bound of error 10%.

According to research, the factors that encourage fishers to throw garbage directly into the sea and bring it back to the port are identified (Chen & Liu 2013). However, this study modified the identified factors by grouping them into internal and external influence factors.

Descriptive analysis. Descriptive analysis was used to identify what types of domestic waste are generated by fishing operations and to identify factors that encourage fishers to throw garbage directly into the sea and bring it back to the port. Analyzing data on the amount of operational waste from fishing vessels was also carried out descriptively. The analysis process for calculating the amount of waste generated uses the estimation formula (Scheaffer et al 2011):

$$\hat{X} = \frac{N \sum yi}{n}$$

where: $\hat{X}$ = estimated amount of fishing vessel operational waste;
N = total number of ships of size 30-100 GT based in PPS Nizam Zachman;
n = number of fishing vessel sampled;
yi = total waste of the fishing vessel trip.

In general, the formulation of coping strategies was described descriptively. In determining strategies for overcoming pollution from fishing vessel waste, the analysis used was Strength, Weakness, Opportunity and Threat analysis (SWOT analysis).

Results. In general, the waste generated by fishing vessels was divided into three general categories, namely consumption waste (consisting of waste packaging supplies), machine waste (the result of per-machine activities), and fishing waste (components of fishing gear). The percentage of waste generated by fishing vessel operations in one fishing trip is presented in Figure 2. The engine waste category comprises used oil (59.77%), iron or metal waste (0.09%), and rubber or rubber engine parts (0.002%). Used oil waste, which has an average of 64.27 kg per fishing trip (Table 1).

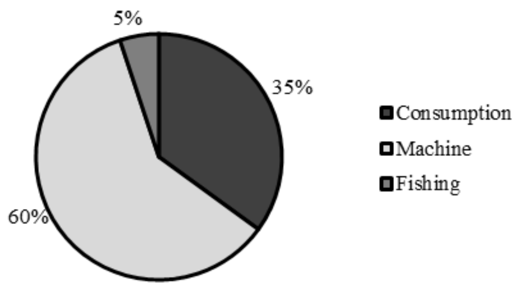


Figure 2. Percentage of waste generated by fishing vessel operations in one fishing trip (calculated by unit weight or kilograms)

Table 1
The total weight (kg) and percentage of types of waste generated by fishing operations

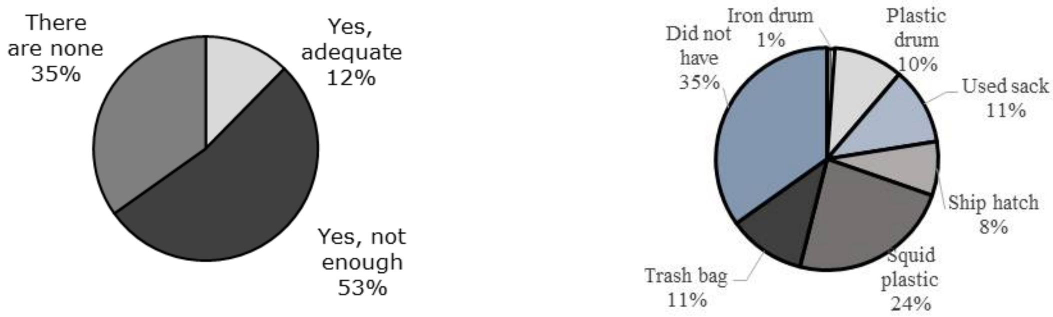
Waste category	*Packaging*	*Average waste generated (kg)*	*Percentage (%)*
Consumption	Cardboard boxes	12.78	11.88
	Cigarette paper box	5.76	5.35
	Plastic jerry can	5.28	4.91
	Plastic box	3.25	3.03
	Wooden crate	3.21	2.99
	Plastic bottle	3.20	2.97
	Plastic wrap	2.42	2.25
	Plastic sachet	0.77	0.72
	Tin box	0.66	0.62
	Plastic bag	0.14	0.13
	Plastic cup	0.14	0.13
	Plastic snack	0.03	0.02
Machine	Used engine oil	64.27	59.77
	Scrap iron	0.09	0.09
	Used rubber parts	0.002	0.002
Fishing	Squid lamp (*bouke ami*)	5.06	4.71
	Net PE (*gillnet*)	0.45	0.42
Total		107.51	100.00

Estimated amount of fishing vessel garbage. Observations and data processing also displayed data on the average weight of waste produced by fishing vessels in several time frames, namely per day, month, fishing trip, and year. The data was also accumulated with the number of fishing vessels measuring 30-100 GT at PPS Nizam Zachman to see the total weight of waste produced in one year. Overall, fishing vessels in one fishing trip produce an average of 107.53 kg (Table 2). When multiplied by the number of trips in one year, fishing vessels will produce an average of 270.63 kg of waste. As for the total number of ships measuring 30-100 GT based at PPS Nizam Zachman, the total amount of waste will reach 204,057.27 kg.

Table 2
Estimated 30 – 100 GT fishing vessel waste at PPS Nizam Zachman fishing port

Category	*Average crew operational waste per day (kg)*	*Average vessel operational waste per day (kg)*	*Average vessel operational waste per month (kg)*	*Average vessel operational waste per trip (kg)*	*Average vessel operational waste for a year (kg)*	*Total ship operational waste 30 - 100 GT at PPS Nizam Zachman for a year (tons)*
Consumption	0.024	0.316	9.48	37.65	91.30	68.8
Engine	0.041	0.554	16.62	64.36	163.85	123.5
Fishing	0.004	0.052	1.57	5.52	15.48	11.7
Total	0.069	0.922	27.67	107.53	270.63	204

Potential factor to affect fishers in handling fishing vessel waste. Fishing vessel shelter facility factor show that as many as 35% of respondents still do not have a public container for any waste (Figure 3a). While the rest have it, in the form of plastic squid (24%), trash bags (11%), used sacks (11%), plastic drums (10%), ship batches (8%), and iron drums (1%) (Figure 3b).



(a) (b)

Figure 3. (a) Percentage of adequate or not accommodated on fishing vessels at PPS Nizam Zachman; (b) Percentage of garbage collection used by fishing vessels at PPS Nizam Zachman.

The data shows that no obstacles have a significant impact because 56.18% of respondents stated that no losses were caused on their ships. However, the limited space for fishing vessels is unavoidable, coupled with the presence of a receptacle placed at the stern or on the vessels' deck, which will hinder the mobilization of crew members in fishing operations (Figure 4).

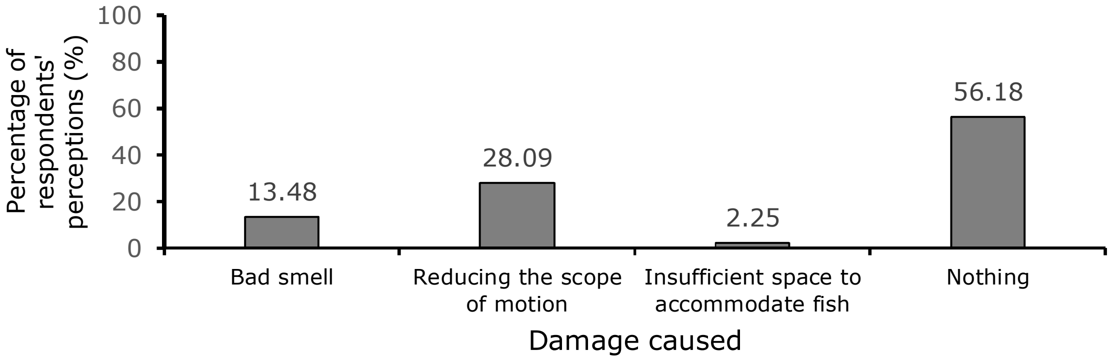
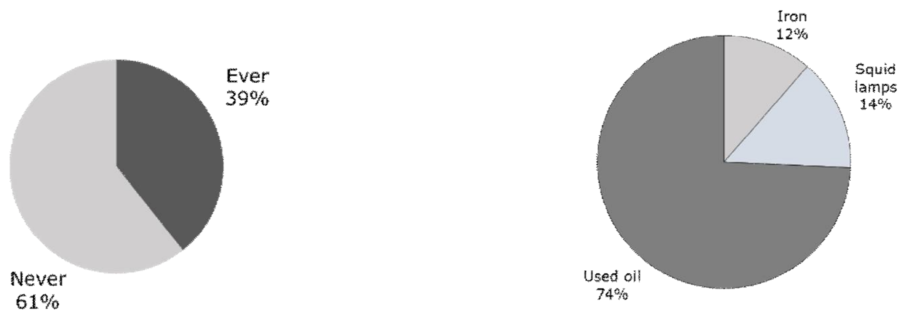


Figure 4. Percentage of perceptions regarding losses in accommodating waste on fishing vessel.

Garbage profit value and knowledge waste on the environment. As many as 61% of respondents said their fishing boats have never once benefited from the waste they produce, while only 39% said they had exchanged fishing boat waste for a profit. However, out of 39% of the respondents, there were only three types of trash that were ever exchanged for profit, namely iron waste (12%), lamps and engine components (14%), and used oil – the most frequently exchanged (74%) (Figure 5).



(a) (b)

Figure 5. (a) Percentage of whether or not respondents have exchanged waste into profit; (b) percentage of types of fishery waste that are usually exchanged for profit.

The collected, used oil is brought back to the port and then sold to the used oil collectors at PPS Nizam Zachman. Sales of used oil to collectors are costed at an average of 30,000

IDR per 18-liter. When multiplied by the average income of used oil waste for one fishing trip, four 18-liter jerry cans, the profit value that can be generated is 120,000 IDR. Large light bulbs that are damaged and become trash are not sold but are given to the product supplier agent to be exchanged for a large light bulb. Knowledge of the impact of waste on the environment shows that most respondents already know the impact of waste pollution on the environment. However, 28.09% of respondents admitted that this knowledge had not been applied through waste management on board ships. On the other hand, the actual observation results show quite encouraging results knowing that as many as 65.17% of respondents have tried to implement waste handling behavior on ships, although not yet fully. Meanwhile, 6.74% of respondents admit that they do not know the impact of waste on the environment.

Fishing vessel waste management regulation and strategies. Based on the observations, 53.93% of respondents stated that they already knew, implemented, and were ready to comply with the applicable regulations, namely Transportation Ministry Decree No. 29 of 2014 (Figures 6a and 6b). Although they did not know the names and articles of the law directly and had never even read them, the respondent knew that regulations required fishing boats to carry garbage collections. The problem stems from the law's content, which is unclear in explaining the criteria for garbage collection sites. This lack of clarity formally makes most fishing vessels carry an inadequate capacity to accommodate waste during fishing operations.

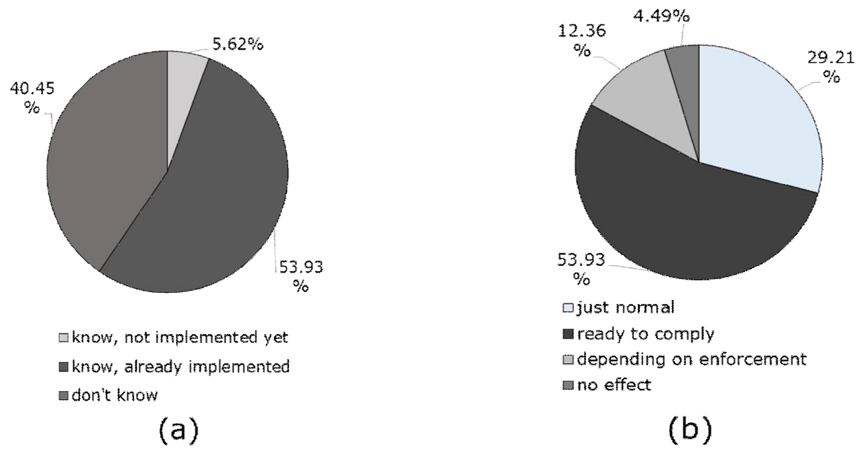
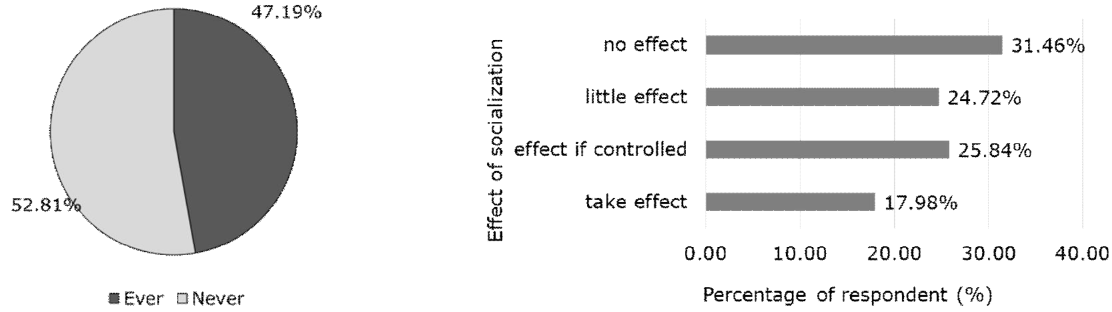


Figure 6. (a) Percentage of respondents regarding knowledge of fishing vessel waste management regulations; (b) percentage of respondents regarding attitudes towards fishing vessel waste management regulations.

In addition to respondents who have complied with the regulation, some respondents admit that they have not implemented it (40.45%) and are not even aware of the regulation (5.62%) (Figure 5a). Meanwhile, the number of respondents is divided into three perceptions regarding regulations preventing waste pollution. Some are just normal (29.21%), implemented foremost if there is enforcement (12.36%), and even state that it will not affect fishery operations (Figure 5b). Some of these attitudes show that no matter the regulations, enforcement, and supervision, preventing pollution from fishing vessel waste will be difficult because fishing activities take place in the middle of the sea.

At PPS Nizam Zachman, garbage collection facilities are available along the harbor pier in the form of tubs or plastic drum containers used for ropes. Its available position along the port helps fishing vessels to directly deposit the waste from fishing trips on the sidelines of loading and unloading activities. This condition is considered ideal according to Chen & Liu (2013), which states that waste deposit facilities need to be strategically made so as not to make it difficult for fishers who are busy with other activities, such as unloading catches and cleaning boats after tiring fishing activities. Another advantage is that every morning the garbage deposited in the plastic tub is transported by the cleaners using a garbage truck and taken to the final disposal site at PPS Nizam Zachman so that the deposited waste is present and not left unattended.

Waste handling show that as many as 52.81% of respondents have received socialization, while the rest (47.19%) have never received any socialization on preventing pollution from fishing boats. Meanwhile, the perception of fishing practitioners regarding socialization is also somewhat less encouraging. Only 17.98% of fishing vessels stated that the socialization of waste pollution prevention would affect the practice of handling waste on board, while the rest did not show a positive response (Figure 7).



(a) (b)

Figure 7. (a) Percentage of respondents who have received socialization and not (b) Percentage of respondents' responses regarding the socialization of prevention of waste pollution by fishing vessels.

Internal factors are divided into two factors, including strengths (S) and weaknesses (W). The strength factor contains the profit value of waste, can be an additional income for one of the crew members, the awareness of fishing practitioners who are aware of the impact of waste on the environment, and the role of captains and ship owners who have the most contribution in the instruction and supervision of waste handling above the fishing boat. Weaknesses include ship waste storage, which is usually provided by fishery practitioners but is still inadequate. Waste collection activities are far less important because they do not generate profits, and garbage storage creates discomfort in the work area of fishing vessels (Table 3).

External factors are also divided into two factors, including opportunities (O) and threats (T). Opportunity factors consist of regulations for preventing fishing boat waste pollution that is already popular and known by fishing practitioners, the waste storage area provided by PPS Nizam Zachman is strategically located and does not interfere with the main activity process (loading and unloading of catches). The waste flow in the deposit system is smoothly transported to a temporary port disposal site. Threat factors consist of the unavailability of waste recycling sites for waste produced by fishing vessels, the implementation of socialization on waste handling on board is not comprehensive to crew members or captains, and enforcement/supervision of regulations is difficult and requires high costs (Table 3).

The strategies for combating pollution caused by fishing vessels is presented in Table 4. The strategy for preventing waste pollution by fishing vessels consists of 8 strategies. The strategy consists of optimizing socialization targeted at fishing boat captains and owners, providing recyclable waste deposit facilities that can convert waste into profit value for fishing vessels, optimizing waste depositing sites and their separation from port operational waste, and providing rewards for fishing vessels that have complied with the prevention of pollution from fishing vessels, making more detailed regulations regarding adequate waste collection sites, optimizing ship space and planning ship design to consider waste collection points, socialization needs to explain the formulation of solutions to technical problems that occur on ships in handling waste, and supervision of adequate waste collection needs to be carried out before and after fishing trips.

Table 3

Strength, weakness, opportunity and threats of fishing boats waste management

Strength (S)	*Weakness (W)*
1. The profit value of waste can be an additional income for crew members.	1. Existence of inadequate fishing vessel shelter.
2. Fishing practitioners have realized that waste pollution will affect the environment.	2. Garbage collection activities are not more important than catching fish and saving oneself.
3. The captain and ship owner have the highest share in handling fishing vessel waste.	3. Garbage collection causes inconvenience.
Opportunity (O)	*Threats (T)*
1. Regulations for preventing pollution of fishing vessel waste are already known to fishing practitioners.	1. Enforcement and oversight of regulations are difficult and costly.
2. Location of strategic waste deposit.	2. There is no waste recycling area for the waste generated by fishing vessels.
3. The transportation of garbage at the port of waste deposit is routinely carried out.	3. Socialization of pollution prevention has not been comprehensive.

Table 4

SWOT analysis strategies for combating pollution caused by fishing boats

SO strategies	*WO strategies*
1. Optimizing the place for depositing waste and separating it from port operational waste (S2, S3, O2, O3).	1. Making more detailed regulations regarding adequate waste collection sites (W1, O1).
2. Rewards for fishing vessels that have complied with the prevention of pollution of fishing vessel waste (S2, O1, O2).	2. Optimization of ship space and ship design planning to consider garbage collection points (W2, W3, O2).
ST strategies	*WT strategies*
1. Optimization of socialization targeted the captain and owners of fishing vessels (S3, T3).	1. Socialization needs to explain the formulation of solutions to technical problems that occur on ships in handling waste (W2, W3, T3).
2. Provision of recyclable waste deposit facilities that can exchange waste into profit value for fishing vessels (S1, S2, T2).	2. Supervision of adequate waste collection needs to be carried out before and after fishing trips (W1, T1).

Discussion. Used oil has the highest value among other wastes from fishing boat activities. Used oil comes from engine oil changes. According to Syamsuri et al (2019), engine oil changes are carried out periodically to maintain the performance and maintenance of the ship's engine. With this statement, used oil waste is certainly produced by fishing vessels at PPS Nizam Zachman, considering the average length of the fishing trip is four months. In general, the dominant type of goods is made of plastic. Similar to on land, plastic packaging in fishing vessel operations is inseparable from the advantages of plastic materials that are flexible, lightweight, and easy to use (Shen & Worrell 2014). Plus, in the formation or manufacture, plastic is easy to form, and the characteristics of the material can be adapted to specific applications for daily consumption products (Lee & Lye 2003). The other material that has the most dominant weight is cardboard. This cardboard packaging can be classified as a form of secondary or tertiary packaging, which is indeed made for larger packaging and facilitates transportation activities, including the process of transporting fishing boat trips (Lee & Lye 2003; Ampuero & Vila 2006). The use of cardboard or paper materials is considered very efficient, light and cheap in transportation, so its use is popular and difficult to avoid for fishing vessels (Lee & Lye 2003; Utami 2020).

The fishing waste from fishing boat operatinal was 5.13%. Overall, the type of fishing waste is influenced by the fishing gear used. For example, the average weight of the squid lamp, which reaches 5.06 kg per trip, is based on the number of buokeami ships that are the object of observation. According to Triharyuni et al (2012) and Gumilang & Susilawati (2020), in its operation, the boukeami ship uses a large light bulb to collect squid, with an entire range of 24-80 pieces and a power of 800-2000 watts. A crew of fishing boats can produce 0.024 kg of consumption waste (plastic packaging waste, cardboard, and paper) per day. Compared to land, this waste generation is still lower than the generation of plastic, paper, and cardboard packaging waste produced by people in urban residential environments per day, which several studies have published, including Dewilda et al (2017) and Hapsari & Herumurti (2017). However, compared to the waste produced by people per day in shopping and school areas, the values do not differ much, referring to Citasari et al (2012) with a weight of 0.0189 kg person^{-1} day^{-1} and Widyawati et al (2020) with a weight of 0.0265 kg person^{-1} day^{-1}.

The average weight of engine waste (used oil) on one fishing trip is 64.36 kg and when viewed in more detail, the weight of used oil per month produced is an average of 16.62 kg per month. According to Effendi & Adawiyah (2014), oil change should be carried out within an engine mileage of 5,000 km, 10,000 km, or more up to 20,000 km. In line with research by Hidayat et al (2019), the oil change period is usually carried out once a month and produces around 10-20 liters of used oil or 9-18 kg when converted into kilograms. Fishing vessels that do not have a shelter will give the crew no choice but to dispose of the garbage. Isthofiyani et al (2016) concluded in their research that the absence of a garbage collection site can lead to low public perceptions and behavior in handling waste, to the point of throwing it away indiscriminately. As many as 53% of respondents' fishing boats still do not have adequate accommodation, and only 12% have adequate waste storage (Figure 3). This is suspected of causing waste leakage from the garbage collection. According to Merkl (2015), using poor containers and improper control will cause waste leakage, considering that 25% of marine debris currently comes from waste that has been collected or accommodated. Therefore, spatial planning of fishing vessels, both in general and specifically for waste collection, must be developed during the shipbuilding process (Ahmad 2008).

This study found that the ship's captain, owner, and stewards had a significant role to play in starting waste management and bringing it back to the port. In their research model, Chen & Liu (2013) explain that the captain’s command is a factor that positively correlates with the handling of waste and its transportation back to the port. The captain has a more significant role in implementing waste management than the ship owner and manager because he is directly responsible and makes the highest decision on fishing trips. The owners and administrators can only control the implementation of pollution prevention from the port. As for this problem, it should be a challenge that motivates fisheries stakeholders to formulate a socialization program that not only describes the impact of environmental pollution but also provides a formulation for solving the problems faced along with discussions on handling waste on board. As stated by Hungerford & Volk (1990), environmental education needs to translate the prevention of environmental pollution into instructions that align with the reliability that occurs. This can be started by holding a discussion program, especially with the captain and ship owner as the highest decision holder for everything on board fishing vessels, including the practice of handling fishing boat waste.

Conclusions. The waste generated by fishing vessels during fishing operations consists of 3 general categories: consumption waste, as much as 35% consumption waste, 60% machine waste, and 5% fishing waste. The estimated waste from 30-100 GT fishing vessels operating in PPNZ was 204,057.27 kg. Internal factors influencing waste management include fishing vessel storage facilities, waste profit value, crew awareness, regulation, deposit system, recycling facilities, and socialization. The primary strategy consists of optimizing socialization aimed to vessel captains and owners and providing facilities for depositing recyclable waste, which can convert it into profit.

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Conflict of interest. The authors declare that there is no conflict of interest.

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