Impact of Marine Debris to Fishing Operation at Ambon Bay

Article *in* IOP Conference Series Earth and Environmental Science · July 2023

DOI: 10.1088/1755-1315/1207/1/012017

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Abstract. Marine debris is a serious problem around the world. The entry of garbage into the sea not only threatens the survival of various marine organisms but also disturbs fishing activities, thereby reducing fishermen's production and income. This study aimed to identify the fishing gear damaged by marine debris during fishing operations and analyze how much the marine debris impacted the production of various fishing units. Data were obtained from 101 fishermen operating at Ambon Bay by observation, interview, and descriptive analysis. Obstacles by the trash during fishing operations are among the trash twisted or attached to fishing gear; trash are twisted at the propeller of the boat and damage the fishing gear. On the fishing line group, the main hurdle is on the vertical hand line, where the trash are entangled at the hook; on the gill net group, the main hurdle is on the bottom gill net, where the trash are twisted to body net; and on the seine group, the main constraint is on the beach seine, where the trash are trapped in the cod end. This condition causes a decline in production, with the biggest impact on the bottom gill net, with a decrease in production of 4.38% from the average production per trip.

Key word: Fishing gear, fishermen, production.

1. Introduction

Marine debris is a global issue that has not been solved until now. According to UN the trash which get into the ocean every year amount 6.4 million tonnes and 83 % are plastic debris [1]. Plastic debris has been detected around the globe in all main marine habitats in sizes ranging from micro to meter [2]. Pollution at sea will impact marine biota and ecosystems at various stages [3]. The impacts arise in terms of trash like lack of aesthetics at coastal areas and tourism as the pile up of trash, smell, and debris can cause various diseases, effect the food chain, lower fish productivity, and impact marine plants like seaweeds, mangroves, and others [4]. Trash at sea is not only a threat to marine organisms; it also has an indirect impact on humans who consume invulnerable fish exposed to scattered trash at sea [5]

Trash is found from the polar to tropical areas and from the coastal line, estuary, and sea surface to the bottom of the sea and could be found even in the most remote areas of the world [6, 7]. Result of a research shown that Indonesia is producer of plastic trash number two after China, amount of trash going into the sea keep increasing in time and is an uncontainable problem currently [8]. Marine trash can cause various economic impacts and high costs, both directly and indirectly [9]. Besides disturbing the marine ecosystem, the trash also perturbs fishermen's activities in fishing. The marine industry in Asia Pacific spent around $1.2 billion per year due to damage from marine trash [10]. The revenue of fishermen at the fishing fleet in Shetland, UK, suffered losses of £ 6,000–£ 30,000 per boat per year in relation to trash existence at sea [11]. A similar condition also occurred at Ambon Bay at this time.

The existence of marine debris at Ambon Bay at present is highly concerning; many problems have been realized by society, especially by fishermen who conduct fishing operations at this bay [13]. Data from the Cleaning and Gardening agency at Ambon Municipality shows the trash volume produced by society in Ambon City is 1,182.22 m3 per day, while only 400 m3, or 140–150 tons per day, can be transferred to the final trash point. Assuming half of the trash is neither transferred nor

detected, it is discarded and drifts into the sea through rivers. The amount of trash going into the sea will increase during the rainy season or in musim Timur, where the fishermen are very active [13]. Trash found at Ambon Bay is plastic debris, rubber, woodenware, etc. [14]. On the other side, Ambon Bay, whose unique morphology contains variety in marine resources with economic value. Three main ecosystems of the coastal area, i.e., mangroves, coral reefs, and seaweeds, are in Ambon Bay, making this bay always productive, and half of the society living around the bay is earning from it [15, 16, 17].

Ambon Bay is potentially to be managed not only as marine tourism but also very potential for various fishery fishing venture. In Ambon Bay, there are several fishing grounds that are still used by fishermen in the area [13]. Nevertheless, the existence of trash at Ambon Bay is very disturbing for fishing activity. A preliminary survey has shown that fishermen are very perturbed by the trash in the bay as it impedes the fishing process and even damages the fishing gear and boat. Therefore, it is very urgent to do scientific analysis relating to various trash against fishing gear operations and how much the impact is until a solution is devised. The purpose of the research is to: (1) identify the obstacles created by trash in fishing operations; and (2) analyse the impact of trash on the productivity of various fishing gear operating at Ambon Bay.

2. **Material and Method.**

This research was conducted at Ambon bay. Sampling location was conducted on 14 villages around the bay i.e: Negeri Galala, Halong, Latta , Passi, Nania, Waiheru, Hunuth, Batu Koneng, Poka, Rumah Tiga, Hative Besar, Laha and Latuhalat (Figure 1). The data collected are primary data gained directly from the targeted fishers through observation and interview. The collecting of data was performed in two parts. Following the fishermen throughout their fishing activities and examining their fishing gear and the constraints they face due to marine debris; the first step is observation.

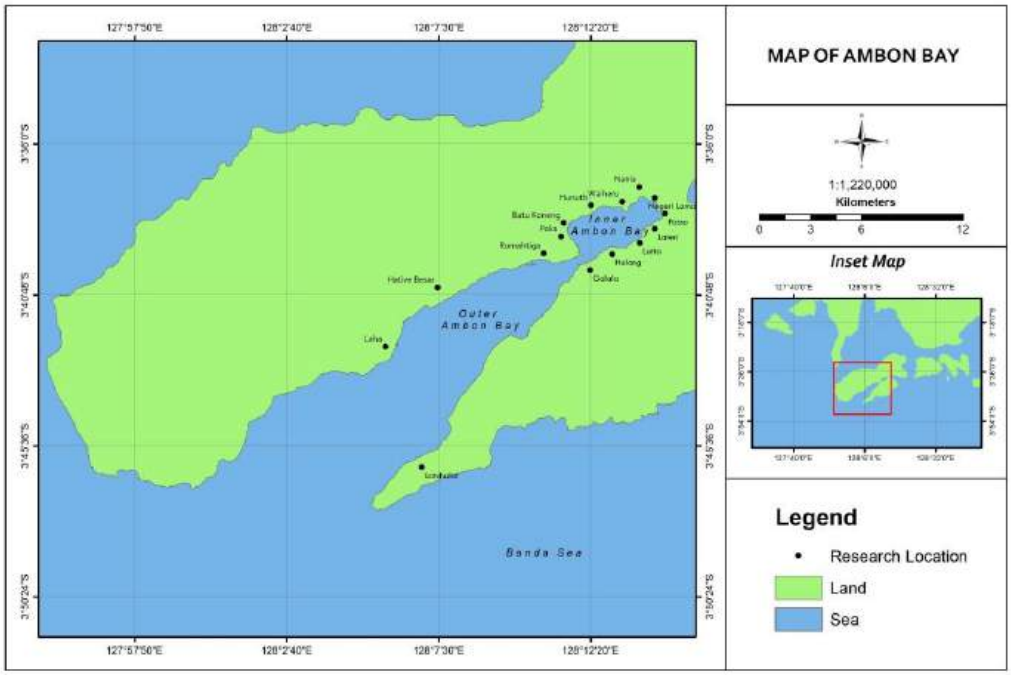

Figure 1 Map of Research Location

The data collected are the primary data, which were obtained from the fishermen, who are the target, directly through observation and interview. Data collection was executed in two steps. First: observation, follow the fishermen during fishing activities and observing, identify the kind and type of fishing gear and the constraint they are facing related to the marine debris. Then the obtained data and

information are used as a baseline to devise question topics once interviewing begins. Second, interviews are conducted non-structurally by involving 101 fishermen, which break down as follows: fishing line fishermen, 31 respondents; bottom line fishermen, 10 respondents; bottom gillnet fishermen, 24 respondents; drift gill net fishermen, 9 respondents; purse seine fishermen, 20 respondents; and beach seine fishermen, 7 respondents. Respondents are determined purposefully by sampling from the population based on certain considerations [18]. Interviews are conducted to obtain production data for each fishing unit based on the thrash's existence at sea. To attain production data from respondent for each fishing unit based on the thrash's existence and amount, the pre-existence of the trash at sea is defined together with respondent as below:

- Few thrash category : Trash are unseen at sea surface
- medium thrash category : Trash cover half of sea surface
- Lots category : Trash spreading on the whole of sea surface

Collected data are analysed descriptively. The descriptive study aims to analyse the characteristics of its sphere [19]. Also, another statement stated that the descriptive method is a systemic figure, factual on facts, characteristic, and its relation among phenomena being analysed [20]. This method is used to obtain information on the kind of fishing gear impacted by marine debris and obstacles experienced during fishing operations and is displayed in a table and pictures. In relation with the impact of the trash on the production of each unit of fishing gear, production data per kind of gear are tabulated based on trash category (low, middle, and high) and analysed using the formula:

$$rPi = \sum PRi_1 + PRi_2 + \ldots\ldots + PRi_n/NRi$$

rPi : Average fishing gear production for i
PRi : Respondent production for i
NRi : Total respondent
r : type of fishing gear
i : responden

Percentage of average production per type of fishing gear based on category (low, middle and high) are used as base valuation point against how much the trash impact as below criteria:

1) If production per fishing gear ≥ 50 % meaning low impact of trash
2) If production per fishing gear 25 - < 50% meaning medium impact of trash
3) If production per fishing gear < 25 % meaning lots impact of trash

Results and Discussion

Fishing Gear and Constraints of Marine Debris on Fishing Operations

Fishing activities at Ambon Bay are relatively high due to the abundance of fishery resources, both pelagic and demersal. Preliminary observation indicated that fishing activities were related to marine debris found in six types of fishing gear, i.e., vertical hand line, bottom gill net, purse seine, drift gill net, and beach seine. The six kinds of fishing gear are often experiencing constraints in the fishing process because of the marine debris. To make it easier in justifying the constraint on fishing gear, the six fishing gears are categorized into three big groups, i.e., (1) line, (2) gill net, and (3) seine, as shown in Table 1.

The categories of fishing gear are based on the constraint of the trash (Table 1). It is shown that for group lines, the main obstacle is at the vertical long line, i.e., more trash is trapped or twisted at the barb instead of the bottom long line. This difference is assumed because of the position of fishing gear in the water. Position of a vertical long line with 5–15 hooks set up vertically in the water from the surface to a certain depth, so flowing trash by the current will be trapped on the hook besides twisted to the hook line. However, the bottom long line with 20–30 hooks stretch horizontally at the bottom of the water, possibly twisted with trash, and is very small. Twisted trash to the bottom long line is possible during the setting process or at hauling. This condition could disrupt the line because

of the current pressure during the hauling process, as twisted trash will add more weight to the fishing gear.

Table 1 Type of fish gear and trash constraint at Ambon bay

Fishing gear	Constraints	Responden of type of gear	effected	(%)
I Type of Lines				
1 Vertical long line	- trash relat at hooks	31	20	64.51
	- trash stuck to the fishing line		21	**67.74***
	- fishing line broke		6	19.35
	- trash entangled in engine propellers		21	**67.74***
2. Bottom long line	- trash relat at hooks	10	2	20
	- trash stuck to the fishing line		6	60
	- fishing line broke		2	20
	- trash entangled in engine propellers		4	40
II Type Gill Net				
3. Bottom gill net	- trash penetrates the net's mesh	24	22	**91.66***
	- trash entangled in engine propellers		10	41.66
4. Drift gill net	- trash ticks to the body of the net	9	6	66,67
	- trash related at net		5	55,56
III Type of Seine				
5. Purse seine	- trash penetrates the net's mesh	20	7	35
	- trash entangled in engine propellers		15	25
6. Beach seine	- trash penetrates the net's mesh	7	4	57.14
	- trash entangled in engine propellers		0	0
	- trash stuck in the bag		5	**71.43***

In the gill net category, the main obstacle is the bottom gill net, as more trash is twisted into the net body than into the drift gill net. More obstacles to bottom gill net because of technical operation i.e embedded to the bottom, vertical against the water and cut the current. According to Martasuganda (2008)[21] and Mallawa (2008)[22] that operation method on bottom gill net are more effective if considering fish feeding habit by operating the net against fish route on tidal process [21,22]. However, the amount of trash going into the sea until it reaches fishing grounds has caused problems for fishing operations using bottom gill nets, as more trash will be trapped in the net body (Figure 2).

Picture 2 Trash trapped in the gill net while operating at sea

The trash found by visual observation consists of organics and non-organics; however, the most are plastics of various sizes, including plastic bags, plastic glass, plastic bottles, plastic gunny sacks, detergent covers, noodle covers, a variety of cosmetic debris, and others that were trapped in or attached to the net. Fishermen said that this condition is very perturbing in the fishing operation and impeding fish from becoming entangled in the net. Plastics are dominant as a globally distributed pollutant in the whole water because of their long existence and easy flotation [23]. Floating ability of plastics trash make it easy flown by the wind, tidal, and accumulated across coastal line even at the very remote isles, open and deep sea [24]. Plastic trash characteristics are floating and drifting by the current to bigger water bodies, increasing the possibility of being trapped at the bottom of the long line (Figure 2).

The same thing happens to the seine group, where most of the obstacles hit the beach group, i.e., the trash is trapped at the end cod, while in the purse group, the trash is trapped at the net body. The differences are caused by the different locations of fishing grounds and fishing methods. Beach seine is fishing gear operated at coastal lines at 5–10 depths. The coastal line is a heap of trash going to the sea through rivers in the rainy season, besides other trash that is directly thrown into the sea. Ambon Bay is so far considered as fishing ground with eight rivers makes more possible that the trash by inhabitants at upper land are taken through river and go into the bay mostly at rainy season causing pile up of the trash at coastal area [25, 26]. Half of the trash is embedded; the rest is taken by the current and waved into the sea then scattered back to coastal land around the bay. This condition is continuing mostly in the rainy season and is very disturbing to fishing activity in coastal areas, mostly in the tidal zone, where fishing activity is fishing in this area.

Fishing ground is close to coastal line (tidal zone) where fishing activity are executed by pulling and dragging fishing gear, start from the bottom till the surface against fish shoal, besides fishing gear structure shaped pouch-like beach seine is inevitably that the floating trash in the water column around the catching area, especially on the hauling. So, the trash is taken along with the fish to the cod. Moreover, the fishermen prefer not to fish if the trash covers the whole surface of the water. On the contrary to the purse seine, though the fishing process involves circling the fish shoal, the technical operation is different, i.e., encircling the fish shoal at the surface of the water at the off-shore at > 100 m depth. The coastal area where purse seines are operated is relatively far from a dense zone of trash, but there are some obstacles that cause half of the trash to be taken off shore. This matter can be found trapped in the net body and also twisted at the boat propeller, hence disturbing fishing activities and fish concentrations at fishing grounds.

For beach seine fishermen, the existence of trash at the coastal area is very concerning for the fishing effort at the coastal area in the tidal zone because it takes 2 hours to split the trapped trash with the fish in the cod. Plastic trash, also known as persistent organic pollutant (POP), which is easily taken in by the flow and pollutes marine habitats around the globe, has now been considered a major environmental issue [27]. Various obstacles caused by trash in fishing operations are really impacting production and revenue for gill net fishermen. [12].

Trash Impact to Fishing Gear Production

Trash discarded to the sea or going through river flow in the rainy season has caused significant impacts to fishing activities and the production of various fishing gear. The analysis results on trash impact on production for six fishing gear operated at Ambon Inner Bay (Teluk Ambon Dalam—TAD) are considerably different from one another and depend on more or less trash during fishing operations (Table 2). This condition is connected to trash obstacles on each fishing gear related to structure, operation method, and fishing zone. Whether at shallow coastal water in the tidal zone, steeply coasting, or off shore, production differences on various fishing gear caused by trash are shown at Table 2.

Table 2 Average production of fishing gear beased on trash category at Inner Ambon bay

No	Fishing gear	Respondent	Few trash		Medium trash		A Lots trash	
			Fish Production (kg)	Average	Fish Production (kg)	Average	Fish Production (kg)	Average
I	Type of line							
1	Vertical hand line	31	15-40	29.52	0.7-14	6.82	0.7-4.0	2.10
2	Bottom long line	10	90-225	146.25	75-225	138.00	20-100	95.25
II	Type of gill net							
3	Bottom gill net	24	8.0-31.0	29.52	0.30-15.5	5.15	0.0-4.0	1.59
4	Drift gill net	9	13.8-41.4	31.48	13.8-41.4	25.34	6.91-20.7	10.75
III	Type of Seine							
5	Purse seine	20	355-790	622.13	79-790	312.05	79-529	312.05
6	Beach seine	7	114-190	157.43	76-118	92.29	19-38	29.86

Impact of trash on the productivity of three type fishing gear, are explained as below:

1) Impact of trash against productivity of fishing gear type lines

Line fishing is fishing gear that always suffers the impact of marine trash during fishing operations. To understand the impact of marine trash on the production of fishing gear, two types of line are used, i.e., the vertical hand line aiming to catch pelagic fishes and the long bottom line targeting demersal fishes. Choosing these two types because they are popular to the fishermen on small to large scales in coastal areas, off shore, or in bays or straits

The result of the analysis of the vertical hand line shows that production or fishing results decrease if the amount of trash is higher. The calculation result of the production of 31 respondents using this unit fishing gear shows that once trash is removed, the average production of this fishing gear is 29.52 kg per respondent, or 76.80% of the average total production. At the middle stage of the trash, there were 7.0 kg, or 17.74% of the average total production, while for the large amount of trash, the average production was only 2.10 kg, or only 5.46%. The same condition happened to fishing gear and long lines. Result of calculation on production from 9 respondents shows that when the trash is little, the average production is 146.25 kg or 38.54 percent; at middle level of trash, the average production is 138.00 kg or 36.36 percent; and at high level of trash, the average production is 95.25 kg or 25.10 percent compared to the average total production. The percentage of fishing gear production impacted by trash is shown in Figure 3.

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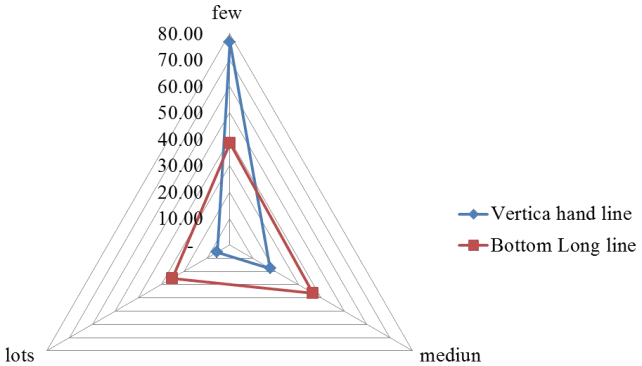

Figure 3 Impact of trash against successfulness of the line operation

Decreasing production for these two fishing lines due to construction fishing line, consist of ropes, fitted to the hook, that enable flowing trash to be trapped in the water column. Besides the huge amount of trash also lowers water transparency; nevertheless, using artificial bait in line fishing especially vertical hand lines, are closely related to water transparency. Several fishery experts said that water transparency determine fishing effectivity, especially using sight sense of fish in relation to the Bait usage in fishing lines Bait attractiveness is diminished when turbidity increases as it obstructs the light which will reflect bait colour to stimulate sight sense fish at various artificial bait either from metal or colourful siphon [28, 29].

2) Trash impact to production of gill net

Gill net is a fishing gear often obstructed by trash during fishing operations at sea and its effect the production. Trash impact to production gill net is analysed from two type of gill net i.e. bottom gill net and drift gill net. Choosing both types of gill net based on different technical operations. The bottom gill net is operated by embedding at the bottom, while the drift gill net is operated by drifting at the sea surfaces follow the current. Analysis result on trash impact on production by two types of these net shown the production will decrease if the trash in big amount found at sea. Calculation result from24 respondents who are using bottom gill nets have shown that at low levels of trash, the average production of this gear is 29.52 kg or 81.42 % from average total production, when at high existence of trash, average production is 1.59 kg, or 4.38 percent of average total production. The same condition is at Drift gill nets depend on the low or high existence of trash, but a decrease in production is not significant. compared to a bottom gill net (Figure 4).

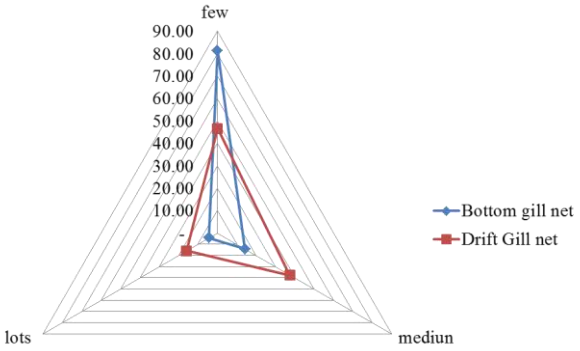

Figure 4 Impact of trash against successfulness of the gill net operation

Trash impact to bottom gill net production is bigger than drift gill net. This is because of the significantly different position of this gear once operating at the water's surface, i.e., bottom gill nets are operated by embedding at the bottom against the current, while drift nets are operated by drifting on the water's surface. In relation to trash obstacles on these two fishing gears, it is shown that the trash is more trapped at the mesh or twisted at the bottom gill net compared to the drift net (Table 1), causing half of the mesh to be covered by the trash and the rest to be twisted at the body net, resulting in a greater burden at the body net. According to fishermen, when more trash is trapped in the body net, they can roll the net, even sinking it to the bottom. This condition reflects the hanging ratio and effect of fishing gear on the catchability of gill nets.

3) Trash impact to seine net production

Purse snare and beach snare are two types of fishing gear operating at Ambon Bay that target small pelagic fish. With the increasing amount of trash going into the sea, this has caused a perturbation in fishing activity for those two types of fishing gear. Analysing the results of 20 respondents who used fishing gear purse seine and 7 respondents who used beach seine showed that the existence of a large amount of trash had a greater impact on beach seine production than purse seine (Figure 5).

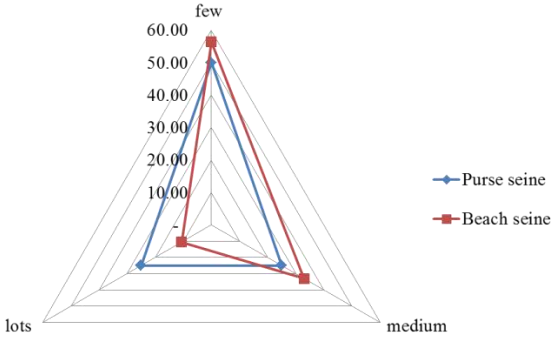

Figure 5 Percentage of trash impact against successfulness of seine operation

When the trash is low, the average production of purse seine is 622.13 kg, or 50 percent of the average total production, while at middle or high levels, each is 312 kg, or 25 percent of the average total production. To fishing gear beach seine, average production when low trash are 157.43 kg or 56.31 % of average total production, at middle level of trash are 92.29 kg or 33.01 % and at high level of trash are 29.86 kg or 10.68 % of average total production. However, the impact of the trash on beach seine fishing gear is greater than purse seine. This is possible because at fishing gear beach seine, the trash are trapped together with fish to the cod once leashing the fish to catching area. On the hauling process, the nearby trash is inevitable, besides fishing ground is at tidal zone and very close to coastal line where accumulated trash are huge at rainy season. Fishing zone of beach seine at Ambon Bay is shown at Figure 6.

Figure 6 Fishing ground of Beach Seine at Inner Ambon Bay

Beach seine is fishing gear constructed to target pelagic small fishes like *Stelephorus* sp. at Ambon Bay, but this species has been declared overfished [30, 31]. Thus, fishing target by beach seine fishermen besides anchovy, also other pelagic fisher like *Sardinella sp, Caranx sp* that high in the population.

Conclusion. Trash at sea has caused various problems to fishing activities using a variety of fishing gear operating at Ambon Bay. Several constraints in fishing operations are caused by the trash being attached to fishing gear or twisted onto fishing gear. Trash also twists around propellers and damages the engine and the fishing gear. At line fishing group, the main hurdle happened on the vertical hand line, i.e., the thrash was hooked at the barb. To the gill net group, the main hurdle happened to the gill net, i.e., the thrash is twisted to body net, and to the seine net group, the main hurdle happened to the beach seine, i.e., the trash are trapped in the cod end. This condition affects the decrease in production, where the decrease at bottom gill net fishing gear is still only 4.38 percent, at vertical handline fishing gear it is 5.46 percent, and at beach seine it is only 10.68 percent of the total for each fishing unit or trip.

Acknowledgements. We would like to thank Directorate of Research and Community Service Indonesia, Directorate General Strengthening of Research and Development Indonesia, the Ministry of Technology Research and Higher Education Indonesia for thefinancial support on this research.

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