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Declining Trend of Pole and Line Fisheries in Bitung, North Sulawesi, Indonesia

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ABSTRACT

The skipjack tuna (*Katsuwonus pelamis*) is an important fish resource for local people in Bitung. It is categorized as economic pelagic fish for export commodity caught by pole and line vessels. However, the catch has declined due to reduced number of fishing operations. This study aids to know the pole and line fisheries conditions in Bitung municipality. The results showed that the contribution of pole and line fisheries to total fish catch in Bitung fell as much as 3.608% year^{-1}. In addition, the decline occurred in the number of trips as much as 30.5 year^{-1}, number of vessels as much as 0.9 or one vessel year^{-1}, number of catches as much as 784.98 tons year^{-1}, productivity as much as 0.479 ton sGT^{-1} year^{-1}, and catchability as much as 1.355 tons trip^{-1} year^{-1}.

INTRODUCTION

Indonesia possesses 17,499 islands from Sabang to Merauke with an area of 7.81 million km^2, comprising 2.01 million km² of land and 3.25 million km² of marine environment, with 2.55 million km^2 of Exclusive Economic Zone (EEZ) **(Roza, 2017)**. This condition makes oceans become a life supporting for Indonesians **(Pregiwati, 2019)**.

Bitung municipality is one of the fisheries production centers in Indonesia, with very strategic position between two fisheries management zone, FMZ 715 in Molucca Sea and FMZ 716 in Sulawesi Sea. Therefore, The Central Government through the Ministry of Marine Affairs and Fisheries has provided facilities to support the fisheries activities there by building two technical implementation units, Samudera Fisheries Port of Bitung and Monitoring Base for Marine and Fisheries Resources of Bitung. With these units, all fisheries activities can be controlled with regulations, and all catches landed by the vessels in Bitung can be well recorded **(Dalegi *et al*, 2020)**.

Bitung has been long known as pole and line fisheries basis, whose development begins with small to large fishing vessels **(Sutrisno, 2017)**. Pole and line fishing gear is one of the environmentally friendly fishing tools, because its operation does not destruct fish habitats and other marine organisms. The major target of pole and line fishing is skipjack tuna as a superior commodity of the fisheries sector in Indonesia **(Jansen & Sumarauw, 2016)**. **Firmansyah *et al.* (2017)** and **Hutama *et al*. (2017)** presented similar statements that pole and line fishing targeted large pelagic fish, with the skipjack tuna as dominant catch.

Pole and line is locally called huhate consisting of a pole and line. The fishing vessel is facilitated with a live bait tank, water spraying system, and fish container. Its operation is very complex due to a live bait need to stimulate the fish habit to hunt the prey **(Sudirman & Mallawa, 2004)**. One of the important factors in pole and line fishing is the availability of live bait **(Firdaus *et al*., 2018)** so that the live bait has become a limiting factor. According to **Arnenda *et al*. (2020)**, live baits help the fishing process since they can take the target fish attention and attract the fish school to gather around the vessel. The live bait availability is so far supplied by lift-net and beach-seine fisheries that are still traditional.

In 2010, total number of pole and line vessels were 50 units, 10 units below 30 GT and 40 units above 30 GT **(Witomo & Wardono, 2012)**. Pole and line fishing activities tend to reduce from 2009-2016, especially 2013-2016 **(Firmansyah *et al.*, 2017)**. This decline appears in number of operating vessels, number of fishing trips, and catches. It could result from the live bait availability. The baits, anchovy (S*tolephorus* sp.), are more and more difficult to find and there may be other technical factors in pole and line fishing operations. This condition is certainly so worrying because the pole and line fisheries highly contribute to fish protein supplier for the people, job opportunity, and revenue of Bitung. This study focused on the operational trend of the pole and line vessels in relation with number of vessels, number of trips, catches, vessel productivity, and catchability in the period of 2019-2023.

MATERIALS AND METHODS

1. Research site

This study was conducted during May to June 2024 in the landing base of pole and line vessels in Bitung (Fig. 1), in which the fishing operations are done at the Fisheries Management Area (FMA) of 715 covering Tomini Bay, Molucca Sea, Halmahera Sea, Seram Sea, and Berau Bay, and FMA of 716 covering Sulawesi Sea and North Halmahera (Fig. 2).

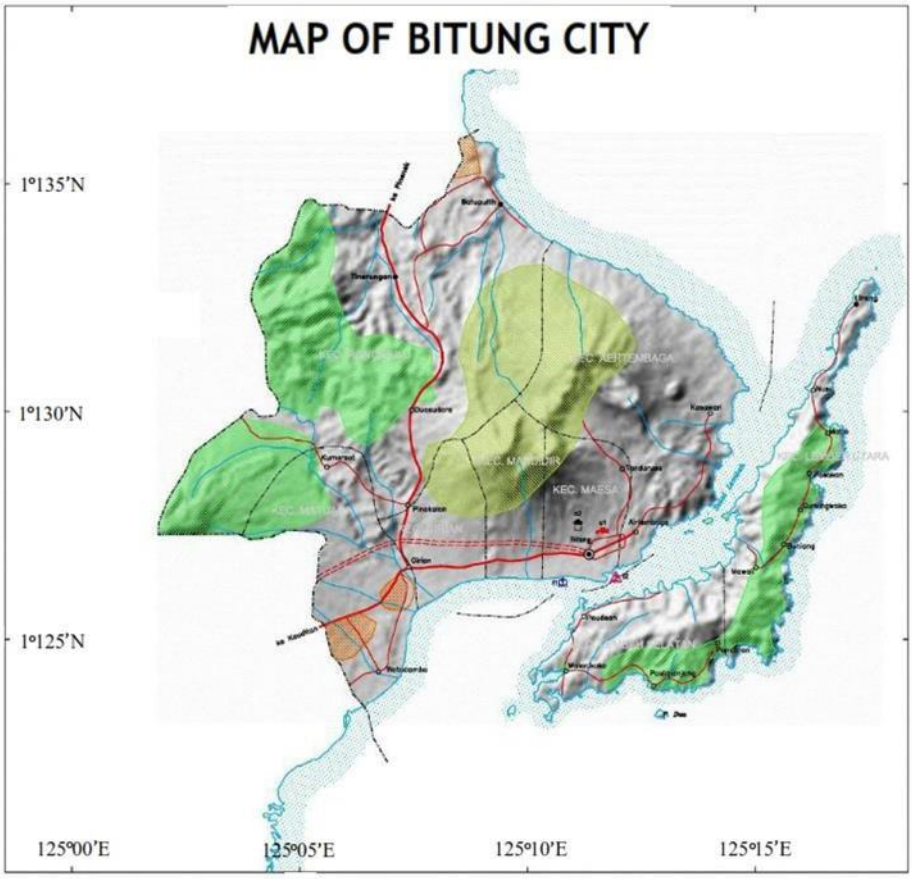

Fig. 1. Map of Bitung Municipality

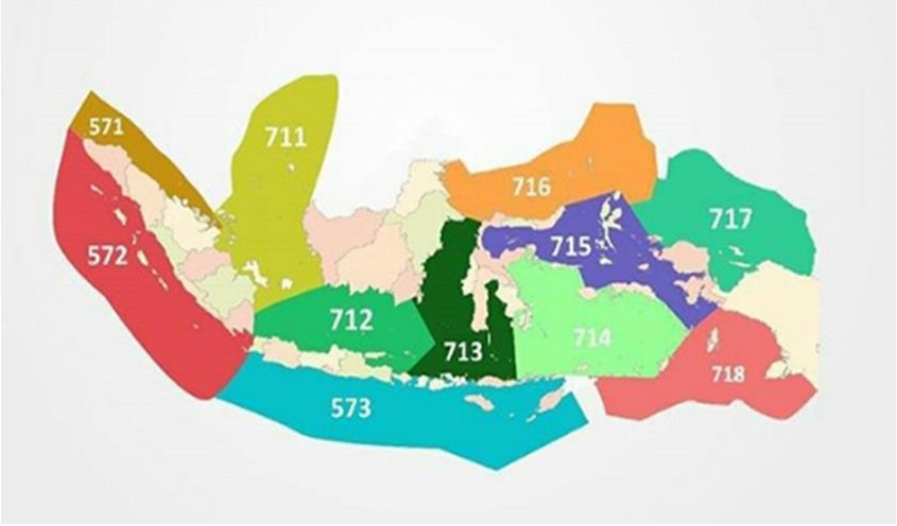

Fig. 2. Fisheries Management Area of 715 and 716)

2. Data sources

Data collected included number of actively operating pole and line vessels, number of trips, catches, vessel productivity, and catchability (CPUE) in the period of 2019-2023. This information was obtained through direct field observations and reports available in the government institutions. Data were also collected through interviews with 30% of pole and line fisherman groups in 2023. The pole and line vessel description, pole and line construction, hook, artificial baits and live bait used are presented in Figs. (3, 4, and 5).

Fig. 3. Pole and line vessel

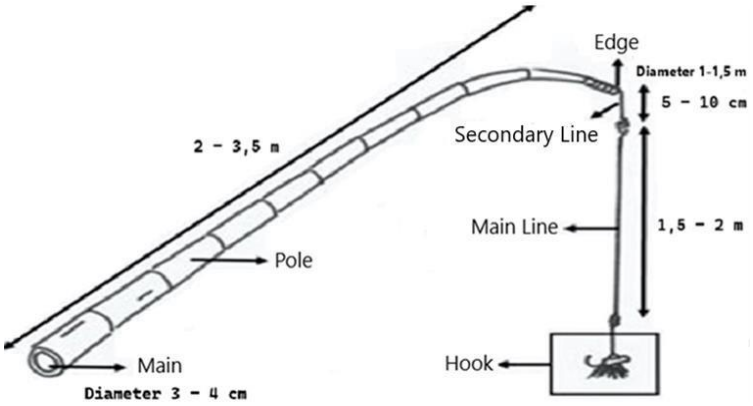

Fig. 4. Pole and line construction

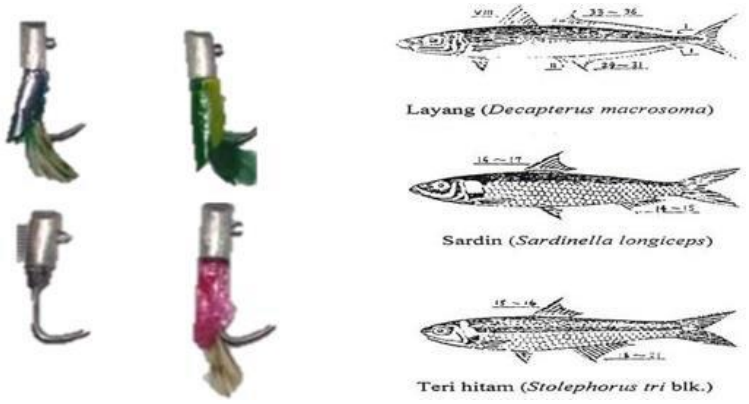

Fig. 5. Hook, artificial baits, and live bait used

3. Data analysis

The present study used a descriptive analysis on the pole and line fishing operations during 2019 to 2023 presented in graphs. The pole and line productivity was analyzed based on the decree of the Ministry of Marine Affairs and Fisheries of Indonesian Republic **(MMAF, 2021)** as follows:

Fish vessel productivity = production (ton) / vessel tonage (GT)

Where, production = total fish catch (ton yr^{-1}), and vessel tonnage = loading capacity (GT).

Catchability was expressed as catch per unit effort estimation using **Sparre and Venema (1998)**:

CPUE= Catch / Effort

Where, catch = number of catches (ton yr^{-1}) and effort = number of fishing trips.

Trend analysis was based on the historical data using linear regression **(Munawir, 2020)** as y = a + bx, where x = time, y = estimated parameter, a = intercept, and b = regression coefficient. Correlation coefficient (r) was also calculated to know whether x variable can be used to predict y variable.

RESULTS AND DISCUSSION

The operational trend of pole and line fisheries measured in Bitung, North Sulawesi, covered number of vessels, fishing operations, catches, vessel productivity, and catchability in the period of 2019-2023. These data were compared with those of purse seine fisheries.

1. Percent contribution of pole and line catch

Pole and line catch contribution in Bitung during 2019-2023 declined with time (Table 1).

Table 1. Fishing gears and total fish catch in Bitung during 2019-2023

Fishing gear	Catch (Kg)				
	2019	**2020**	**2021**	**2022**	**2023**
Hand Line	6,338,707	6,672,323	6,181,806	7,986,833	8,209,788
Pole and Line	5,204,119	5,478,020	4,386,427	3,666,660	2,428,441
Small Purse Seine	51,656	66,225	106,310	63,000	36,800
Small pelagic purse seine	12,122,503	15,541,670	17,037,695	19,936,499	22,786,616
Big pelagic purse seine	700,343	897,876	971,933	1,024,800	907,994
Surface Long Line	49,506	52,112	78,135	70,306	93,366
Oceanic Gill Net	169,566	217,392	181,043	351,136	176,257
Total catch	24,636,400	28,925,618	28,943,349	33,099,234	34,639,262
Pole and LineContribution	21.12 %	18.94 %	15.16%	11.08%	7.01%

Source: Catch landing of MMAF in Bitung.

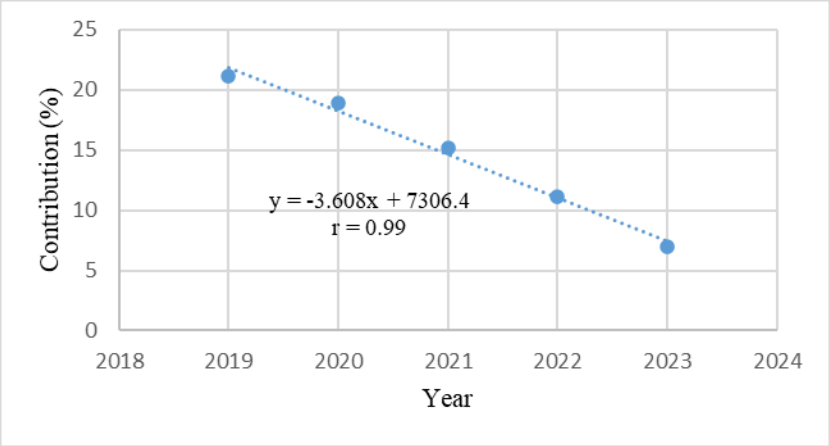

Fig. 6. Contribution of pole and line to catches of all fishing gears in Bitung during 2019-2023

Table (1) shows that total fish catch of all fishing gears used in Bitung, but pole and line have increasing and fluctuating trend. Pole and line fisheries exhibited declining catches during the period of 2019-2023. Linear regression demonstrates that there is strong correlation. The declined trend of pole and line is shown by regression line $y = -3.608x + 7,306.4$ and $r = 0.99$ indicating that pole and line contribution to total catch declines as much as 3.608% year^{-1}.

2. Number of trips and pole and line vessels

Number of fishing trips and pole and line vessels in Bitung during 2019 – 2023 is presented in Table (2), then the trend analysis is shown in Figs. (7, 8).

Table 2. Number of fishing trips and pole and line vessels in Bitung during 2019-2023

Description	Fishing trips and vessels				
	2019	**2020**	**2021**	**2022**	**2023**
No. trips	385	444	432	381	264
No. vessels	16	17	20	14	13

Source: Catch landing of MMAF in Bitung.

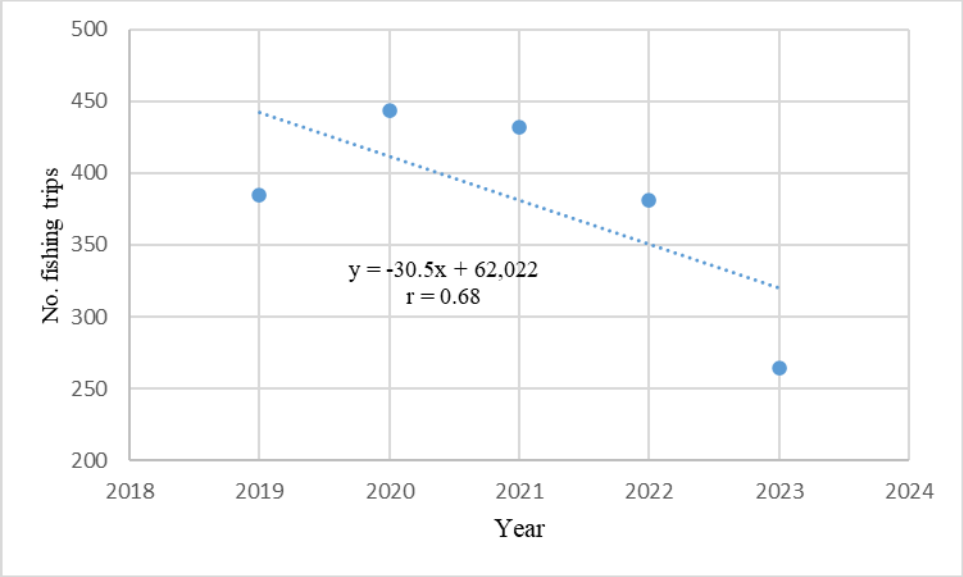

Fig. 7. Number of pole and line fishing trips

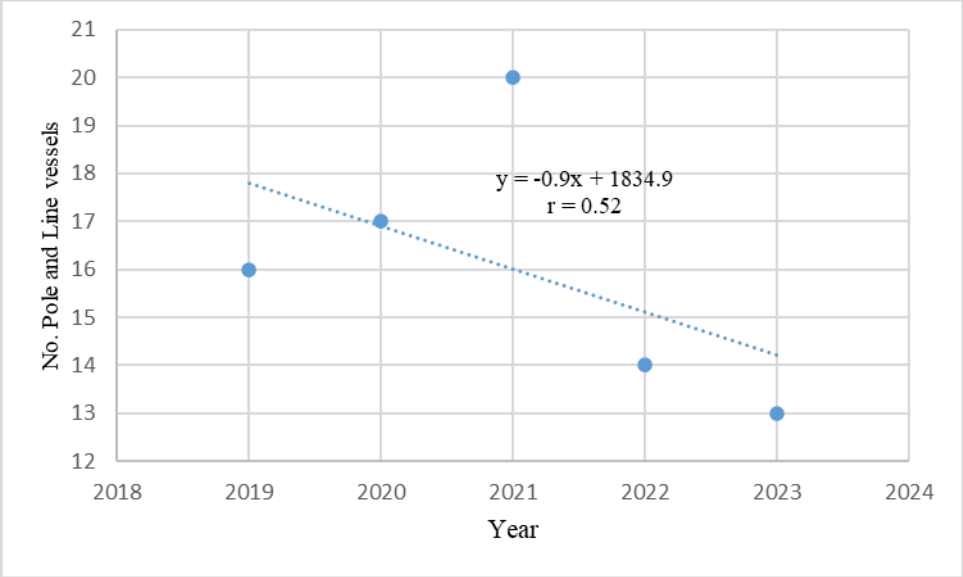

Fig. 8. Number of pole and line vessels during 2018-2023

Number of fishing trips followed the number of pole and line vessels in which the presence of higher number of pole and line vessels will add the number of fishing trips. However, there is low correlation between both variables (Figs. 7, 8). The trend analysis reflected declined number of trips and pole and line vessels during 2019 - 2023 following regression line of y = -30.5x + 62,022 (r = 0.68) and y = -0.9x + 1,834.9 (r = 0.52) as much as 30.5 year^{-1} and 0.9 (1 unit) year^{-1}, respectively.

3. Catch and vessel productivity

Catch and pole and line vessel productivity in Bitung during 2019-2923 are presented in Table (3) and the trend analysis is shown in Figs. (9, 10).

Table 3. Pole and line catch and productivity in Bitung during 2019-2023

Description	**Catch and vessel productivity**				
	2019	**2020**	**2021**	**2022**	**2023**
Catch (Ton)	5,222.16	5,516.12	4,654.43	3,891.26	2,109.68
Productivity (ton GT^{-1})	4.35	4.17	3.08	3.70	2.19

Data source: Catch landing of MMAF in Bitung

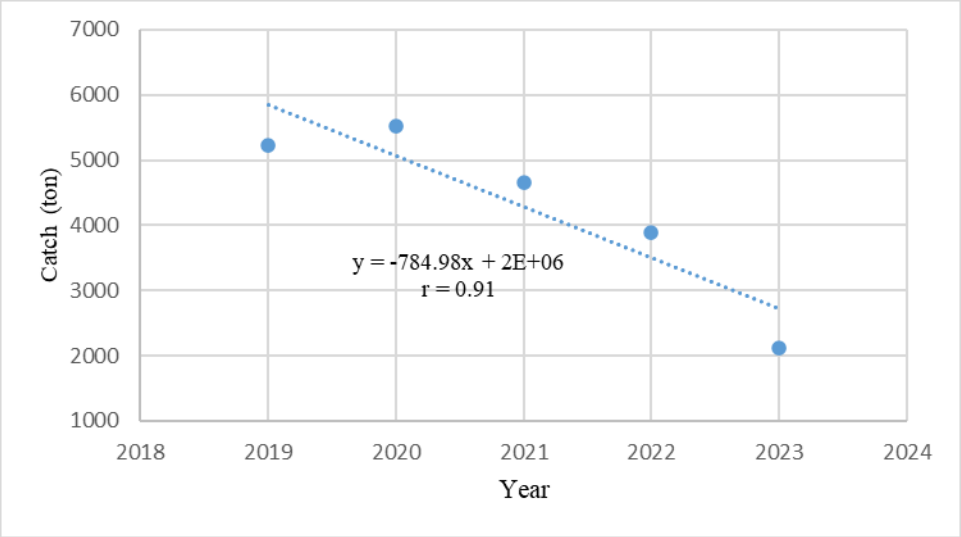

Fig. 9. Catch trend of pole and line vessels

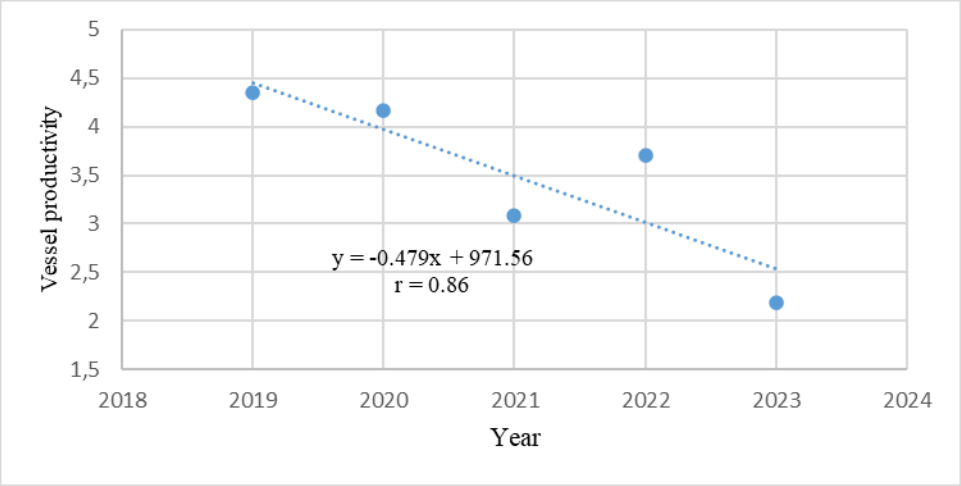

Fig. 10. Pole and line vessel productivity trend

Figs. (9, 10) demonstrate that the pole and line catch and productivity during 2019-2023 follow the regression line of y = -784.98x + 2E+06 (r = 0.91) dan y = -0.479x + 971.56 (r = 0.86) indicating the declined fish catches of 784.98 tons year^{-1} and productivity of 0.479 tons GT^{-1} year^{-1}. This productivity decline still brings the productivity level above the standard of 1.17 tons GT^{-1} year^{-1} based on the Ministry of Marine Affairs and Fisheries of Indonesia (MMAF. 2021), in which it reached 2.19 tons GT^{-1} year^{-1} in 2023 (Fig. 10).

4. Catchability of pole and line (CPUE)

The catchability of pole and line in Bitung is expressed in catch per unit effort (CPUE). Table (4) shows the CPUE during 2019 – 2023, whereas the trend analysis is presented in Fig. (11).

Table 4. Catchability of pole and line (CPUE) in Bitung during 2019-2023

Description	Catchability (ton trip^{-1})				
	2019	**2020**	**2021**	**2022**	**2023**
Catchability (CPUE)	13.56	12.42	10.77	10.21	7.99

Data source: Catch landing of MMAF in Bitung.

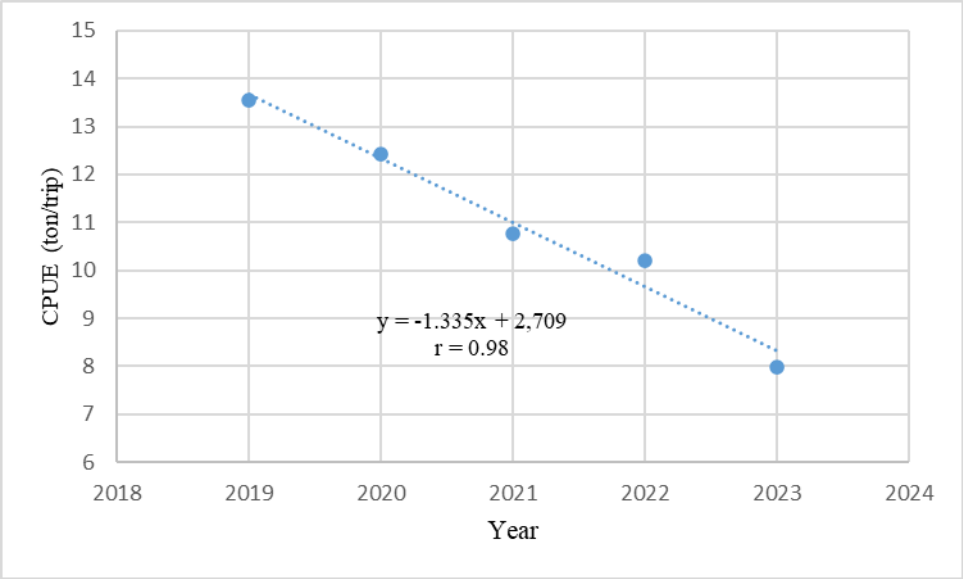

Fig. 11. Catchability trend of pole and line in Bitung during 2029 – 2023

Pole and line catchability (CPUE) in Bitung during 2019 – 2023 declined with time following the linear line of: y = -1.335x + 2,709 with r = 0.98 meaning that the pole and line catchability falls as much as 1.335 tons year^{-1}.

5. Comparison between pole and line and purse seine in Bitung during 2019 – 2023

The comparison between pole and line and purse seine is focused on skipjack (*Katsuwonus pelamis*) catches (Table 5), and the trend analysis is shown in Fig. (12).

Table 5. Comparison between skipjack catches of pole and line and purse seine in Bitung during 2019-2023

Fishing gears	Catch (ton)				
	2019	**2020**	**2021**	**2022**	**2023**
Pole and Line	5,222.161	5,516.120	4,654.427	3,891.260	2,109.678
Purse seine	5,028.592	6,418.104	6,163.418	7,905.893	9,387.749

Data source: Catch landing of MMAF in Bitung.

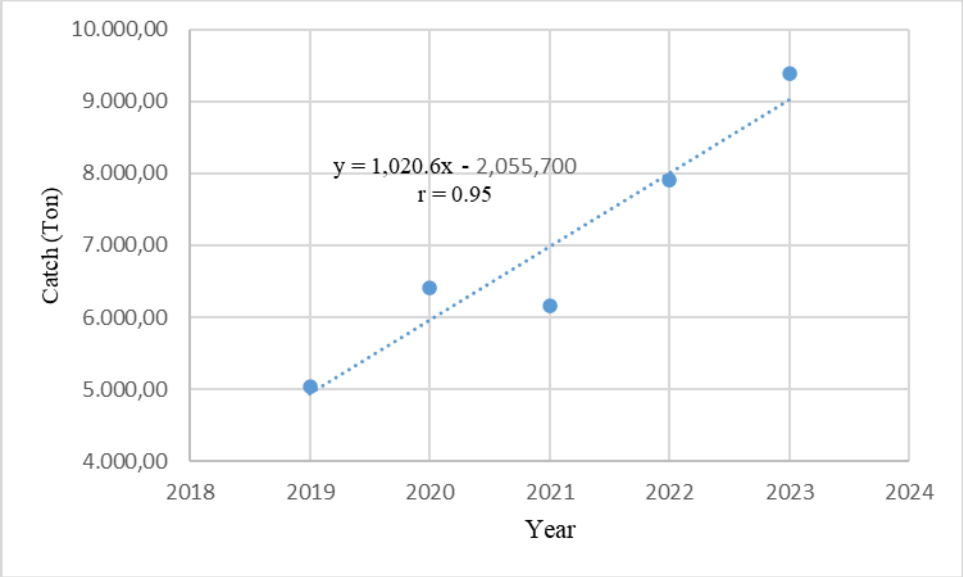

Fig. 12. Purse seine skipjack catch trend in Bitung during 2019 – 2023

Table (5) demonstrates that pole and line catches are not much different from purse seine in 2019, and the catches of both gears increased in 2020, then the catches went to an opposite direction, the pole and line catches fell and the purse seine catches rose until 2023.

The present study, in general, indicates that in the period of 2019-2023, the catch contribution of pole and line, number of pole and line vessels, number of fishing trips, catches, productivity, and catchability tend to fall down. The previous study on tuna, skipjack, and mackerel in Bitung by **Witomo and Wardono (2012)** reported that in 2010, there were 50 pole and line vessels actively operating, 10 units of 10-30 GT and 40 units of >30 GT. **Firmansyah *et al.* (2017)** reported the pole and line fisheries condition in Bitung during 2012 – 2016 (Table 6).

Table 6. Number of pole and line vessels, catch species, total catch, and productivity in Bitung during 2009 – 2016

Year	No. vessels	Production (ton)			Total (ton)	Production trip^{-1} (ton) (CPUE)	
		Skipjack	Tuna	Others		Skipjack	Tuna
2009	40	3,541.16	812.13	29.93	4,383.21	266.16	58.80
2010	38	3,073.4	639.36	17.76	3,730.46	246.11	54.64
2011	40	3,560.09	978.35	30.08	4,568.51	255.51	59.13
2012	38	8,094.70	1,549.07	28,.25	9,672.02	393.18	79.40
2013	32	10,773.74	3,359.41	120.83	14,253.98	438.68	138.59
2014	30	8,425.75	3,775.73	50.45	12,251.93	437.24	177.68
2015	29	6,147.43	2,794.33	60.62	9,002.38	398.15	146.84
2016	22	3,605.68	1,392.19	76.60	5,074.47	332.53	133.14

Source: **Firmansyah *et al* (2017)**.

Based on Table (6), there is decline in number of pole and line vessels in Bitung

during 2009 – 2016; the decline occurred in the number of vessels (2011-2016), number of catches (2013-2016), and the number of productions per trip (2014-2016). It means that the pole and line operations during 2019-2023 had technically appeared in previous years (Table 6). Change in one fisheries parameter will influence the other as they are affecting one and another. This finding is similar to that of **Sutrisno *et al.* (2017)** postulating that number of fishing trips will influence catch and productivity.

There are several reasons for the present fisheries conditions: First, declined live bait availability limits the pole and line fishing operations. This finding is in line with the result of **Hutapea *et al.* (2021)**, who argued that there is an interdependence between live bait supply and pole and line catches. The live baits (anchovy) are collected from lift nets or beach seine. In the past, they were easily found in light fishing at the dark moon period and enhanced with favorable environmental conditions. Nevertheless, the presence of anchovy is decreasing with time. According to **Witomo and Wardono (2012)**, the anchovy catches significantly declined from 127.999kg in 2009 to 82.846kg in 2010, and became very rare afterwards. It could be caused by high damages of coastal ecosystems from human activity and coastal development. Significant development in the tropical area has tremendously threatened biodiversity, from species loss **(Lugo, 1988)**, forest clear cut, to damages from population growth **(Raven, 1988; Spears, 1988)**, particularly on small islands **(Simberloff, 2000)**. Ecosystem is a net of living organisms and dead materials interconnected through nutrient cycles and energy flows. Coastal ecosystem covers a limited space and provides services to support various marine species **(Nichols *et al.*, 2019)**. In fact, many potential areas, such as mangrove forests, a place where the live baits are obtained, have rapidly changed to development.

Second, increased fish raft placement has occupied the potential fishing ground for pole and line fisheries. The raft placement in a big amount has inhibited regular path of fish migrations, especially the skipjack and tuna, which eventually reduced the opportunity of pole and line fishing operations on the fish school. Third, permit regulation for fisheries management zone (FMZ) limited only to 1-2 FMZ **(MMAF, 2014)** can inhibit the search for targeted fish schools so that fishing operations cannot be well done. Fourth, declined interest of young people to work as pole and line fishermen as part of maritime culture. The success of pole and line fishing operations are highly determined by the fishermen's skill **(WWF, 2023)**. Fifth, the declined number of pole and line fisheries could also result from high operational costs. High fuel consumption in pole and line operations causes low fishing efficiency for fish school hunting, and could reduce economic benefit.

This finding reflects the interdependence between measured parameters since all pole and line fishing activities are dependent upon the availability of live baits. Thus, a sustainable and integrated perspectives of forest, river, and marine ecosystems are highly important for conservation and rehabilitation as major solution to recover the ecosystem equilibrium. It needs serious monitoring and control of the related stakeholders to optimally and sustainably manage the fish resources in Indonesia.

CONCLUSION

The study concluded that in the time period of 2019-2023, there was a degradation trend of pole and line vessels in Bitung municipality, which is indicated with reduced number of fishing vessels, fishing operations, catches, productivity, and catchability. Percent contribution of pole and line fisheries to total catches in Bitung fell as much as 3.608% $year^{-1}$. It could result from the decline of fishing trips as much as 30.5 trips $year^{-1}$, number of vessels as much as 0.9 or 1 vessel $year^{-1}$, catches as much as 784.98 tons $year^{-1}$, productivity as much as 0.479 tons GT^{-1} $year^{-1}$, and catchability CPUE) as much as 1.355 tons $trip^{-1}year^{-1}$. This condition should encourage many studies on coastal ecosystem-dependent organisms to describe the environmental changes with time. Future researches focused on environmental rehabilitation need to be pursued in order to yield good environmental policy on ocean space utilization and support the favorable living conditions for marine life in the coastal waters. It could be done through the involvement of related stakeholders, particularly fishermen, government and fisheries entrepreneurs.

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