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Original research article

Analysis of Fish Catch Diversity Index on Purse Seine Vessels in Indonesia Fisheries Management Area 718 (IFMA-718)

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ABSTRACT

Indonesia Fisheries Management Area 718 (IFMA-718), located in the Arafura Sea, is known for its high marine biodiversity and serves as a strategic fishing ground. However, the lack of fishing gear selectivity in this area poses a significant threat to the sustainability of marine resources. This study aims to evaluate the selectivity of purse seine fishing gear through biodiversity analysis using the Shannon-Wiener diversity index (H'), evenness index (E), and dominance index (C). Data collection was conducted from September 2023 to March 2024 in the Arafura Sea using a 149 GT purse seiner. Catch data were categorized into target species, bycatch, and discards. The results showed that the values of H' ranged from 0.77 to 1.40, E values were mostly greater than 1, and C values were below 0.5. These findings indicate a high species diversity and evenness, alongside low dominance, suggesting a relatively balanced community structure. However, such diversity also reflects the low selectivity of the fishing gear, which captures both target and non-target species, including demersal and benthic organisms. In conclusion, the purse seine gear used in IFMA-718 is considered to have low selectivity and is potentially harmful to non-target marine ecosystems. This study provides essential insights for improving selective fishing practices and implementing sustainable fisheries management in the region.

Introduction

Indonesia Fisheries Management Area 718 (IFMA-718), which encompasses the Arafura Sea, is recognized as one of the regions with high potential for fishery resources and significant ecosystem complexity. Fishing activities in this area, particularly using purse seine gear, have intensified

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over the past few decades. However, the increase in catch volume has not always been accompanied by adherence to sustainability principles or high gear selectivity (Froese et al., 2012; FAO, 2020).

Purse seine is widely known as an efficient gear for capturing pelagic fish species, but it is also associated with low selectivity and a high potential for producing bycatch and discards (Hall et al., 2000; Gilman et al., 2014). The use of this gear in the Arafura Sea requires serious attention, given the area's high species diversity. Improper management may lead to the degradation of fish populations and disruptions to the marine ecosystem (Pauly et al., 2005).

One important approach to assessing the ecological impact of fishing gear is through the analysis of biodiversity indices, such as the Shannon-Wiener diversity index (H'), evenness index (E), and dominance index (D). These indices provide insight into community structure and the selective impact of fishing gear on marine biodiversity (Magurran, 2004; Clarke & Warwick, 2001). A high diversity index indicates a more stable and complex community, while a high dominance index reflects the prevalence of certain species due to gear selection pressure (Krebs, 1999).

Previous studies have shown that the selectivity level of purse seine gear in several Indonesian waters is generally low, with diversity index values for both target and non-target species ranging between 0.77 and 1.40. This indicates a tendency for the gear to capture multiple species indiscriminately, regardless of size or type (Nurhakim et al., 2015; Mubarok et al., 2023). Such ecological impacts have the potential to disrupt the aquatic ecosystem and threaten the sustainability of fishery resources (Jennings & Kaiser, 1998).

This study is essential to thoroughly evaluate the community structure of the catch and reassess the effectiveness and environmental friendliness of purse seine operations, particularly in IFMA-718. Using biodiversity index analysis, this research aims to provide scientific evidence to support policymaking for sustainable capture fisheries management in the region (Pitcher & Cheung, 2013).

Research methods

This research was conducted in the Arafura Sea, located within IFMA-718. The data collection period spanned from September 1st, 2023, to March 1st, 2024. The selection of this area was based on its status as a major fishing ground with high biodiversity and frequent operations of purse seine vessels. The following is a research map which can be seen in Figure 1.

The primary object of this study was the fish catch from a 149 GT purse seine vessel. The research focused on identifying and quantifying fish species caught during routine fishing operations. Catch data were grouped into three categories: target catch, bycatch, and discarded catch.

Data were obtained through direct observation and enumeration of landed catches, which included taxonomic identification of all fish species; counting the number of individuals per species; measuring the biomass (weight) of each species; and categorizing each species into target, bycatch, or discard groups.

Biodiversity indices were used to assess the ecological selectivity of the fishing gear. The indices calculated include:

- Shannon-Wiener Diversity Index (H')
  Used to determine the diversity of species in each catch category.
- Evenness Index (E)
  Used to evaluate the distribution uniformity of individuals among species.
- Dominance Index (C)

Used to assess the extent to which certain species dominate the community.

All calculations were performed using spreadsheet tools and were interpreted with reference to ecological theories by Magurran (2004) and Krebs (1999).

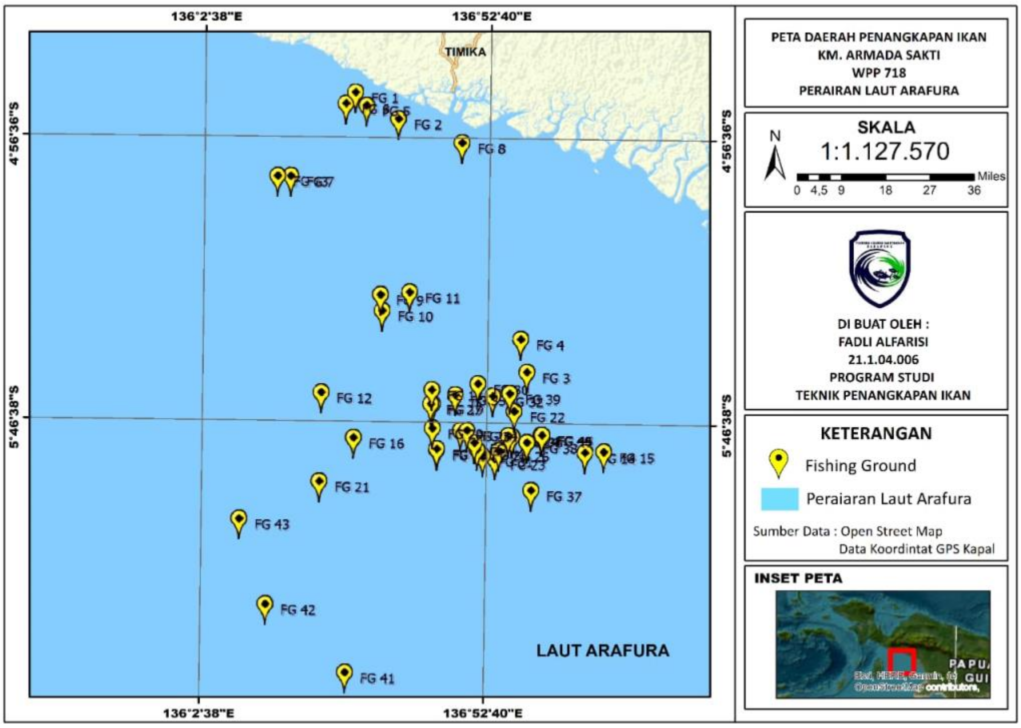

Figure 1. The Research Location, and setting-hauling coordinate

Result

Caught fish species

Based on the results of species identification, a total of 29 fish species belonging to 10 orders and 17 families were recorded during the sampling period. The composition reflects a high diversity of fish communities within the fishing ground, indicative of a complex and ecologically rich marine environment.

The dominant orders include:

- Carangiformes, which contributed the highest number of species (10 species), dominated by the family Carangidae, such as *Decapterus russelli* (Indian scad), *Selar crumenophthalmus* (Bigeye scad), and *Alepes kleinii* (Razorbelly scad).
- Scombriformes, represented by commercially important pelagic species such as *Rastrelliger kanagurta* (Indian mackerel), *Euthynnus affinis* (Kawakawa), and *Scomberomorus commerson* (Narrow-barred Spanish mackerel).
- Other significant orders include Acanthuriformes, Clupeiformes, and Tetraodontiformes, contributing to the structural complexity of the catch.

Several species categorized as non-target or bycatch, such as *Lagocephalus sceleratus* (Silver-cheeked toadfish) and *Neotrygon kuhlii* (Blue-spotted stingray), were also present, suggesting a low level of gear selectivity. Additionally, the presence of demersal species like *Saurida undosquamis* (Brushtooth lizardfish) and *Nemipterus* *virgatus* (Golden threadfin bream) implies that the purse seine gear may also impact non-pelagic communities.

This species composition illustrates that purse seine operations in IFMA-718 capture a wide array of taxa, including pelagic, demersal, and reef-associated species. Such diversity in catch, while beneficial from a multi-species utilization perspective, raises concerns over the ecological sustainability of the fishing gear, particularly in relation to bycatch and potential impacts on ecosystem balance.

Table 1. Caught fish species

No.	Ordo	Family	Species	Common Name
1.	Scombriformes	Scombridae	*Rastrelliger kanagurta*	Indian mackerel
2.	Carangiformes	Carangidae	*Decapterus russelli*	Indian scad
3.	Carangiformes	Carangidae	*Decapterus macarellus*	Mackerel scad
4.	Scombriformes	Scombridae	*Euthynnus affinis*	Kawakawa
5.	Carangiformes	Carangidae	*Parastromateus niger*	Black pomfret
6.	Mulliformes	Mullidae	*Mulloidichthys vanicolensis*	Yellowfin goatfish
7.	Acanthuriformes	Leiognathidae	*Eubleekeria splendens*	Splendid ponyfish
8.	Scombriformes	Trichiuridae	*Trichiurus lepturus*	Largehead hairtail
9.	Carangiformes	Echeneidae	*Echeneis naucrates*	Live sharksucker
10.	Tetraodontiformes	Tetraodontidae	*Lagocephalus sceleratus*	Silver-cheeked toadfish
11.	Beloniformes	Exocoetidae	*Hirundichthys oxycephalus*	Bony flyingfish
12.	Acanthuriformes	Priacanthidae	*Priachantus hamrur*	Moontail bullseye
13.	Aulopiformes	Synodontidae	*Saurida undosquamis*	Brushtooth lizardfish
14.	Acanthuriformes	Nemipteridae	*Nemipterus virgatus*	Golden threadfin bream
15.	Carangiformes	Carangidae	*Alepes kleinii*	Razorbelly scad
16.	Carangiformes	Carangidae	*Selar crumenophthalmus*	Bigeye scad
17.	Acanthuriformes	Lutjanidae	*Lutjanus lutjanus*	Bigeye snapper
18.	Tetraodontiformes	Monacanthidae	*Aluterus monoceros*	Unicorn leatherjacket filefish
19.	Clupeiformes	Chirocentridae	*Chirocentrus dorab*	Dorab wolf-herring
20.	Clupeiformes	Dorosomatidae	*Sardinella lemuru*	Bali sardinella
21.	Clupeiformes	Engraulidae	*Encrasicholina heteroloba*	Shorthead anchovy
22.	Myliobatiformes	Dasyatidae	*Neotrygon kuhlii*	Blue-spotted stingray
23.	Acanthuriformes	Lutjanidae	*Lutjanus malabaricus*	Malabar blood snapper
24.	Carangiformes	Latidae	*Lates calcalifer*	Barramundi
25.	Pleuronectiformes	Psettodidae	*Psettodes erumei*	Indian halibut
26.	Carangiformes	Menidae	*Mene maculata*	Moonfish
27.	Scombriformes	Scombridae	*Scomberomorus commerson*	Narrow-barred Spanish mackerel
28.	Centrarchiformes	Terpontidae	*Terapon jarbua*	Jarbua terapon
29.	Carangiformes	Carangidae	*Elagatis bipinnulata*	Rainbow runner

Shannon-Wiener Diversity Index (H')

The evaluation was conducted to measure the selectivity of the purse seine fishing gear used at the Bajomulyo Coastal Fisheries Port in Juwana, using the Shannon-Wiener Diversity Index (H') approach on the main catch, bycatch, and discard. The trend graph showing the changes in the diversity index over the six months of observation is presented in Figure 2.

H' values greater than 1, recorded in October and November, indicate a high species diversity in the catch. However, this diversity actually reflects low gear selectivity, as it suggests that the fishing gear is still capturing a wide variety of non-target organisms. The gradual decline in the Shannon-Wiener Index (H') from October to March indicates a decrease in the diversity of captured species, which may be attributed to several factors:

- A decline in fish stock abundance in the waters due to fishing pressure;
- Seasonal or oceanographic condition changes;
- Unchanged fishing gear operation behavior, including method, timing, and fishing location.

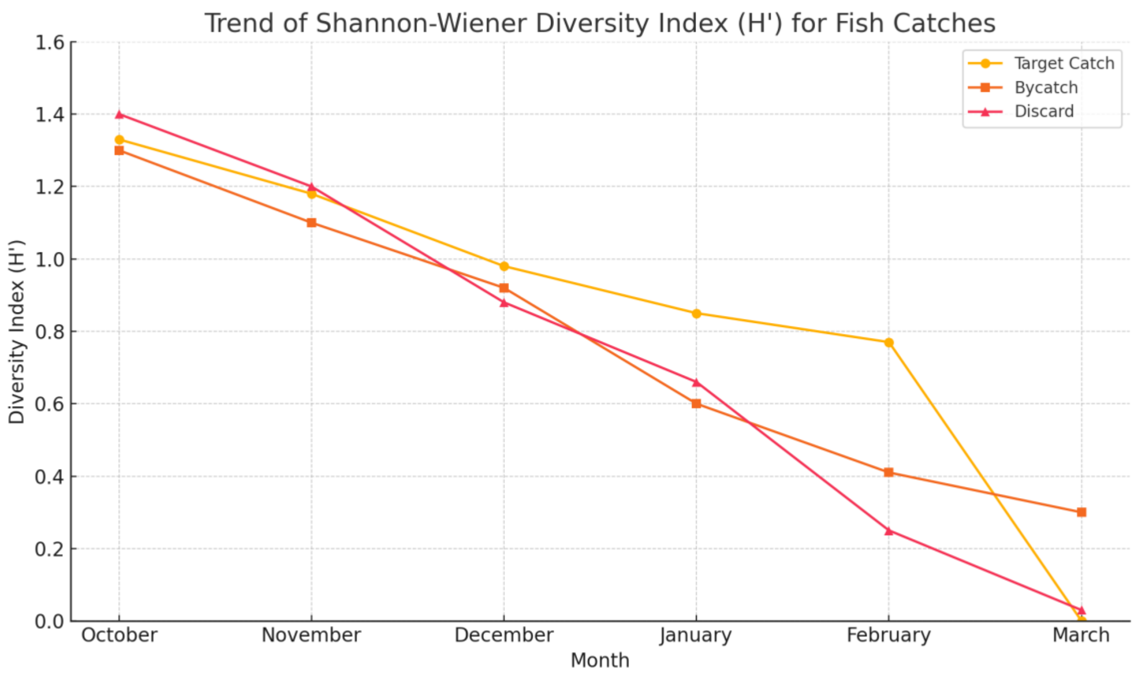

Figure 2. Trend of the Shannon-Wiener Diversity Index (H')

Evenness Index (E)

The evenness index values for the target species, bycatch, and discards from the purse seine fishing gear are presented in Figure 3. On average, the evenness index values were above 1, indicating that the distribution of individuals among species was relatively even, with no significant dominance by a single species. However, in March (Month VI), the index value dropped drastically, approaching zero, which suggests a dominance by one or two particular species.

Dominance Index (C)

Figure 4 presents the dominance index (C) values for the target species, bycatch, and discards, with the following key observations:

- The average C value is below 0.5, indicating that no single species overwhelmingly dominates the catch.
- The lowest C values were observed in the discard catch (Figure 70), approaching zero at points V and VI, suggesting a lack of dominant species — possibly due to the random nature

of captured species or predominance of bycatch.

- A clear inverse relationship between the Evenness Index (E) and Dominance Index (C) is evident — when E is high (species are evenly distributed), C tends to be low (no dominant species), which is consistent with ecological literature.

Based on Figure 4, the dominance index (C) values for all catch categories remained below 0.5, with particularly low values observed in the discard category. These low C values indicate that no single species overwhelmingly dominates the community, further reinforcing the conclusion that the species composition in the catch is relatively diverse and balanced. However, the very low dominance values in the discard category may also suggest random capture of non-target species, which typically have low or no economic value and are consequently discarded.

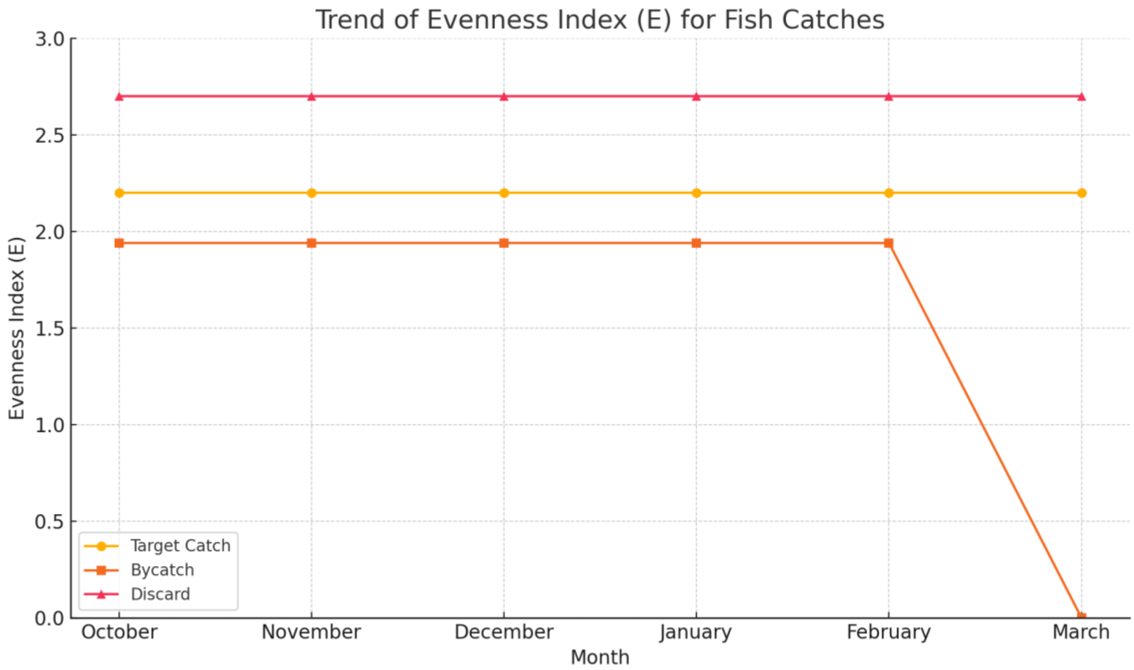

Figure 3. Trend of the Evenness Index (E)

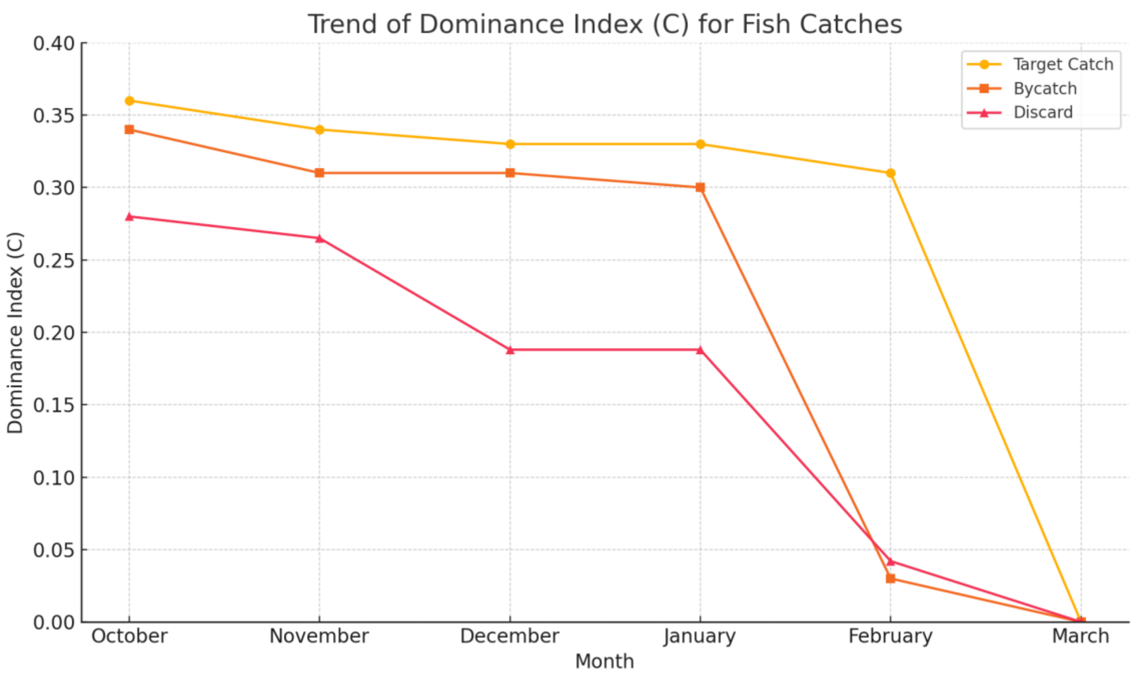

Figure 4. Trend of the Dominance Index (C)

Discussion

The diversity observed in the catch composition indicates a high level of species richness, as reflected in the Shannon-Wiener diversity index (H'), which ranged from 0.77 to 1.33 for target species, 0.30 to 1.30 for bycatch, and 0.03 to 1.40 for discards. According to Krebs (1989) and Magurran (2004), H' values above 0.1 still represent ecologically meaningful diversity. However, in the context of fishing gear performance, high H' values in bycatch and discard categories signal low gear selectivity, indicating the capture of a broad array of non-target species in substantial proportions.

From a fisheries ecology standpoint, there is a well-documented inverse relationship between the Evenness Index (E) and the Dominance Index (C), where high evenness corresponds with low dominance and vice versa (Krebs, 1999). This trend was consistently observed in this study, reinforcing the validity of the ecological indices used. Nevertheless, from a fisheries management perspective, such a pattern reflects the non-selective nature of purse seine gear, as it captures numerous species in relatively balanced proportions, including non-target organisms.

These findings confirm that the purse seine gear employed in the study area exhibits low species selectivity, capturing fish indiscriminately in terms of size, species, and ecological function. This aligns with the observations of Hall et al. (2000), who reported high bycatch rates in purse seine fisheries operating in biodiverse regions, and Gilman et al. (2014), who highlighted that poor gear selectivity increases fishing pressure on non-target species, including those of low economic value but high ecological importance.

Taxonomic analysis revealed the presence of benthic and semi-demersal species such as Mobula mobular (devil ray) and Psettodes erumei (Indian halibut), suggesting that purse seine operations may unintentionally extend beyond their intended pelagic target zone. This could result from gear modifications, inappropriate mesh sizes, or incorrect deployment techniques, leading to unintended ecological consequences.

These patterns are also in agreement with the findings of Perangin-angin et al. (2017), who examined demersal fish communities in the South China Sea and reported that fishing pressure and environmental factors such as dissolved oxygen and light penetration significantly influenced community structure. Their study found that low diversity and high dominance were indicators of ecological stress, especially in areas subjected to intense fishing activity. Similarly, the temporal decline in evenness and increase in dominance observed in the current study suggests a shift toward community imbalance, likely caused by fishing gear impacts on a diverse ecosystem.

Consequently, the purse seine gear utilized at Bajomulyo Coastal Fisheries Port can be classified as having low ecological selectivity. This raises considerable concern in the framework of sustainable fisheries management, as it may:

- Exacerbate overfishing of non-target stocks,
- Increase discard volumes,
- Disrupt trophic and ecological balance within marine ecosystems.

As emphasized by the FAO (1996), fishing gears should exhibit high selectivity to reduce bycatch and minimize environmental impact. While this study confirms the richness of the catch composition, it also underscores the urgent need for gear modification, regulation, and enforcement to improve selectivity and promote environmentally responsible fishing practices.

Conclusion

The diversity index values for target catch, bycatch, and discards indicate that the Shannon-Wiener diversity index (H') exceeds 1, suggesting a high level of species diversity, while at the same time reflecting low gear selectivity. The evenness index values for all catch categories also exceed 1, indicating a relatively even distribution of individuals across species, with no dominant species strongly prevailing. The dominance index (C) values are consistently low across target catch, bycatch, and discards, reinforcing the conclusion that no single species dominates the catch composition. In summary, the purse seine gear used by fishers operating from Bajomulyo Coastal Fishing Port (PPP Bajomulyo) demonstrates low selectivity and is not environmentally friendly, as it captures a wide range of non-target species in relatively balanced proportions. This underscores the need for improved gear management and selectivity enhancement to support sustainable fisheries practices.

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