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Microplastic Analysis in Mackarel Tuna and Milkfish at Selili Fish Landing Site, East Kalimantan

Mahesa Islamy Eka Juniar[1], Abdunnur[2*], Moh Mustakim[2], Iwan Suyatna[2], Fitriyana[2]

[1]Master of Fisheries Science Student, Mulawarman University, Indonesia
[2]Master of Fisheries Science Lecturer, Mulawarman University, Indonesia

*Correspondence Author: abdunnur67@yahoo.co.id

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ABSTRACT

Microplastic pollution in coastal waters poses a serious threat to marine ecosystem sustainability and food safety. However, data on microplastic contamination in edible fish from the Selili Fish Landing Station (PPI Selili), Samarinda, remains limited. This study aimed to identify the types and abundance of microplastics in mackarel tuna (Euthynnus affinis) and milkfish (Chanos chanos), and to analyze the relationship between fish size and microplastic count. The methodology involved random sampling, microplastic extraction from digestive tracts using 22% KOH solution, and statistical analysis using ANOVA and linear regression. The results showed that mackarel tuna contained an average of 3.87 particles per individual, while milkfish had 1.8 particles per individual. The dominant type of microplastic in both species was film (>80%). ANOVA revealed a significant difference in microplastic abundance between the two species ($p = 0.010$), whereas regression analysis indicated that fish length and weight had no significant effect on microplastic quantity ($R^2 < 0.03$). In conclusion, mackarel tuna are more prone to microplastic accumulation than milkfish, likely due to differences in habitat and feeding behavior. It is recommended to conduct regular monitoring of water quality and educate local communities about reducing single-use plastic to minimize microplastic pollution around PPI Selili.

INTRODUCTION

The marine aquatic ecosystem is one of the most vulnerable environments to plastic pollution, especially microplastics. Plastic debris has become a pressing global issue since the rapid growth of plastic production in the 20th century (Geyer et al., 2017). Microplastics, defined as plastic particles smaller than 5 mm, originate from the breakdown of larger plastics or directly from primary sources (Auta et al., 2017). Due to their persistent physical and chemical properties, microplastics are widespread in marine environments. Studies have reported the presence of microplastics across all marine components, including the water column, sediments, and organisms from lower to higher trophic levels (Bessa et al., 2018). These particles have been detected in plankton, bivalves, crustaceans, and fish (Auta et al., 2017), indicating widespread contamination and potential ecological disruption. Their accumulation in organisms can impair physiological functions and behavior, threatening population sustainability and ecosystem balance (Jovanović, 2017).

Fish play a crucial role in the marine food web and are a primary source of protein for humans, especially in developing nations such as Indonesia. Microplastics can be unintentionally ingested by fish due to their resemblance in size, shape, and color to natural prey. Once ingested, they can accumulate in the digestive tract, gills, or tissues, leading to physiological disorders such as internal injuries, oxidative stress, inflammation, appetite loss, and metabolic disturbances (Lu et al., 2016; Rochman et al., 2015). These disruptions can affect growth and reproduction, ultimately impacting fishery yields and food security (Barboza, L. G. et al., 2018). Moreover, microplastics can act as vectors for toxic compounds, including heavy metals like Pb, Cd, and Hg, and persistent organic pollutants (POPs) such as pesticides and polychlorinated biphenyls (PCBs), which adhere to their hydrophobic surfaces. These contaminants can enter the food chain through bioaccumulation and biomagnification, posing health risks to consumers (Smith et al., 2018). An estimated 80% of marine plastic waste originates from land-based sources, including household, industrial, and agricultural waste (GESAMP, 2015). Discarded plastics undergo degradation processes such as photodegradation, oxidation, hydrolysis, and biodegradation eventually forming microplastics. Their distribution in marine environments is affected by hydrodynamic forces, water chemistry, and interactions with biota.

Indonesia, as an archipelagic nation, relies heavily on marine resources for food, economy, and coastal livelihoods. Mackarel tuna (*Euthynnus affinis*) and milkfish (*Chanos chanos*) are two economically significant species in Southeast Asia, commonly consumed and widely available (Misnawi, S et al., 2021). Mackarel tuna, a pelagic fish, is often caught in offshore waters, while milkfish, a demersal species, is also extensively farmed (Lebreton et al., 2019). Previous studies in Indonesia have identified microplastic contamination in both pelagic and demersal fish, including fibers, films, and fragments (Arifin *et al.,* 2022; Misnawi *et al.,* 2021) (Arifin, Z et al., 2022; Misnawi, S et al., 2021). Fibers often originate from textiles and fishing gear, films from plastic bags and packaging, and fragments from larger plastic debris (Napper & Thompson, 2016). The type and abundance of microplastics found in marine organisms are influenced by habitat, feeding behavior, and local pollution sources (Hernandez et al., 2017).

Selili Fish Landing Base (PPI Selili) in Samarinda, East Kalimantan, is a key regional hub for capture fisheries, receiving landings of mackarel and milkfish from various locations. Its proximity to residential areas, industrial zones, and shipping lanes increases the risk of microplastic pollution from terrestrial sources (Santoso, H et al., 2020). However, there is limited data on microplastic presence in commercially consumed fish from this location, despite its significance as a protein source for local communities. Ongoing land-use changes, urban expansion, and industrial development around PPI Selili further elevate the risk of marine pollution. Therefore, research on the presence, types, and abundance of microplastics in mackarel and milkfish from this area is essential to understand contamination risks and implications for public health and fisheries sustainability (Santoso, H et al., 2020).

This study aims to analyze the microplastic content in the gastrointestinal tract of mackarel tuna and milkfish landed at PPI Selili, and to identify the types and quantify the abundance of microplastics found. The findings are expected to provide initial insights into the environmental and health risks posed by microplastic contamination in fishery products, and to support sustainable plastic waste management and fisheries conservation policies.

LITERATURE REVIEW

1. Microplastics and Marine Pollution

Microplastics are synthetic polymer particles smaller than 5 mm, resulting from the degradation of larger plastics or direct release from consumer and industrial products. These particles are widespread in aquatic environments due to their durability and buoyancy. In the marine ecosystem, microplastics are not only ingested by various trophic-level organisms but also act as vectors for harmful substances such as heavy metals and persistent organic pollutants (POPs), increasing ecological and health risks (Rochman et al., 2015).

Microplastics are morphologically categorized into types such as fragments, fibers, films, pellets, and foams. Their physical characteristics such as density, size, and surface area determine their movement in the water column and accumulation in sediments (Geyer et al., 2017). Fibers typically originate from textiles and fishing gear, films from packaging materials, and fragments from broken plastic objects (Napper & Thompson, 2016).

2. Distribution and Sources

The distribution of microplastics in the marine environment is influenced by hydrodynamic factors, salinity, water chemistry, and biofouling processes. Wind, currents, and wave action contribute to both horizontal and vertical transport of particles, while biofouling alters buoyancy and facilitates ingestion by marine organisms (Peng et al., 2018; Victoria, 2017). Terrestrial-based sources, including domestic, agricultural, and industrial waste, are the dominant contributors, entering the ocean through runoff and river flow (GESAMP, 2015).

3. Microplastics in Fish

Numerous studies have documented microplastic ingestion in fish, including both pelagic and demersal species. Ingested particles can be retained in the gastrointestinal tract, gills, or tissues, leading to various physiological effects such as internal injury, oxidative stress, and reproductive disruption (Barboza, L et al., 2018). Fiber and fragment microplastics are commonly found in commercial fish, raising concerns about seafood safety and human health.

4. Mackarel Tuna and Milkfish

Mackarel tuna (*Euthynnus affinis*) is a pelagic predator with a diet dominated by small fish and cephalopods, often captured in areas with high surface pollution. Studies indicate that this species frequently ingests floating microplastics due to its feeding behavior and habitat range (Lebreton et al., 2019; Misnawi, S et al., 2021). Milkfish (*Chanos chanos*), in contrast, is a demersal species often cultured in brackish water environments. It's omnivorous to herbivorous feeding habit and benthic interaction increase its exposure to settled microplastics, especially in areas with sediment contamination (Islamiya, 2020; Putri, E., & Caesar, 2017).

5. PPI Selili and Pollution Risk

Selili Fish Landing Base (PPI Selili) is a major fishery hub in Samarinda, East Kalimantan, receiving fish from various coastal and offshore regions. Its proximity to urban settlements and industrial zones enhances the risk of microplastic contamination in landed fish. Although equipped with supporting infrastructure, pollution control in the area remains limited, necessitating scientific studies to assess environmental quality and food safety (Misnawi, S et al., 2021; Santoso, H et al., 2020).

METHOD

1. Study Site and Sampling

This research was conducted from September to November 2024 at the Selili Fish Landing Base (PPI Selili), located in Samarinda City, East Kalimantan Province. The research location is illustrated in Figure 1.

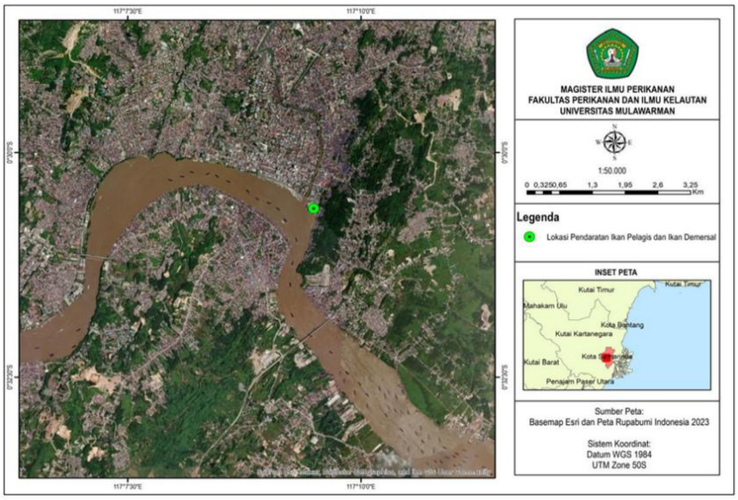


Figure 1. Map of Landing Locations for Mackarel Tuna and Milkfish
Source: Processed Data (2024)

Thirty fish samples, consisting of 15 mackarel tuna (*Euthynnus affinis*) and 15 milkfish (*Chanos chanos*), were randomly collected from local fish vendors at the landing site using a random sampling technique. Fish body lengths ranged from 28 to 35 cm and weights from 217 to 430 grams.

2. Microplastic Extraction

Microplastics were extracted from the gastrointestinal tracts of fish using the protocol developed by Rochman et al., (2015), with modifications. Each dissected digestive tract was placed in a 500 mL beaker, followed by the addition of a 22% potassium hydroxide (KOH) solution in a 1:3 volume ratio. The beaker was covered with aluminum foil and heated in an oven at 60°C for 24 hours, then left at room temperature for 14 days or until fully digested. The digested solution was vacuum-filtered using 0.45 µm Whatman filter paper to isolate microplastic particles. Filters were dried in an oven at 105°C for one hour before further analysis.

3. Identification and Classfication

Dried filters were examined using a stereomicroscope (40x–100x magnification) to identify and classify microplastics based on their morphology, including shape (fiber, film, fragment) and color.

4. Equitment and Materials

Essential tools included a dissecting kit, analytical balance, beaker glass, oven, vacuum pump, magnetic stirrer, aluminum foil, and stereomicroscope. Reagents included 22% KOH solution, 30% H_2O_2, and distilled water. Filter paper used was Whatman 0.45 µm pore size.

5. Data Analysis

- Microplastic Abundance: Calculated as the number of particles per individual using the formula:

$$K=Ni/N$$

  Where K is the microplastic abundance, Ni is the total particles, and N is the number of fish examined.
- Statistical Analysis:
  1. Linear Regression: Used to assess the relationship between fish size (length and weight) and the number of microplastics.
  2. Levene's Test: Applied to test the homogeneity of variances between the two fish groups.
  3. One-way ANOVA: Conducted to determine whether there were significant differences in microplastic abundance between mackarel tuna and milkfish. Significance was set at $p < 0.05$.

RESULT AND DISCUSSION

A. Microplastic Abundance in Mackarel Tuna and Milkfish

This study revealed a notable difference in the abundance of microplastics between mackarel tuna (*Euthynnus affinis*) and milkfish (*Chanos chanos*) landed at the Selili Fish Landing Base (PPI Selili). As shown in Table 1, mackarel tuna had a total of 58 microplastic particles across 15 individuals, with an average of 3.87 particles per fish. Meanwhile, milkfish showed a total of 27 particles from the same number of individuals, with an average of 1.80 particles per fish.

Table 1. Microplastic abundance in mackarel tuna and milkfish from PPI Selili

Species	Sample Size	Total Particles	Abundance (particles/individual)
Euthynnus affinis	15	58	3.87
Chanos chanos	15	27	1.80

This discrepancy reflects the distinct ecological characteristics and feeding habits of the two species. mackarel tuna is a pelagic predator occupying higher trophic levels, making it susceptible to trophic transfer of microplastics through consumption of contaminated prey such as smaller fish and zooplankton (Aryani, R. T et al., 2024). In contrast, milkfish typically inhabits brackish environments, including estuarine ponds and coastal waters, and feeds primarily on phytoplankton, detritus, and suspended organic matter. Its lower trophic level and different habitat reduce its exposure to floating microplastics in open marine systems.

In addition, mackarel tuna are migratory and highly active swimmers that forage across larger areas, including polluted coastal zones and offshore convergence zones where plastic debris accumulates. On the other hand, milkfish, particularly those raised in aquaculture or semi-wild environments, tend to have more limited movement and may be exposed predominantly to localized pollution. Nevertheless, the presence of microplastics in both species especially those meant for human consumption raises concerns about food safety and underscores the pervasiveness of microplastic contamination even in managed fisheries.

These findings are consistent with earlier reports from other Indonesian coastal areas. Yogia, P et al., (2023) found that pelagic fish such as mackerel and skipjack tend to accumulate more microplastics compared to demersal or herbivorous species. The relatively lower mean particle count in milkfish suggests either reduced exposure or differences in ingestion mechanisms. However, the detection of particles in every sample confirms that no species is immune to the growing threat of marine plastic pollution.

B. Homogeneity Test (Levene's Test)

To assess the assumption of equal variances required for parametric analysis, a Levene's test was conducted on the microplastic abundance data. As displayed in Table 2, the significance values for all test bases (mean, median, adjusted median, and trimmed mean) were above 0.05, indicating homogeneity of variance between the two fish species.

Table 2. Levene's test result for microplastic abundance variance

Test Basis	Levene Statistic	df1	df2	Sig.
Mean	1.521	1	28	0.228
Median	1.383	1	28	0.250
Median (adjusted df)	1.383	1	18.492	0.255
Trimmed mean	1.748	1	28	0.197

This statistical outcome supports the use of ANOVA for comparing group means, as it confirms that both groups share similar variance characteristics. The result is also aligned with the findings of Syahadatina, R. F et al., (2024), which demonstrated homogeneous microplastic distribution across different species in tropical marine ecosystems. This homogeneity may reflect relatively uniform exposure to microplastic sources at PPI Selili, such as domestic waste inputs and port-related activities.

C. ANOVA Test

A one-way ANOVA test revealed a statistically significant difference in microplastic abundance between the two species ($F = 7.593$; $p = 0.010$), confirming that species identity plays a significant role in microplastic accumulation levels.

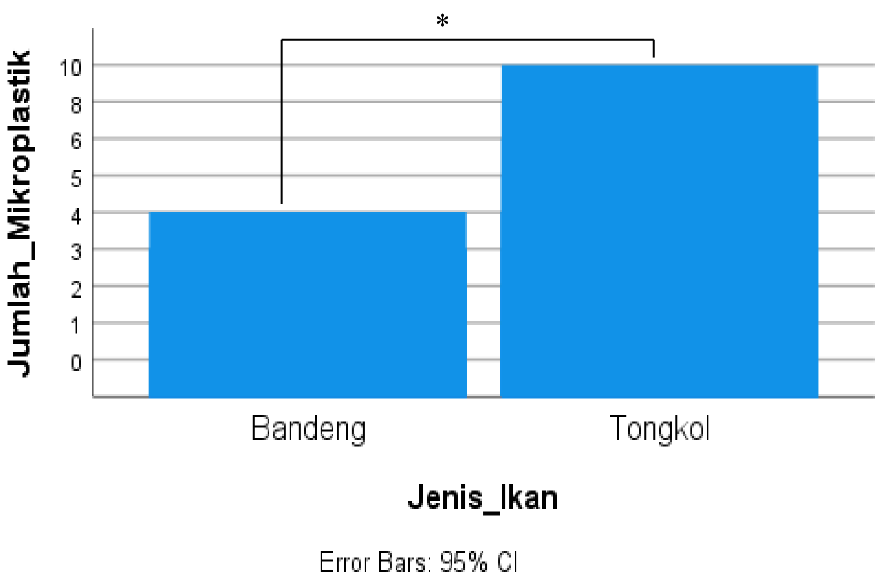
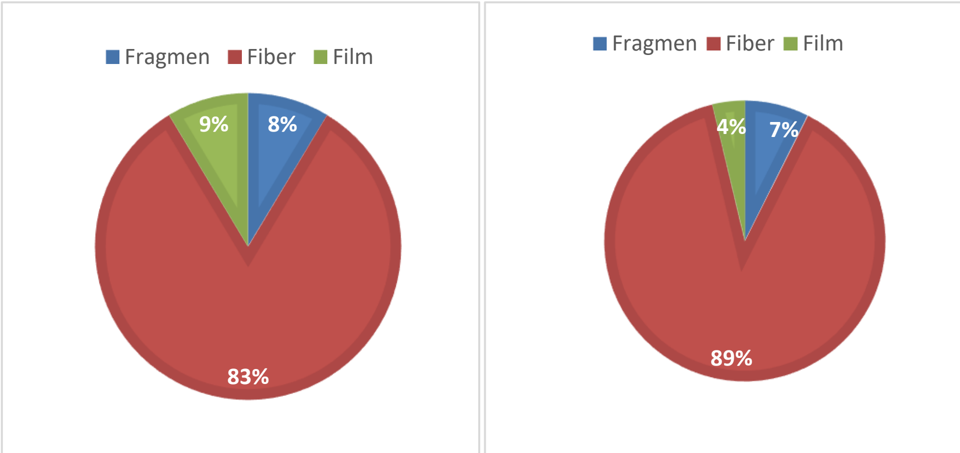


Figure 2. ANOVA test result for microplastic abundance in mackarel tuna (*Euthynnus affinis*) and milkfish (*Chanos chanos*)
Source: Processed Data (2025)

This supports ecological theory that feeding behavior, diet composition, and habitat use strongly influence microplastic ingestion rates. The result echoes the work of Azuri, L et al., (2024), who observed that predatory pelagic fish tend to ingest more microplastics than demersal or herbivorous species.

D. Microplastic Types Identified

The morphological analysis of microplastic particles extracted from the digestive tracts of mackarel tuna (*Euthynnus affinis*) and milkfish (*Chanos chanos*) revealed that film-type microplastics were the most dominant in both species. In mackarel tuna, 83% of the identified particles were films, followed by 9% fragments and 8% fibers. In milkfish, the dominance of film was even more pronounced, comprising 89% of all particles, with fragments at 4% and fibers at 7%.



Euthynnus affinis *Chanos chanos*

Figure 3. Microplastic type composition in fish from PPI Selili

The overwhelming presence of film-type microplastics in both species suggests a common and pervasive source namely, single use plastic materials such as food wrappers, plastic bags, and flexible packaging. These plastics are lightweight, easily fragmented by UV exposure and physical abrasion, and remain suspended or floating in surface waters for extended periods. This makes them highly available for ingestion, especially by surface dwelling or filter feeding organisms like milkfish.

In the case of milkfish, the high proportion of film microplastics is likely associated with its feeding mechanism. Milkfish are known as surface or mid-water filter feeders, consuming suspended particles, phytoplankton, and detritus. Their non-selective feeding style makes them particularly vulnerable to ingesting film-like plastic debris that floats along the water surface precisely where thin plastic films tend to accumulate due to their low density.

Conversely, mackarel tuna is a fast-swimming pelagic predator that consumes smaller fish, crustaceans, and cephalopods. The presence of fragments and fibers in its digestive tract, although lower in proportion, may be attributed to secondary ingestion where tuna consumes prey that has already ingested various types of microplastics or direct ingestion during foraging in polluted surface waters. Fibers are often derived from fishing nets, ropes, and textiles, while fragments usually result from the breakdown of larger rigid plastics like bottles and containers.

The difference in microplastic types between the two species illustrates how ecological niche, feeding strategy, and habitat influence the nature of contamination. These patterns align with the findings of Susanti, D et al., (2023), who reported similar type compositions in demersal and pelagic fish from Jakarta Bay, where film-type plastics were consistently dominant due to high input from urban and domestic sources.

The dominance of film microplastics also points to land-based pollution as a major contributor, especially considering the location of PPI Selili near densely populated and commercial zones. Waste mismanagement, improper disposal of household plastics, and runoff from urban areas likely contribute to the input of such materials into the Mahakam River and subsequently into the adjacent marine environment. This reflects a broader trend observed in Southeast Asian coastal regions, where rapid urbanization has outpaced waste management infrastructure, resulting in plastic leakage into waterways (Cordova, M. R et al., 2021; Lebreton et al., 2019).

Thus, the type composition of microplastics found in fish at PPI Selili not only reflects biological factors but also provides insight into dominant local sources of pollution. The prevalence of film-type plastics should be a focus of future waste management and marine conservation policies, especially considering their high ingestion potential and persistent presence in marine food webs.

E. Relationship Between Fish Weight and Microplastic Abundance

To evaluate whether body weight influences microplastic ingestion, a linear regression analysis was applied to both mackarel tuna (*Euthynnus affinis*) and milkfish (*Chanos chanos*). The regression result for mackarel tuna produced the equation $y = 0.0047x + 1$, with a coefficient of determination (R^2) of 0.0286 and a correlation coefficient (r) of 0.169. This indicates a very weak positive relationship between body weight and the number of microplastic particles ingested. For milkfish, the regression equation was $y = -0.0015x + 2.2682$, with $R^2 = 0.0025$ and $r = 0.050$, suggesting an even weaker, essentially negligible, negative relationship.

These results clearly demonstrate that body weight is not a strong predictor of microplastic contamination in either species. The very low R^2 values less than 3% for mackarel tuna and less than 1% for milkfish indicate that the variation in particle count is largely independent of fish mass. This could be due to the randomness of microplastic ingestion events, which are influenced more by behavioral, ecological, and environmental factors than by size metrics alone.

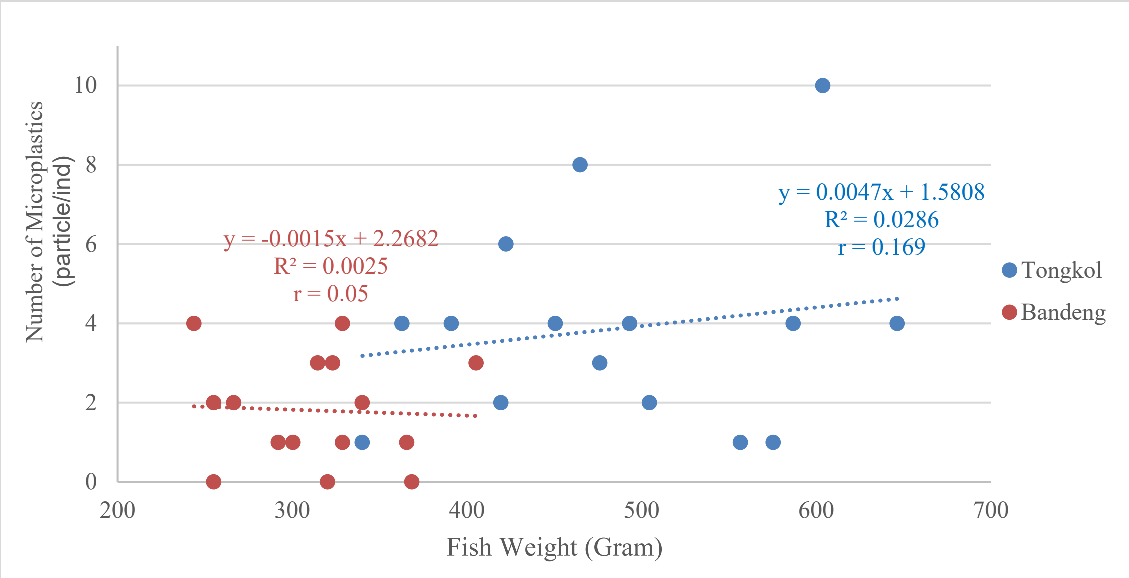


Figure 4. Linear regression between fish weight and microplastic abundance

One possible explanation is that fish of various sizes forage in overlapping areas and encounter similar levels of pollution, particularly in a heavily utilized area like PPI Selili. This homogeneity in exposure may cause fish of different weights to have relatively equal chances of ingesting microplastics, regardless of their growth stage or nutritional intake. Moreover, fish may not retain microplastics permanently; many particles are excreted rather than bioaccumulated over time, which contrasts with the accumulation patterns of heavy metals or organic pollutants.

This finding aligns with similar research by Syahadatina, R. F et al., (2024), which reported no significant relationship between body mass and microplastic burden in pelagic fish. Although some studies have suggested a tendency for larger fish to ingest more microplastics (e.g., Azuri, L et al., 2024), such relationships are often context-dependent and weak, especially when pollution is widespread and evenly distributed.

Overall, this study indicates that fish weight is not a meaningful variable in predicting microplastic ingestion. Future research may benefit from focusing on ecological traits such as feeding mode, prey type, or habitat preference to better understand the mechanisms of microplastic exposure in marine organisms.

F. Relationship Between Fish Length and Microplastic Abundance

To assess whether fish length contributes to the variation in microplastic contamination, a linear regression analysis was carried out using the total length of both mackarel tuna (*Euthynnus affinis*) and milkfish (*Chanos chanos*) as the independent variable. For mackarel tuna, the regression equation obtained was y =

−0.0343x + 14.079, with a coefficient of determination (R^2) of 0.0517 and a correlation coefficient (r) of 0.227. This result indicates a weak negative relationship between fish length and the number of microplastic particles. In other words, longer mackarel tuna were slightly less likely to contain higher microplastic counts, although the relationship was very weak and statistically insignificant.

In contrast, the regression equation for milkfish was y = 0.0125x − 1.5723, with an R^2 value of 0.0147 and an r value of 0.121. This reflects a similarly weak but slightly positive relationship, suggesting that larger milkfish may ingest more microplastics but again, the correlation is negligible. Both species therefore demonstrated no meaningful linear association between length and microplastic abundance.

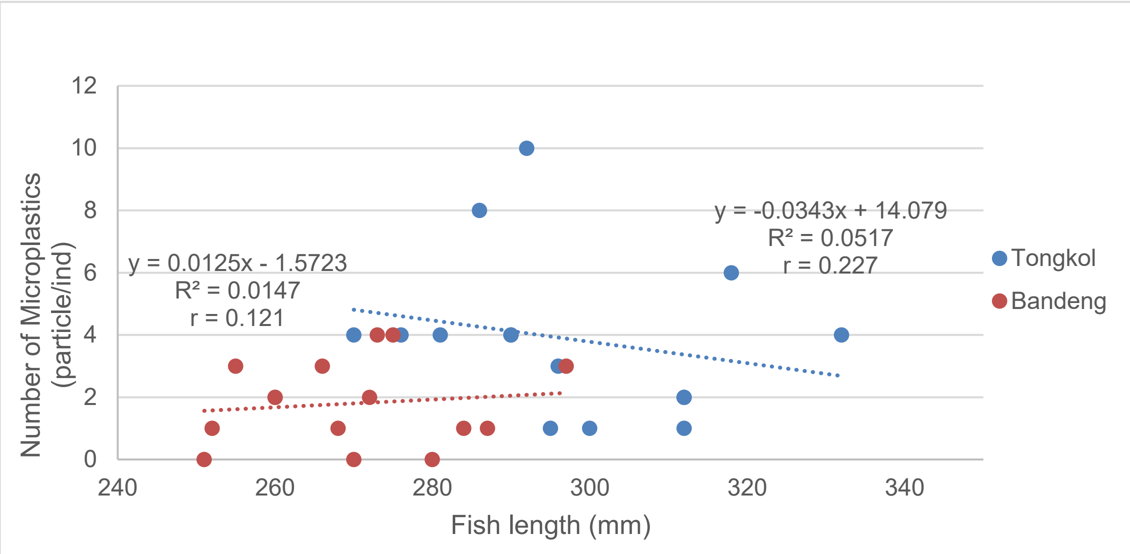


Figure 5. Linear regression between fish length and microplastic abundance

The limited predictive value of fish length implies that body size is not a dominant factor in determining microplastic ingestion in these species under the environmental conditions at PPI Selili. It is likely that other factors such as feeding behavior, habitat-specific contamination levels, and the presence of microplastics in prey or detritus have greater influence. For instance, mackarel tuna, being a carnivorous pelagic fish, forages widely and may ingest microplastics through trophic transfer rather than directly from the water. Milkfish, on the other hand, are more likely to ingest microplastics suspended in the water column through their filter-feeding activity, regardless of their size.

These findings align with those of (Syahadatina, R. F et al., (2024), who also reported no significant correlation between fish length and microplastic content in pelagic fish species in the waters of Lombok. Other studies, such as that by Azuri, L et al., (2024), have reported a weak trend of increasing microplastic load with increasing size, but such patterns are often inconsistent and strongly influenced by habitat characteristics, prey availability, and local pollution gradients.

The absence of a strong length-based trend may also result from the stochastic nature of microplastic exposure. Unlike persistent pollutants that bioaccumulate in tissues over time, microplastics can be ingested and later excreted, meaning their presence in the digestive system reflects recent feeding behavior rather than long-term accumulation. As such, even individuals of similar length can display vastly different particle counts depending on where and when they fed.

Furthermore, behavioral ecology must be considered. In some fish species, size is associated with shifts in diet or habitat preference; however, in species like mackerel tuna and milkfish, these changes may not be as pronounced, especially within the limited sample size or size range of this study. It is also possible that all individuals, regardless of size, are similarly exposed due to homogeneous pollution levels in their environment particularly in a busy, anthropogenically influenced area like PPI Selili.

In conclusion, this study finds that fish length, like body weight, is not a significant explanatory variable for microplastic ingestion. These results highlight the importance of considering environmental exposure pathways and species-specific ecological behavior over simple morphometric indicators when studying microplastic contamination in marine organisms.

CONCLUSION

This study investigated the presence, types, and abundance of microplastics in two economically and ecologically significant fish species mackarel tuna (*Euthynnus affinis*) and milkfish (*Chanos chanos*) landed at the Selili Fish Landing Base (PPI Selili), Samarinda, East Kalimantan. The research focused on comparing pelagic and demersal species in terms of microplastic contamination and exploring the potential influence of body size on ingestion levels.

The findings revealed that microplastics were present in all analyzed samples, with three major morphotypes identified: film, fragment, and fiber. Among these, film-type microplastics overwhelmingly dominated in both species, comprising 83% in mackarel tuna and 89% in milkfish. This dominance indicates a strong influence of low-density, flexible plastics such as food wrappers and shopping bags, which are likely introduced into marine environments through household waste and coastal activities. Their tendency to float on the surface makes them easily accessible for ingestion, either directly in filter-feeding fish like milkfish or indirectly through trophic transfer in predatory species such as mackarel tuna.

Quantitatively, mackarel tuna showed a significantly higher microplastic load compared to milkfish. On average, 3.87 particles per individual were recorded in mackarel tuna, while milkfish contained 1.8 particles per individual. ANOVA analysis confirmed this difference to be statistically significant ($F = 7.593$; $p = 0.010$), with species identity accounting for approximately 21.3% of the variation in microplastic abundance ($\eta^2 = 0.213$). This suggests that feeding strategy and habitat exposure strongly influence microplastic ingestion levels.

The Levene's test for homogeneity of variances yielded a p-value of 0.228, indicating no significant difference in variance between the two species. This validated the use of parametric tests such as ANOVA and suggests that microplastic exposure in the study area is relatively uniform across different fish groups.

Further analysis examining the relationship between fish morphometrics and microplastic abundance showed very weak and statistically insignificant correlations. Regression analyses returned R^2 values of 0.0286 (weight) and 0.0517 (length) for mackarel tuna, and 0.0025 (weight) and 0.0147 (length) for milkfish. These results imply that body size both in terms of length and weight is not a meaningful predictor of microplastic contamination in these species. The homogenous distribution of pollution and the overriding influence of ecological traits such as feeding behavior and trophic position are likely more important factors.

In summary, microplastic pollution is evident in both pelagic and demersal fish at PPI Selili, with significant variation by species but not by size. These findings highlight the pressing need for improved plastic waste management in coastal zones and reinforce the relevance of microplastic monitoring as a key indicator of marine environmental health.

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