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# Analysis of Microplastics in the Digestive Tracts of Mackerel Tuna (Euthynnus affinis) and Skipjack Tuna (Katsuwonus pelamis) for SDG 14

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**ABSTRACT**

***Objective:*** *Marine ecosystems are increasingly threatened by microplastic pollution, which can accumulate in commercially important fish species and potentially affect human health. This study aimed to identify the characteristics and abundance of microplastics in the digestive tracts of mackerel tuna (Euthynnus affinis) and skipjack tuna (Katsuwonus pelamis) from Boneoge waters, Donggala Regency, and examine the relationship between digestive tract size and microplastic abundance.* ***Method:*** *A quantitative descriptive approach was employed using 30 specimens of each fish species collected from local fishermen. Digestive tract samples were digested using 10% KOH, incubated at 75°C, filtered, and observed under a binocular microscope. Microplastic abundance was expressed as particles per gram of digestive tract weight. Simple linear regression analysis using SPSS 25 was performed to evaluate the relationship between digestive tract size and microplastic abundance.* ***Results:*** *Three microplastic types were identified: film, fragment, and fiber, with film being dominant in both species. Total microplastic abundance reached 3.940 particles/g in mackerel tuna and 3.071 particles/g in skipjack tuna. Regression analysis showed a weak positive relationship between digestive tract size and microplastic abundance ($R^2$ = 0.137 and 0.140), suggesting that other environmental and biological factors play a greater role.* ***Novelty:*** *Providing the first baseline data on microplastic contamination in mackerel tuna and skipjack tuna from Boneoge waters, Central Sulawesi, and contributes to SDG 14 (Life Below Water) by strengthening evidence-based efforts to address marine microplastic pollution.*

## INTRODUCTION

Fish is a highly favored food due to its nutritional value, relatively low cost, and ease of availability. However, fish are not immune to the negative impacts of pollution in aquatic areas. The presence of microplastic contamination found in fish has prompted researchers in various countries to conduct studies to monitor the spread of microplastic pollution (Alwi, 2015). Examples of research on fish contaminated with microplastics include swanggi fish (Priacanthus tayenus) in the Brondong Lamongan Coastal Waters (Andrady, 2011), mackerel (Rastrelliger sp.), and scad (Selaroides eptolepis) in the Tambak Fish Market.

Mackerel tuna (Euthynnus affinis) and skipjack tuna (Katsuwonus pelamis) are commonly found in shallow tropical and subtropical waters (Barboza et al., 2018). Both species are highly favored due to their affordable prices, delicious taste, and abundant catches. Additionally, their bellies are frequently eaten by locals for their palatability. Mackerel tuna and skipjack tuna are carnivorous fish that primarily feed on Crustaceans, Cephalopods, and Mollusks (Barboza et al., 2018). These fish prefer to forage at night near the water's surface, with peak feeding activity in the early morning hours.

Both mackerel tuna and skipjack tuna have high economic value for export and domestic consumption due to their abundance and low cost (Dueri et al., 2016; Squires et al., 2023; Velmurugan et al., 2026). One of the landing areas for mackerel tuna and skipjack tuna is Boneoge in Donggala Regency, Central Sulawesi (Hasanuddin, 2024). This area, in addition to being a fishing ground, is a tourist destination along the Donggala coast, where significant local activities have increased the volume of plastic waste generated by vendors and visitors.

Plastics degrade under UV radiation from the sun, triggering reactions that break them down into smaller particles (Boerger et al., 2010). Today, plastic is one of the most widely used materials in daily life and commercial activities (de Sousa, 2023; Dey et al., 2024; Gautam et al., 2024; Mohamadi, 2023). Eventually, this plastic waste is discarded into aquatic environments. Floating plastic particles accumulate in pelagic habitats, forming large patches of trash. Meanwhile, plastic debris that sinks degrades in the water column and sediment, becoming microplastics (Dai et al., 2018). Sources of microplastics in aquatic environments are categorized into primary and secondary types (Adetuyi et al., 2024; Babaei et al., 2024; Inobeme et al., 2024). Primary microplastics come from products containing plastic particles and from textile degradation during laundry. Secondary microplastics form from the degradation of plastic materials.

The increasing prevalence of microplastic contamination in marine environments also underscores the urgency of achieving Sustainable Development Goal (SDG) 14: Life Below Water. Microplastic pollution threatens marine biodiversity, disrupts food webs, and may compromise the sustainability of fisheries resources that support coastal livelihoods and food security. Therefore, generating scientific evidence on the occurrence of microplastics in commercially important fish species is essential to support marine pollution monitoring, promote sustainable fisheries management, and strengthen efforts to conserve and sustainably use marine resources in line with SDG 14 targets.

Research on microplastics in the digestive tracts of mackerel tuna and skipjack tuna at this study site remains very limited. This study aims to identify the characteristics of microplastics accumulated in the digestive tracts of mackerel tuna and skipjack tuna, and to analyze the relationship between the size of these fish and the abundance of microplastics. The findings are expected to provide preliminary information on the presence of microplastics in these commonly consumed fish.

## RESEARCH METHOD

The research was conducted in August 2022 at a single sampling point at a fish collection center in Boneoge Village, Banawa District, Donggala Regency. The location was selected based on its status as a fishing area and the lack of prior research on microplastic contamination. This area is also a tourist destination with frequent visits, leading to significant plastic waste accumulation and contamination from nearby households and rivers. The tools and materials used in this research include sample pots, gloves, rulers, trays, binocular microscopes, scissors, aluminum foil, scales, dissection tools, Whatman 4 filter paper, an incubator, an oven, Petri dishes, 10% potassium hydroxide (KOH), distilled water, alcohol, mackerel tuna, and skipjack tuna.

A total of 30 specimens each of mackerel tuna and skipjack tuna were collected from different fishing vessels, but all within the same fishing ground near the coast of Boneoge. The sample size of 30 from each fishing vessel was deemed sufficient to capture size variation. For large populations, a sample size of 30 is generally adequate to obtain accurate results (Dalimunthe et al., 2021). All collected fish samples were placed in styrofoam containers with ice to maintain their freshness before being tested in the laboratory. The method for observing fish samples follows the procedures outlined by Diningrum et al. (2019) and Wotton (2020). Before dissection, the fish samples were measured for length (cm) and weight (g). Dissection was performed to extract the digestive tract. The digestive tract was then weighed on a digital scale and recorded as its wet weight (g). The next step involved placing the digestive tract in a 500 ml beaker and covering it with 10% KOH solution until fully submerged. It was then covered with aluminum foil and incubated at 75°C for 70 hours. After incubation, the samples were cleaned using distilled water and filtered. The filtered residues were placed into new aluminum foil and heated in an oven at 65°C for 24 hours to facilitate identification using a binocular microscope.

The analysis includes identifying microplastic types contaminating the digestive tracts of mackerel tuna and skipjack tuna, as well as calculating microplastic abundance to assess their presence in each sample. Microplastic abundance is calculated based on the number of microplastic particles found per weight of the fish's digestive tract. Statistical analysis in this study employed a simple linear correlation analysis in SPSS 25 to examine the relationship between fish size and microplastic abundance. Simple linear regression analysis explores the linear relationship between one independent variable (X) and one dependent variable (Y). This analysis helps determine the direction of the relationship between the independent and dependent variables when the dependent variable increases or decreases.

## RESULTS AND DISCUSSION

### *Results*

The analysis results show that both types of tuna, mackerel tuna (Euthynnus affinis) and skipjack tuna (Katsuwonus pelamis), used in the study, contain microplastic types such as film, fiber, and fragments in their digestive tracts in Figure 1.

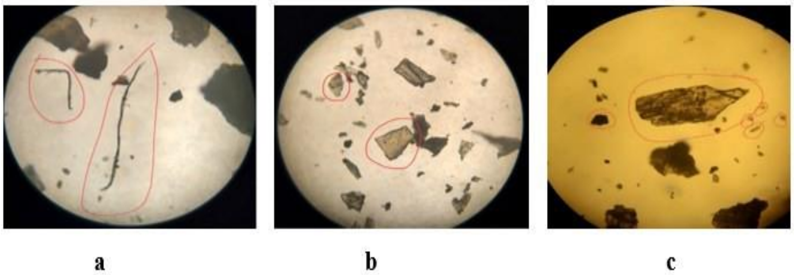


**Figure 1.** Types of microplastics found: (a) Fiber, (b) Fragment, and (c) Film

In mackerel tuna (Euthynnus affinis), the average number of microplastic particles was 18.07/ind for fiber, 59.9/ind for fragments, and 77.7/ind for film. In skipjack tuna (Katsuwonus pelamis), the average number of microplastic particles was 25.7/ind for fiber, 50.27/ind for fragments, and 97.97/ind for film in Figure 2. Film particles are the dominant microplastic type in both fish species. Film is a type of microplastic that is irregularly shaped and colored (Hidalgo-Ruz et al., 2012; Rifandi & Ratnasari, 2023), originating from very thin, transparent plastic fragments that are less dense than other microplastic types, thereby facilitating their dispersal. Fragments are irregularly shaped microplastics originating from broken plastic (Rambacher et al., 2023). These fragments are difficult to crush with tweezers and generally have irregular shapes with sharp edges. Conversely, (Jiang et al., 2025) identified that the most common microplastic types found in the digestive tracts of mackerel tuna (Euthynnus affinis) caught at the Island Baai Fishing Port, Bengkulu City, were fiber, filament, and fragments, with average concentrations of 21.53 and 21.43 particles per individual, respectively. Granules, recorded at 2.08 particles per individual, were the least found and were not detected in this study. The high presence of fiber particles is attributed to the use of fishing lines or nets. According to Rifandi and Ratnasari (2023), fiber-shaped microplastics originate from the fragmentation of fishing nets and monofilament lines. Labibah & Triajie (2020) reported that fragments account for the largest proportion of microplastics, at 94%. These fragments result from the breakdown of macro waste due to mechanisms such as UV radiation, wave action, oxidative degradation of plastics, and the hydrolytic effects of seawater (Andrady, 2011).

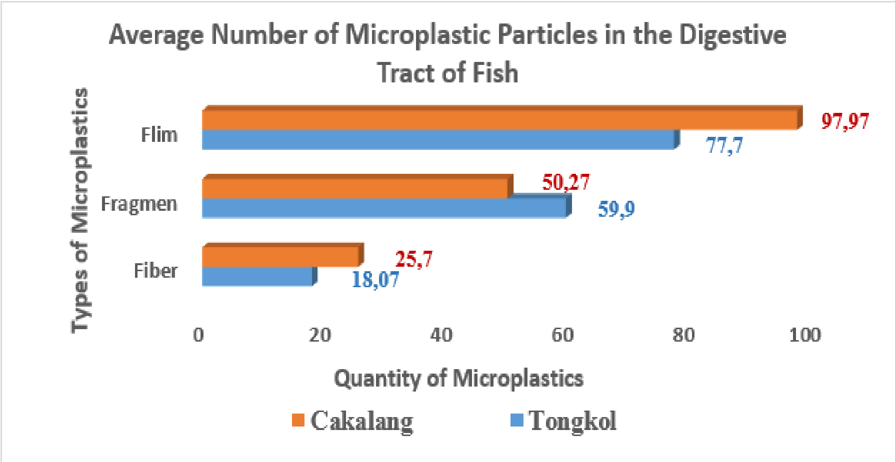


**Figure 2.** Types and average quantity of microplastic particles in the digestive tracts of mackerel tuna (Euthynnus affinis) and skipjack tuna (Katsuwonus pelamis)

The calculated abundance of microplastics per gram of digestive tract weight in mackerel tuna (Euthynnus affinis) is a total of 3.940 particles/gram, consisting of film = 1.937±1.111, fiber = 0.460±0.263, and fragments = 1.543±0.670, with film being the most abundant microplastic particle. In skipjack tuna (Katsuwonus pelamis), the total microplastic abundance is 3.071 particles/gram, comprising film = 1.716±0.872, fiber = 0.443±0.408, and fragments = 0.912±0.518, with film also being the most abundant particle in Table 1. In both types of fish, the highest abundance of microplastic particles is found in the film category, although the quantities differ. This variation may be due to differing levels of contamination in their feeding areas. Skipjack tuna and mackerel tuna also differ in their habitats and distributions, with skipjack tuna more commonly found in shallow tropical and subtropical waters, while mackerel tuna is typically found in waters closer to the shore.

**Table 1.** Calculation results of microplastic abundance in the digestive tracts of mackerel tuna (Euthynnus affinis) and skipjack tuna (Katsuwonus pelamis)

| Types of fish | Types of Microplastic | Microplastic Abundance (digestive tract/gr.) |
|---|---|---|
| Mackerel Tuna | Film | 1.937±1.111 |
| | Fiber | 0.460±0.263 |
| | Fragment | 1.543±0.670 |
| Total | | **3.940** |
| Skipjack Tuna | Film | 1.716±0.872 |
| | Fiber | 0.443±0.408 |
| | Fragment | 0.912±0.518 |
| Total | | **3.071** |

The highest percentage of the three types of microplastics found was the film type in Figure 3, followed by fragments and fibers. The lower number of fragment and fiber particles can be attributed to their higher density compared to film and their origin from strong synthetic polymers, making them more likely to sink and reside in the sediment or deeper waters, where they are ingested by benthic organisms (Dai et al., 2018; Wotton, 2020).

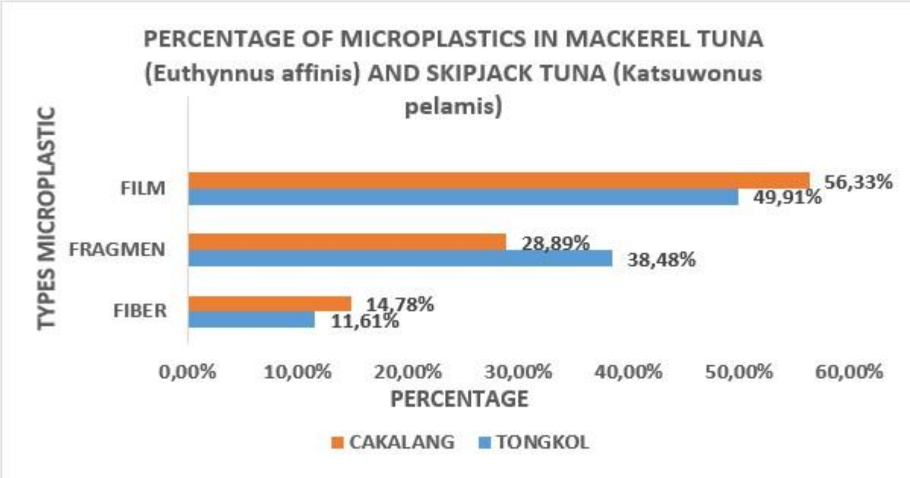


**Figure 3.** Percentage composition of microplastics per digestive tract in mackerel tuna (Euthynnus affinis) and skipjack tuna (Katsuwonus pelamis)

***Discussion***

Based on the results of simple linear regression analysis with a confidence level of 95% or a significance level of 5% ($\alpha = 0.05$), the t-test result for mackerel tuna was $0.044 < 0.05$, and similarly, for skipjack tuna, the significance value of the t-test was $0.042 < 0.05$. This indicates that as the weight of the digestive tract in skipjack tuna increases, the number of microplastic particles also increases, although the significance is very small. To assess the degree of association or the extent to which the independent variable influences the dependent variable in this case, the weight of the digestive tract of mackerel tuna and skipjack tuna concerning the content of microplastic particles the R-squared value is used. This value indicates the proportion of the dependent variable's variability explained by the independent variable. For mackerel tuna, the R-squared value is 0.137, indicating that 13.7% of the variability in microplastic particle content can be explained by digestive tract weight. Conversely, 86.3% of the variability cannot be explained by this variable or may be due to other factors. Similarly, for skipjack tuna, the R-squared value is 0.140, indicating comparable explanatory power. This means that 14.0% of the variability in microplastic particles is explained by the weight of the digestive organs in skipjack tuna. In comparison, 86.0% is not explained by the independent variable and may be attributable to factors outside it.

This is consistent with previous research, which also found a positive but weak correlation between total fish length and microplastic abundance (Ory et al., 2017). However, some studies have found an inverse correlation between fish size and microplastic abundance (Prameswari et al., 2022). Additionally, other studies have found no relationship between fish size and microplastic content in fish (Ory et al., 2017; Sarasita et al., 2020). Intensive human activities have led to various environmental impacts, including widespread microplastic pollution in terrestrial and aquatic areas. Microplastics are now found in various products, ranging from cosmetics (Ghosh et al., 2023) to sediments at the bottom of the Pacific Ocean (Zhang et al., 2020). These particles, which are ≤ 5 µm in size and insoluble in water

(Sarasita et al., 2020) are not only found in the environment but also accumulate in the bodies of organisms such as fish. Fish often ingest microplastics because these particles resemble their natural prey. For instance, scads fish have been found to consume microplastics, mistaking them for copepods, which are part of their diet (Ory et al., 2017).

Additionally, microplastics in sediments can be ingested by benthic fish that forage on the seafloor (Wan et al., 2019). Fish are an important food source for humans due to their delicious taste and high nutritional value. The presence of microplastics in fish consumed by humans can pose significant health risks. When microplastics enter the human body, these particles can be toxic and cause physical damage to cells. If absorbed through cell membranes, these particles can disrupt cellular metabolic processes (Rifandi & Ratnasari, 2023).

From an SDG perspective, these findings contribute to SDG 14 (Life Below Water) by providing evidence of microplastic contamination in commercially important fish species from Boneoge waters. The predominance of film-type microplastics and their occurrence in fish frequently consumed by local communities highlight the need for strengthened marine pollution monitoring and improved plastic waste management. Furthermore, the results underscore the importance of protecting marine ecosystems and promoting sustainable fisheries practices to reduce the long-term impacts of microplastic pollution on aquatic biodiversity and ecosystem health.

## CONCLUSION

**Fundamental Finding:** This study found that all samples of Tongkol (Euthynnus affinis) and Cakalang (Katsuwonus pelamis) contained microplastics in their digestive tracts. The detected microplastics were classified into films, fragments, and fibers, with films being the most dominant type. Simple linear regression also showed a weak correlation between digestive tract weight and microplastic abundance. **Implication:** These findings indicate that microplastic contamination in fish is influenced not only by digestive tract size but also by habitat, feeding behavior, diet, and the level of microplastic pollution in the waters. Therefore, microplastic pollution in aquatic environments requires serious attention because it may affect marine organisms and potentially human health. These findings contribute to SDG 14 (Life Below Water) by highlighting the importance of monitoring marine pollution, effective plastic waste management, and sustainable fisheries practices to protect marine ecosystems from the long-term impacts of microplastic contamination. **Limitation:** This study was limited to microplastic identification and abundance analysis in the digestive tracts of Tongkol and Cakalang fish from the research area. Other factors, such as seasonal variation, water quality, and polymer composition of microplastics, were not analyzed in detail. **Future Research:** Future studies are recommended to involve broader sampling locations, larger sample sizes, seasonal comparisons, and polymer identification to obtain a more comprehensive understanding of microplastic contamination in marine fish.

## AUTHOR CONTRIBUTIONS

**Masriani** contributed to the conceptualization, field data collection, laboratory analysis, data curation, and drafting of the manuscript. **Abd. Hakim Laenggeng** was involved in methodology development, supervision, validation, and manuscript review. **Fatmah Dhafir** contributed to the research design, formal analysis, supervision, and critical revision of the manuscript. **Aan Febriawan** assisted in sample preparation, laboratory work, data tabulation, reference management, and manuscript editing. All authors have reviewed and approved the final version of this submission.

## CONFLICT OF INTEREST STATEMENT

The authors state that no financial or personal conflicts of interest exist that may have affected the content or findings of this research.

**STATEMENT ON THE USE OF AI OR DIGITAL TOOLS IN WRITING**

The authors acknowledge the use of digital tools, including AI-based technologies, to support the writing and refinement of this article. Specifically, ChatGPT was used to assist with language improvement, sentence clarity, and academic writing refinement, while reference management tools were used to organize and format the cited sources. All outputs generated with digital assistance were critically reviewed, verified, and revised by the authors to ensure accuracy, academic rigor, and ethical standards. The final responsibility for the content, analysis, and conclusions of this manuscript rests entirely with the authors.

**REFERENCES**

Adetuyi, B. O., Mathew, J. T., Inobeme, A., Falana, Y. O., Adetunji, C. O., Shahnawaz, M., Oyewole, O. A., KIT, E., & Yerima, M. B. (2024). Sources, uses and transport of secondary microplastics from land to marine environment. In *Microplastic pollution* (pp. 35–49). Springer. https://doi.org/10.1007/978-981-99-8357-5_3

Alwi, I. (2015). Kriteria empirik dalam menentukan ukuran sampel pada pengujian hipotesis statistika dan analisis butir. *Formatif: Jurnal Ilmiah Pendidikan MIPA*, *2*(2). https://doi.org/10.30998/formatif.v2i2.95

Andrady, A. L. (2011). Microplastics in the marine environment. *Marine Pollution Bulletin*, *62*(8), 1596-1605. https://doi.org/10.1016/j.marpolbul.2011.05.030

Babaei, A. A., Reshadatian, N., & Feizi, R. (2024). A state of the art-mini review on the sources, contamination, analysis, and consequences of microplastics in water. *Results in Engineering*, *23*, 102827. https://doi.org/10.1016/j.rineng.2024.102827

Barboza, L. G. A., Vethaak, A. D., Lavorante, B. R. B. O., Lundebye, A.-K., & Guilhermino, L. (2018). Marine microplastic debris: An emerging issue for food security, food safety and human health. *Marine Pollution Bulletin*, 133, 336-348. https://doi.org/10.1016/j.marpolbul.2018.05.047

Boerger, C. M., Lattin, G. L., Moore, S. L., & Moore, C. J. (2010). Plastic ingestion by planktivorous fishes in the North Pacific Central Gyre. *Marine Pollution Bulletin*, *60*(12), 2275-2278. https://doi.org/10.1016/j.marpolbul.2010.08.007

Dai, Z., Zhang, H., Zhou, Q., Tian, Y., Chen, T., Tu, C., Fu, C., & Luo, Y. (2018). Occurrence of microplastics in the water column and sediment in an inland sea affected by intensive anthropogenic activities. *Environmental Pollution*, *242*, 1557-1565. https://doi.org/10.1016/j.envpol.2018.07.131

Dalimunthe, A. M., Amin, B., & Nasution, S. (2021). Microplastic in the digestive tract of kurau (Polydactylus octonemus) in the coastal waters of Karimun Besar Island, Riau Islands Province. *Journal of Coastal and Ocean Sciences*, *2*(2), 80-86. https://doi.org/10.31258/jocos.2.2.80-86

de Sousa, F. D. B. (2023). Consumer awareness of plastic: An overview of different research areas. *Circular Economy and Sustainability*, *3*(4), 2083–2107. https://doi.org/10.1007/s43615-023-00263-4

Dey, S., Veerendra, G. T. N., Babu, P. S. S. A., Manoj, A. V. P., & Nagarjuna, K. (2024). Degradation of plastics waste and its effects on biological ecosystems: A scientific analysis and comprehensive review. *Biomedical Materials & Devices*, *2*(1), 70–112. https://doi.org/10.1007/s44174-023-00085-w

Diningrum, T. D. B., Triyono, H., & Jabbar, M. A. (2019). Aspek Biologi Cakalang (Katsuwonus pelamis, Linnaeus 1758) di Sulawesi Tenggara. *Jurnal Penyuluhan Perikanan dan Kelautan*, *13*(2), 139-147. https://doi.org/10.33378/jppik.v13i2.195

Dueri, S., Guillotreau, P., Jiménez-Toribio, R., Oliveros-Ramos, R., Bopp, L., & Maury, O. (2016). Food security or economic profitability? Projecting the effects of climate and socioeconomic changes on global skipjack tuna fisheries under three management strategies. *Global Environmental Change*, *41*, 1–12. https://doi.org/10.1016/j.gloenvcha.2016.08.003

Gautam, B. P. S., Qureshi, A., Gwasikoti, A., Kumar, V., & Gondwal, M. (2024). Global scenario of plastic production, consumption, and waste generation and their impacts on environment and human health. In *Advanced strategies for biodegradation of plastic polymers* (pp. 1–34). Springer. https://doi.org/10.1007/978-3-031-55661-6_1

Ghosh, S., Sinha, J. K., Ghosh, S., Vashisth, K., Han, S., & Bhaskar, R. (2023). Microplastics as an emerging threat to the global environment and human health. *Sustainability*, *15*(14), 10821. https://doi.org/10.3390/su151410821

Hasanuddin, A. (2024). Optimizing Tuna Fish Quality through a Science-Based Sustainable Partnership Approach and Ecological Management in Boneoge Village, Central Sulawesi. *Jurnal Penelitian Pendidikan IPA*, *10*(10), 7677–7687. https://doi.org/10.29303/jppipa.v10i10.9364

Hidalgo-Ruz, V., Gutow, L., Thompson, R. C., & Thiel, M. (2012). Microplastics in the marine environment: a review of the methods used for identification and quantification. *Environmental Science & Technology*, *46*(6), 3060-3075. https://doi.org/10.1021/es2031505

Inobeme, A., Shahnawaz, M., Adetunji, C. O., Mathew, J. T., Adetuyi, B. O., Popoola, O. A., Olaitan, F. Y., Akinbo, O., Kolawole, O. M., & Oyewole, O. A. (2024). Primary microplastic: source, uses, transportation from land to marine environment. In *Microplastic pollution* (pp. 23–33). Springer. https://doi.org/10.1007/978-981-99-8357-5_2

Jiang, S., Jiao, S., Shen, L., Wang, Y., & Wan, Y. (2025). Fragmentation dynamics of granular materials: the role of particle shape and moisture content. *Acta Geotechnica, 20*(11), 5663-5681. https://doi.org/10.1007/s11440-025-02687-8

Labibah, W., & Triajie, H. (2020). Keberadaan mikroplastik pada ikan swanggi (priacanthus tayenus), sedimen dan air laut di PERAIRAN Pesisir Brondong, Kabupaten Lamongan. *Juvenil: Jurnal Ilmiah Kelautan dan Perikanan,* *1*(3), 351-358. https://doi.org/10.21107/juvenil.v1i3.8563

Mohamadi, M. (2023). Plastic types and applications. *Plastic Waste Treatment and Management: Gasification Processes*, 1–19. https://doi.org/10.1007/978-3-031-31160-4_1

Ory, N. C., Sobral, P., Ferreira, J. L., & Thiel, M. (2017). Amberstripe scad Decapterus muroadsi (Carangidae) fish ingest blue microplastics resembling their copepod prey along the coast of Rapa Nui (Easter Island) in the South Pacific subtropical gyre. *Science of the Total Environment, 586*, 430-437. https://doi.org/10.1016/j.scitotenv.2017.01.175

Prameswari, A. P., Muhammad, F., & Hidayat, J. W. (2022). Kandungan mikroplastik pada ikan belanak (Mugil cephalus) dan kerang hijau (Perna viridis) di Pantai Mangunharjo Semarang dan Pantai Sayung Demak. *Bioma: Berkala Ilmiah Biologi, 24*(1), 36-42. https://doi.org/10.14710/bioma.24.1.36-42

Rambacher, J., Pantos, O., Hardwick, S., Cameron, E. Z., & Gaw, S. (2023). Transforming encounters: A review of the drivers and mechanisms of macrofaunal plastic fragmentation in the environment. *Cambridge Prisms: Plastics, 1,* e6. https://doi.org/10.1017/plc.2023.6

Rifandi, R. A., & Ratnasari, A. V. (2023, July). Abundance of microplastics and hazard to the environment in estuary water in Pemalang, Central Java, Indonesia. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1211, No. 1, p. 012012). IOP Publishing. https://doi.org/10.1088/1755-1315/1211/1/012012

Sarasita, D., Yunanto, A., & Yona, D. (2020). Microplastics abundance in four different species of commercial fishes in Bali Strait. *Jurnal Iktiologi Indonesia*, *20*(1), 1-12. https://doi.org/10.32491/jii.v20i1.508

Squires, D., Jiménez-Toribio, R., Guillotreau, P., & Anastacio-Solis, J. (2023). The ex-vessel market for tropical tuna in Manta, Ecuador. A new key player on the global tuna market. *Fisheries Research*, *262*, 106646. https://doi.org/10.1016/j.fishres.2023.106646

Velmurugan, B., Samima, N., Banu, A. A., Safrin, J. H., & Balan, A. (2026). *From Catch to Consumer: Oceanic Wealth and Economic Insights of Fisheries at the State, National and Global Perspective*. Deep Science Publishing.

Wan, Z., Wang, C., Zhou, J., Shen, M., Wang, X., Fu, Z., & Jin, Y. (2019). Effects of polystyrene microplastics on the composition of the microbiome and metabolism in larval zebrafish. *Chemosphere, 217*, 646-658. https://doi.org/10.1016/j.chemosphere.2018.11.070

Wotton, R. S. (2020). Methods for capturing particles in benthic animals. In *The Biology of Particles in Aquatic Systems, Second Edition* (pp. 183-204). CRC Press. https://doi.org/10.1201/9781003070146-8

Zhang, D., Liu, X., Huang, W., Li, J., Wang, C., Zhang, D., & Zhang, C. (2020). Microplastic pollution in deep-sea sediments and organisms of the Western Pacific Ocean. *Environmental Pollution*, *259*, 113948. https://doi.org/10.1016/j.envpol.2020.113948

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