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Ingestion of microplastics by bigeye scad, *Selar crumenophthalmus* in Municipal Waters of Malimono, Surigao del Norte, Philippines

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Abstract

This study evaluated the presence of microplastic ingestion by bigeye scad, *Selar crumenophthalmus* from the Municipal Waters of Malimono, Surigao del Norte, Philippines. The microplastics were found in seven (7) fish individuals (11.67%) from a total of 60 fish samples examined, with an average of 0.12 ± 0.04 (mean ± SD) items per fish. Fibers (42.86%) made up the majority of the ingested plastic, followed by beads and fragments (28.57%). Only one piece of plastic was found in each of the stomachs of the seven fish samples that had consumed microplastic. The amount of microplastic that fish consumed in this study is relatively low compared to other findings from various locations. The statistical analysis proved that there is no significant difference (p>0.05) in the condition of all samples with or without microplastic ingestion in the stomach. The mean relative condition factor (Kn) both with and without microplastic ingestions is (K>1), which indicates that fish have good condition.

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Introduction

Microplastics are fragments of any type of plastic less than 5 mm (0.20 in) in length (Arthur *et al.,* 2009; Collignon *et al.,* 2014), produced from fragmenting bigger plastics through the biological, photolytic, mechanical, and physical breakdown (Li *et al.,* 2020). Further, the breakdown and fragmentation of plastic garbage in the ocean produce tiny plastic particles, or "microplastics" (Browne *et al*., 2011).

Microplastics are frequently identified in the digestive tracts of aquatic species all around the world (Roch *et al*., 2020). Many marine animals, including plankton, mammals, bivalve, filter feeders, and fish, mistakenly eat microplastics because of their small sizes (Lusher *et al.,* 2018; Baechler *et al.,* 2019; Rist *et al.,* 2020).

These microplastics directly endanger marine organisms and indirectly impact the ecosystem by adsorbing other marine contaminants (Subhankar and Shivika, 2019). Fish exposed to microplastics may suffer from tissue damage, oxidative stress, changes in immune-related gene expression, and a decline in antioxidant status. Moreover, neurotoxicity slowed growth, and abnormal behavior would occur in fish (Bhuyan, 2022). Humans may also suffer oxidative stress, cytotoxicity, neurotoxicity, immune system disruption, and the spread of microplastics to other organs after being exposed to them (Bhuyan, 2022). Fish intake can increase human exposure to microplastics because of the presence of these particles in fish (Barbosa *et al.,* 2018; Barbosa *et al.,* 2020).

Most Filipinos, particularly in Malimono, Surigao del Norte depend on fish as a main source of food and for their livelihood. Bigeye scad, a schooling pelagic species that occurs in tropical inshore waters, is one of the species abundantly caught by fishermen in the area. There is no study focused on the ingestion of microplastics by bigeye scad. Some studies on the microplastic ingestion of fish are focused only on rabbitfish, *Siganus fuscescens* (Bucol *et al.,* 2020), commercial fish (Wu *et al.,* 2010), demersal fish (Gomez *et al.,* 2022), freshwater fishes (Rios *et al.,* 2022), small coastal fish (Sainio *et al.,* 2021) and others. Thus, this research was conducted to provide a piece of baseline information on the types of microplastics ingested by bigeye scad. This species feeds on small shrimp, benthic invertebrates, and forams while inshore and on zooplankton and fish larvae when offshore (Smith-Vaniz, 1995; Allen and Erdmann, 2012), making it a useful indicator of microplastic pollution in the study area.

Materials and methods

Sampling procedure

Samples were collected from the fishermen engaged in catching bigeye scad in the municipal waters of Malimono, Surigao del Norte, Philippines. Malimono is situated on the southwestern coast of Surigao del Norte with a 30 km coastline facing the Bohol Sea (Fig**.** 1). The municipality is 32 km away from Surigao City and is composed of 12 coastal and 2 upland barangays.

A total of 60 samples were collected from January to February 2023. The collected samples were placed in the ice box with sufficient ice and transported to the Surigao del Norte State University (SNSU) - Malimono Campus laboratory for analysis.

The total length (cm) was measured using an ordinary ruler and the weight (g) was determined using Digital Weighing Scale (0.01× 500 g) calibration before the fish was dissected.

Laboratory analysis

The 60 fish specimens were dissected to remove the microplastics in the digestive tract following the established protocol recommended by the Civic Laboratory for Environmental Research (CLEAR) (Liboiron, 2017) with some modifications as followed by Gomez *et al.* (2020). The digestive tract was cut from the esophagus to the anus allowing the contents to fall gently into the dissecting pan. Using scissors, the stomach intestine was cut while collecting any spilled contents in a coffee filter. To separate and eliminate any gastrointestinal debris, the content was slowly and carefully poured with water.

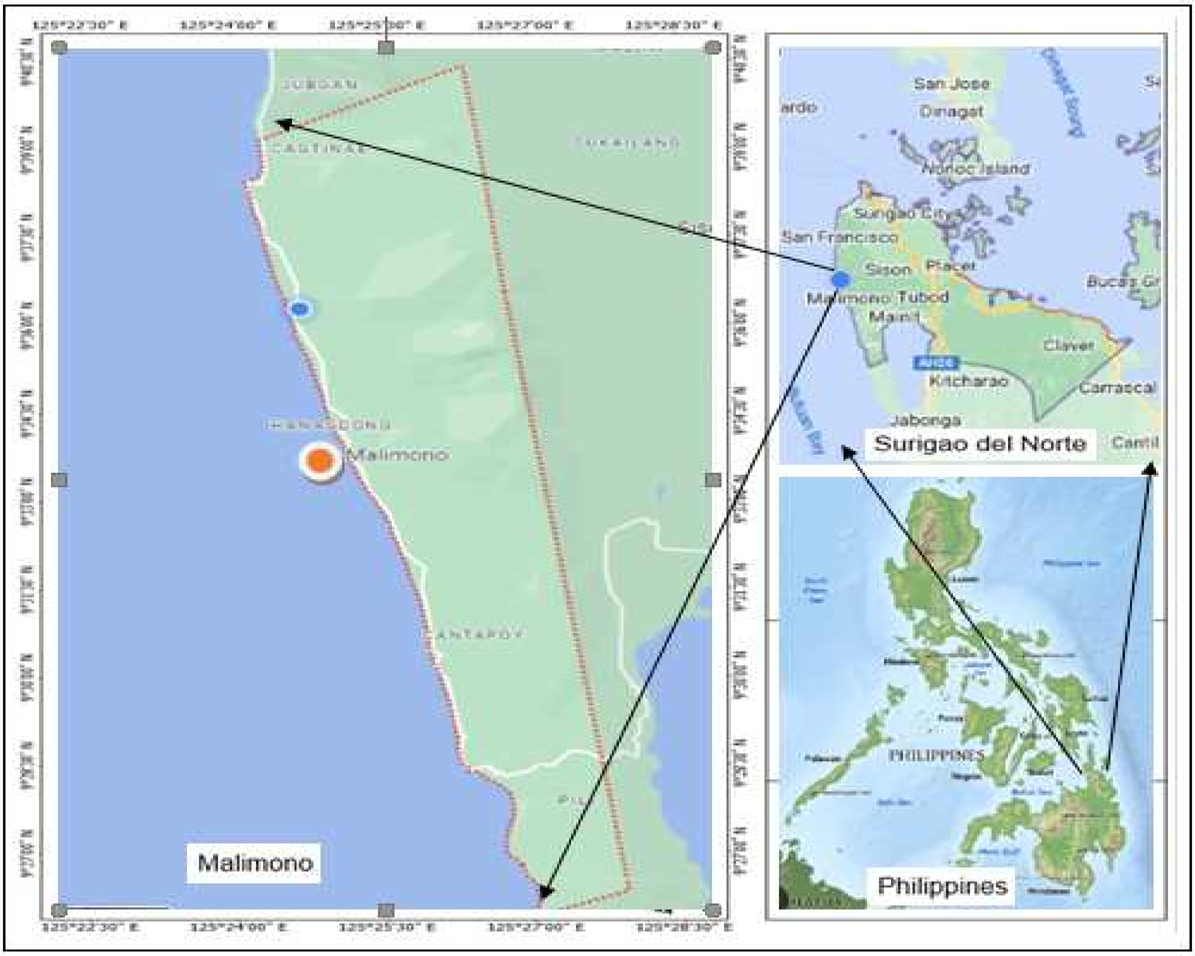

Fig. 1. Location of sampling site in Malimono, Surigao del Norte, Philippines.

The organic digestion protocol adapted from Enders *et al.* (2016) and Strand and Tairova (2016) was used in this study. For digestion, a solution of 50 ml sodium hypochlorite (6-14 % reactive chlorine) is poured into the stomach content and soaked for 12 to 24 hours to dissolve the natural food of the fish.

The coffee filter was placed in the strainer with the residual debris and water to wash away the sodium hypochlorite. The microplastics in the filter paper were imaged under a Digital Lab LED Microscope equipped with a digital camera. All of the suspected microplastics on filter papers were recorded under microscopic observation and visually identified using the Spotters Guide of Civic Laboratory for Environmental Research (CLEAR).

Data and statistical analyses

The formula of Hyslop (1980) was used to compute the Percentage Frequency of Occurrence (FOC) of microplastic ingestion of bigeye scad: % FOC = (Ni / N) × 100; Where: FOC = Percentage occurrence of the particular microplastics; Ni = Total number of stomachs with particular microplastics; N = Total number of stomachs with microplastics.

The condition factor was determined using the formula of (Pauly, 1983) to show the degree of the well-being of the fish in their habitat: Condition Factor (K) = $100W/L^3$; where *W* is the weight (g) and *L* is the total length (cm).

The relative condition factor (K_n) was calculated to assess the condition of each fish individual using the equation of (Le Cren, 1951). $Kn = W / aL^b$; where (Kn) is defined as Wo / Wc, where Wo is the observed weight, and Wc is the calculated weight from the length-weight relationship. The data were tested for homogeneity of variances using Levene's and Kolmogorov–Smirnov's tests to confirm normal distribution. The Mann-Whitney U Test was used to compare the differences in the condition of all samples with or without microplastic ingestion in the stomach. Minitab 17 and Microsoft Excel 2016 were used in the processing and analyzing the data.

Results and discussion

This study offers a preliminary evaluation of microplastics found in bigeye scad in municipal waters of Malimono, Surigao del Norte, Philippines. A total of 60 samples were investigated in the study area with a total length of between 15.90 and 21.30 cm and the weight ranged from 46.0 to 129.0 g. The result showed that only 7 (11.67%) of the 60 fish that were studied had microplastics in their digestive systems. The three (3) fish samples had ingested fibers (42.86%), 2 samples had microbeads (28.57%), and 2 fish samples ingested plastic fragments (28.57%) (Fig. 2). Microplastics ingested by all the sampled fish resulted in an average of 0.12 ± 0.04 (mean ± SD) items per fish individuals. The seven fish samples that had ingested microplastic contained only one piece of plastic in each of their stomachs, giving a mean of 1.00 ± 0.00 (mean ± SD) items per individual. The maximum length of microbeads and plastic fragments found is less than 5 mm, while the fiber had a maximum length of more than 5 mm (Fig. 3).

The result of this study is lower compared to some studies on microplastic ingestion by the samples of pelagic and mesopelagic species (Table 1). Nadal *et al.* (2016) reported that 57.86% of 337 semi-pelagic fish, *B. boops* samples in the Balearic Islands, ingested microplastics, with an average of 3.75 MPs/individual.

Table 1. Percentage of microplastic ingestion by pelagic and mesopelagic species reported by the different authors.

Study Area	Type of Fish/ Species	No. of Sample	% Ingestion	Average MPs/fish	Predominant Type (%)	Reference
North Pacific Subtropical Gyre	Mesopelagic fish	141	9.2%	0.09	57% fragments, 36% fibers	Davison and Ash (2011)
NW Iberian Shelf	Pelagic and benthic	64	78%	1.92	88% fibers	Filgueiras *et al.* (2020)
South Africa	Small pelagic fish	593	68%	1.36	80% fibers	Bakir *et al.* (2020)
Balearic Islands (Western Mediterranean)	Pelagic fish, *Seriola dumerili*	52	98%	12.2	81.8% fibers	Solomando *et al.* (2022)
Northwest Atlantic	Mesopelagic fish	280	73%	1.8	99%, fibers	Wieczorek *et al.* (2018)
Canary Island, North Atlantic	Middle-size pelagic species, *Scomber colias*	120	78%	2.77	74%, fibers	Herrera *et al.* (2019)
East China Sea, China	Commercial fish species	125	37.6%	0.43	90.74% fibers	Wu *et al.* (2020)
Balearic Islands	Semi-pelagic fish (*Boops boops*)	337	57.86%	3.75	100% fibers	Nadal *et al.* (2016)
Malimono, Surigao del Norte, Philippines	Small coastal pelagic fish	60	11.67%	0.12	42.86% fibers	This study

The study by Herrera *et al.* (2019) reported that 78% of 120 *Scomber collas* (middle-size pelagic species) sampled in the Canary Island, North Atlantic had microplastic ingestion in an average of 2.77MP/individual. Wieczorek *et al.* (2018) also stated that 73% of 280 mesopelagic fish in the Northwest Atlantic consumed microplastics (1.8 MP/individual). 98% of 52 *Seriola dumerili,* from the Balearic Islands ingested microplastic (Solomando *et al.,* 2022). 68% of 593 small pelagic fish in South Africa with 1.36 MP/individual (Bakir *et al.*, 2020) and 78% of 64 pelagic and benthic fish from the NW Iberian Shelf had microplastic ingestion. The study area's geographic location may be a contributing factor to the very low percentage of microplastic ingestions compared to fish in other study sites. The present study area is away from the city with no industrial factories, commercial vessels, and less population density and anthropogenic pressures. Nadal *et al.* (2016) claimed that plastic could be released both from terrestrial (urbanized areas, wastewater, and sewage treatment plants) and maritime sources (commercial and recreational vessels and fishing ships).

Table 2. Mean ± SD of total length (cm), body weight (g), and relative condition factor (Kn) of bigeye scad samples with and without microplastic ingestion.

Type of Fish Samples	n	Total Length	Body Weight	Kn
Fish without MP	53	19.04 ± 1.51	91.47 ± 23.50	1.01 ± 0.08
Fish with MP	7	19.37 ± 1.70	100.3 ± 27.40	1.04 ± 0.06

This kind of contamination is widely dispersed and comes from various sources (Nadal *et al.,* 2016). Based on the idea that microplastics result from the reckless human discharge of plastic garbage into aquatic habitats, Free *et al.* (2014) and Wagner *et al.* (2014) claim that proximity to urban areas has been one of the biggest contributors to microplastic pollution. Plastics can be accidentally dumped into the water, or they can be released directly from shipping and recreational activities in coastal areas Li *et al.* (2020). The other major causes of the microplastic contamination found in beach sediments are recognized as domestic discharge, surface runoff, municipal dumping, and factory spillage (Zbyszewski *et al.*, 2014). Schmidt *et al.* (2017) stated that rivers are a major pathway for plastic transport into the sea, which contributes between 80% and 94% of the total plastic load. Fish eating habits, species type, age, and the geographic niche that a population or species inhabits can all have an impact on the risk of ingesting microplastic waste (Boerger *et al.*, 2010; Foekema *et al.*, 2013; Neves *et al.*, 2015).

The majority of the microplastics identified in this investigation were fibers (42.86%), which is similar to the vast majority of published studies (Table 1). Fibers are the most common microplastics present in marine fish intakes (Avio *et al.,* 2015; Botterell *et al.,* 2019). The majority of the fibers are extracted from sewage. It has been shown that washing garments causes wastewater discharges that release thousands of synthetic fibers into the ocean (Browne *et al.*, 2011; Napper and Thompson, 2016). Claessens (2011) reported that several marine activities, such as fisheries, can result in the production of microfibers. Fishing nets and ropes, as well as laundry and municipal waste, may be possible sources of fiber in the marine environment. Fibers are typically lightweight and can float in the water column for a greater period of time than beads and denser fragments. Different locations will contain different microplastic types depending on the original sources of plastics (Cole *et al.*, 2011; Wright *et al.*, 2013). Derraik (2002) claimed that because microplastic fibers can tangle and form agglomerates, obstructing organs and preventing them from being expelled from the organism along with feces, fish have a tendency to ingest and retain more MPs fibers than fragments.

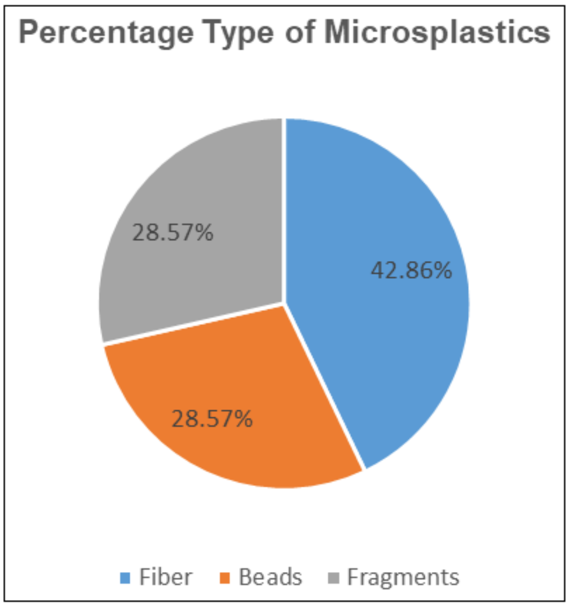

Fig. 2. Percentage of each microsplastic found in the seven (7) bigeye scad samples.

The relative condition factor of 53 fish samples without microplastic ingestions ranged from 0.87 to 1.19, with a mean of 1.01 ± 0.08. The 7 fish individuals with microplastics obtained the mean relative condition factor of 1.04 ± 0.06 ranging from 0.95 to 1.12 (Table 2).

The Mann-Whitney U test proved that there is no significant difference (p>0.05) in the condition of fish individuals with microplastics in their gastrointestinal tract and fish samples without microplastics.

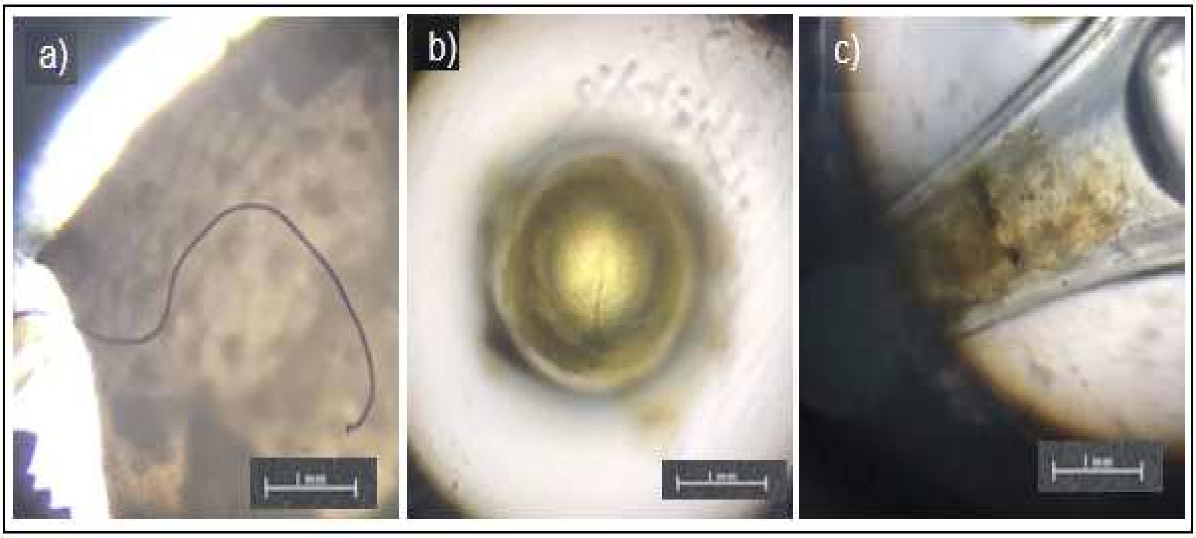

Fig. 3. Examples of types of microplastics found in the stomach of bigeye scad (a) fiber, (b) bead, and (c) plastic fragment.

This is attributed to the number of plastics ingested by the fish. It was noted that only one piece of plastic was found in each of the seven samples that had ingested microplastic. This indicates that with the little consumption of microplastic, the condition of fish could not be affected. If the condition factor (K) is greater than 1, the fish is in good condition (Le Cren, 1951), has a good level of feeding, and has proper environmental conditions (Ujjania *et al.*, 2012). K=1 is the baseline between the slender and robust condition of the organism (Hopkins, 1992; Araneda, 2008; Gautam, 2014).

Conclusion

The findings of this study indicated that microplastics, namely fibers, beads, and fragments, were present in the stomach of the bigeye scad in a minimal number with an overall occurrence of 11.67%. The ingestion of microplastic in small amounts could not affect the fish's health, and it is still considered to be in good condition.

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