Microplastics in water and their influence in the species *Chelon labrosus*

María F. Chacón Aranda, Ing., Gianella B. Fanarraga Tasayco, Ing., Carlos A. Castañeda Olivera, Dr., Elmer G. Benites Alfaro, Dr. and Eusterio H. Acosta Suasnabar, Dr.
Universidad César Vallejo, Campus Los Olivos, Lima, Peru
fernanda.aranda.1197@gmail.com, fanarragag@gmail.com, *caralcaso@gmail.com, ebenitesa@ucv.edu.pe, eacostas@ucv.edu.pe

Abstract*– The presence of microplastics in water negatively affects marine species, and sufficient measures must be taken to eradicate marine pollution. Ingestion of microplastic particles (MP) affects organisms, including organ damage, gastrointestinal obstruction and growth restriction. Thus, this research evaluated the presence of microplastics in the marine species Chelon labrosus (thicklip grey mullet) from the fisherma's wharf of Chorrillos in Lima, Peru. The study followed a protocol for sampling and analysis of microplastics in surface marine waters, where six samples (M1, M2, M3, M4, M5 and M6) of Chelon labrosus of different sizes (small, medium and large) were chosen and worked with their digestive tract. The visualization and identification of microplastics (MP) was performed by stereoscope images and infrared spectrometry analysis (FTIR), respectively. The results showed predominance of microplastics in the form of fibers in the samples analyzed. Finally, the study identified the presence of 04 types of microplastics in the species Chelon Labrosus, including cellophane, polyvinylpyrrolidone, poly (4-methycaprolactam) and poly (2, 2, 2-trifluoroethyl vinyl ether), and evidence that microplastic contamination is an emerging threat to that species, which will allow future studies to explain the factors that influence the occurrence of MP in the water and its influence on other marine species.
***Keywords*— microplastics, Chelon labrosus, color, shape.**

I. Introduction

Plastics are synthetic polymer compounds containing other chemical agents to increase their performance and efficiency [1]. These are used in the daily activities of the population and in the constant development of the basic infrastructure of a city [2], [3]. However, its uncontrolled production and unconscious use has generated pollution of water, soil and air, representing a global problem. As a clear example of its uncontrolled use, we have plastic packaging that accounts for about half of the world's plastic waste [4]. Plastic waste can be divided into 2 groups: macroplastics and microplastics. Microplastics have genesis of plastics with greater volume or area due to physical and chemical degradation such as the action of waves, changes in temperature, radiation, oxidation, etc. [5].

As a pollutant, plastic is the main component of waste on beaches [6], and much of it reaches the ocean where they interact with marine life [7]. This material has come to be found even in remote areas such as glaciers, islands and in the Andaman and Nicobar archipelagoes in India, as a result of tourist activity [8]. Plastic properties such as their shape and density of these wastes have also been proven to be predominant in the behavior of their transport by the environment [9], [10]. These plastic wastes are durable, and because of their micro size, they are very capable of mobilizing along the trophic chain from zooplankton and phytoplankton to the final consumer who is human. In the ingestion of microplastics, the chemicals present in them also enter and are redirected to the vascular system and other organs [11].

The exact number of plastics in the seas worldwide is still unknown, but based on theoretical estimates, the amount of waste would be around 5.25 trillion plastic fragments, representing approximately 268 940 tons, not including the residues found on the seabed [12]. On the other hand, there is its degradation, and this can be so precise, as to form particles and fibers that are almost undetectable to human view. This is worrying because it can mean the ingestion of microplastics by marine fauna causing blockages in the digestive tract, internal lacerations and effects on both internal and external locomotion of the organism [13].

For several decades, various scientific research has been carried out on microplastics and their effects on species transiting the sea, including fish, birds and marine mammals [14]–[20]. Thus, research on microplastics is a very complex topic because these have tiny length and various forms that significantly influence the survival of species in the long-term. That is, there is a latent risk that species affected by microplastics will perish before reaching their adult stage or on the other hand decreases their life expectancy.

In the fisherman's wharf of Chorrillos in Lima, there is a risk of contamination by microplastics, since it is located in an area surrounded by a lot of anthropic activity, which is responsible for the agglomeration of single-use plastic waste (both industrial and municipal plastic waste) that due to mishandling can end up in waterways, sea, and drainage systems. This generates concern in the local population because marine life species may suffer from suffocation, malnutrition, airway obstruction and chemical contamination, previously absorbed by microplastics, which would decrease the specimens and modify the food chain, as well as consequences on the final consumer. Thus, the present investigation evaluated the presence of microplastics in *Chelon*

Digital Object Identifier: http://dx.doi.org/10.18687/LACCEI2021.1.1.233
ISBN: 978-958-52071-8-9 **ISSN**: 2414-6390
DO NOT REMOVE

labrosus, known as thicklip grey mullet. This contribution allows both food engineers and environmental engineers to know the nutritional quality of the species that is consumed and will be consumed by future generations. It also allows to adopt sufficient measures to eradicate marine pollution, improving the aquatic ecosystem and consequently the life of the species.

II. Materials and Methods

A. Sample collection

The collection of samples of the species *Chelon labrosus* were taken in October 2019 at 50 m from the seashore of the fishermen's wharf of Chorrillos in Lima - Peru, and these were carried out with the support of artisanal fishermen of the same place. The UTM coordinates of the sampling point were 279123.17E, 8654556.078N (Figure 1).

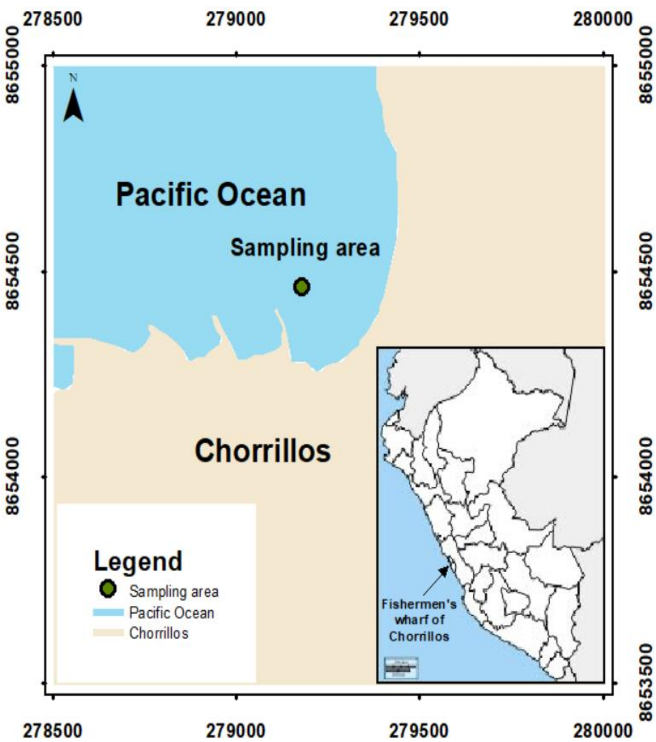

Figure 1 Location of *Chelon labrosus* sample collection area

All samples were refrigerated to preserve them and arrive in good condition at the microbiology laboratory of César Vallejo University to comply with the research process. The samples were divided into 3 different sizes (small, medium and large) in groups of two, registering their corresponding size and mass of each fish, as shown in Table 1.

Table 1: Size and mass of fish collected from the fishermen's wharf of Chorrillos in Lima – Peru

Size	Sample	Length (cm)	Body Mass (g)
Small	M1	32.3	372.51
	M2	35.0	419.29
Medium	M3	37.3	490.86
	M4	37.9	533.64
Large	M5	38.2	576.07
	M6	38.4	704.71

B. Digestive tract extraction procedure

The extraction of the digestive tract followed the methodology of INVEMAR [21]. To remove the digestive tract completely (esophagus, stomach and intestines), a cut was made from the anus to the chin of each fish, as shown in Figure 2. All material extracted from each fish was arranged in Petri dishes to be washed with a hypersaline solution (300 ml of distilled water 14 g of NaOH) for the degradation of organic matter. It then went into the filtration process using millipore membrane filters of 0.45 µm. Subsequently, the material retained in the membrane filters went through a drying process on an UF1060plus stove, and then each sample was stored in a glass desiccator until they were subjected to the microplastics identification and visualization equipment's.

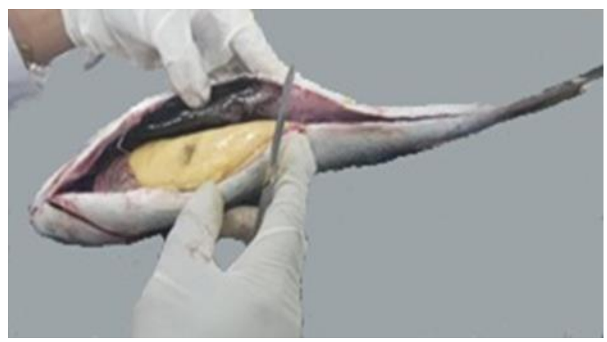

Figure 2 Extraction of the digestive tract from the fish

C. Inspection, quantification and identification microplastics

An Olympus SZ51 stereoscope was used for the display of the microplastics present in each sample. Each observed microplastic particle was recorded according to the number of samples treated (M1, M2, M3, M4, M5 and M6).

Already, for the identification of the microplastics present in each sample studied, Fourier Transform Infrared Spectroscopy (FTIR) analysis was performed using a FTIR Nicolet iS50 spectrophotometer. To do this, each sample was properly mixed with potassium bromide (KBr), and then the obtained pill was placed in the equipment for the realization of the spectrum. The spectra were obtained in a spectral range between 400 and 4000 cm^{-1} with 32 scans. To confirm the type of microplastic, the spectra were compared to Hummel's polymer and additive library as a reference.

III. Results and Discussion

A. Morphological characteristics of the species Chelon labrosus and visualization of microplastics

Most marine species vary greatly in their external and internal appearance, so this research worked with fundamental morphological characteristics such as size and mass of the species *Chelon labrosus*, as shown in Table 1. From this, it was observed that all the fish used in the study are different in both size and mass, which indicated that they had different ages and consequently different times of exposure to the environment where they were collected. Therefore, the presence of microplastics in each fish is different. This is backed by Hossain et al. [16] and Barboza et al. [22] who affirmed that larger microplastics are ingested by fish of greater body size. The literature review reports that small microplastics are more easily ingested and accumulated in organs [23], [24]. This research showed the presence of microplastics in the digestive tract of the species *Chelon labrosus*. Figure 3 shows the images of the microplastics found in the six samples of fish analyzed. The microplastics found are shaped like fibers (M1, M2-A, M2-B, M3, M4-A, M4-B, M5-B, M5-C and M6) and fragments (M5-A), the first being the most commonly found in the analyzed samples. These fibers were mainly long and thin, and had transparent, black and reddish color. Already, the microplastic fragment that was found had a three-dimensional shape and transparent color.

Several studies revealed that color, shape, size and odor could contribute to the active ingestion of microplastics by fishes [16], [22], [25], [26]. Microplastics during their long stay in the marine environment can acquire odors similar to those of prey, causing predatory behavior [27], [28]. In addition, laboratory studies suggest that particles of a size <1230 µm may cause fish feeding behavior more by chemical stimulation than by visual stimulation [29].

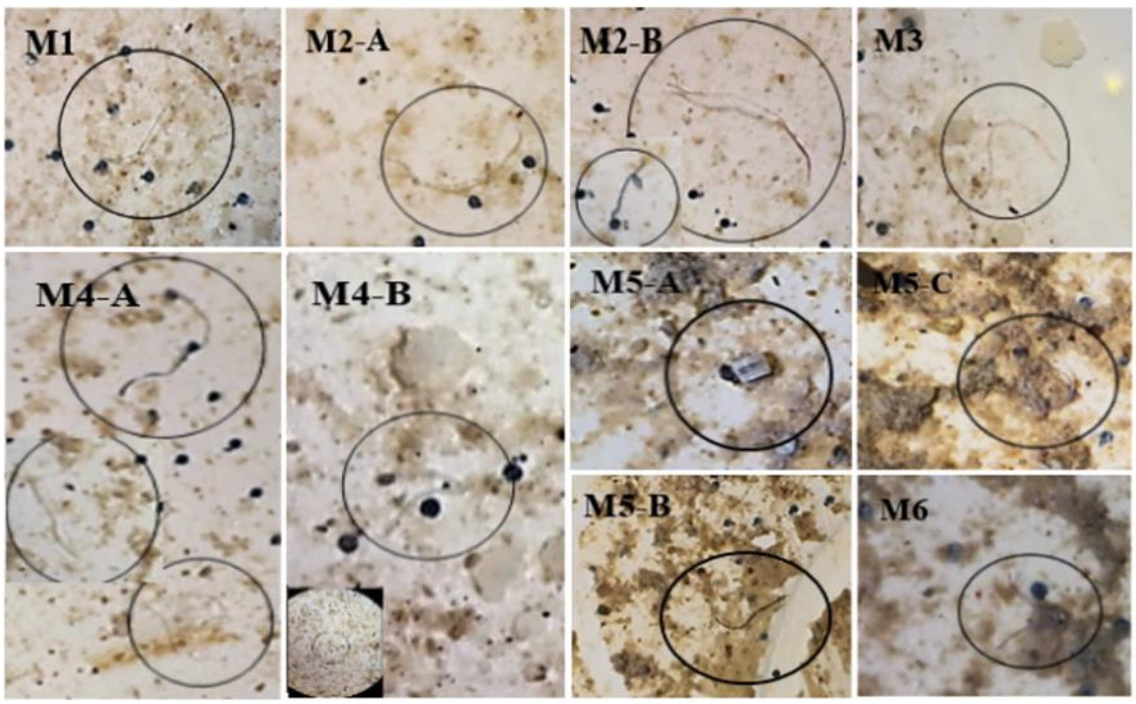

Figure 3 Images of the types of microplastics found in the species *Chelon labrosus*: Fibers (M1, M2-A, M2-B, M3, M4-A, M4-B, M5-B, M5-C and M6) and fragment (M5-A)

Qiao et al. [30] studied the presence of microplastics in the gut of zebrafish, and their results showed microplastics in the form of pearls, fragments and fibers. Microplastics in fiber forms were the most present in the samples studied. Similarly, Lefebvre et al. [31] reported only microplastics in fiber forms in the samples analyzed of small fish such as sardine and anchovy, indicating that these depend heavily on the species, sampling site, fish size, among other factors that may interfere with the results.

On the other hand, Nie et al. [23] studied microplastic contamination in fish for both carnivorous species (*Balistes capistratus*, *Melichthys vidua*, *Cephalopholis urod*eta and *Odonus niger*) as herbivorous species (*Zebrasoma veliferum*, *Acanthurus pyroferus* and *Acanthurus lineatus*), showing that herbivorous fish that feed on algae had lower intake of microplastics. The ingested microplastics were mainly blue or transparent fibers with <0.5 mm sizes. In the same way, Zhang et al. [32] and Huang et al. [33] evaluated the presence of microplastics in fishes, and blue and transparent fibres were identified.

With all of the above mentioned, the results suggest that the ingestion of microplastics by fishes is related to various factors such as their feeding habits, habitats and the concentration of microplastics in the aquatic environment, as stated in their studies various authors such as Romeo et al. [34], Battaglia et al. [35], Jabeen et al. [36], Baalkhuyur et al. [37], Qiao et al. [30] and Nie et al. [23].

B. Quantification of microplastics in the species Chelon labrosus

In order to state an exact numerical value of the microplastics found in the digestive tract of the species *Chelon labrosus*, the quantification of these was performed in each sample studied (Figure 4).

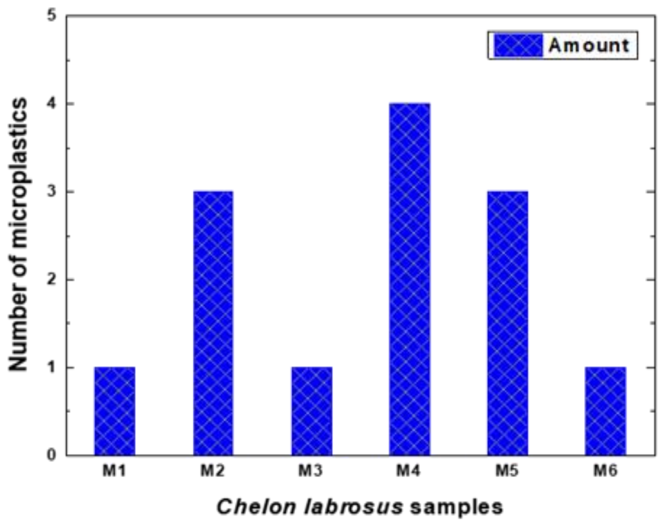

Figure 4 Quantification of microplastics in *Chelon labrosus* samples

From Figure 4, it was observed that the number of microplastics found in each fish sample was different. This indicated that the samples analyzed were mainly affected by the eating habits of each fish because they were collected from the same site and close to each other [23].

ZHU et al. [38] quantified the microplastics present in deep-sea fish in the continental slope of the China Sea, and their results showed average levels of 1.96 g of microplastics in the intestines. Similarly, Baalkhuyur et al. [37] quantified the microplastics present in fishes from the Red Sea coast of Saudi Arabia, finding 26 fragments of microplastics in the 178 fishes analyzed. Likewise, Nie et al. [23] studied the density of microplastics present in fishes from the Nanxun Reef, and identified an average of 3.1 particles of microplastics per fish. Already, Peters et al. [39] identified an average of 1.93 particles of microplastics in sampled fish off the Gulf of Texas coast.

C. Identification of microplastics in the species Chelon labrosus

The main forms of microplastics present in the digestive tract of the species *Chelon labrosus* were fibers and fragment. The characterization of these microplastic samples using FTIR spectroscopy (Figure 5) showed four types of microplastics, which were cellophane, polyvinylpyrrolidone, poly (4-methycaprolactam) and poly (2, 2, 2-trifluoroethyl vinyl ether). Of all these, cellophane was most coincident in the analysis of the microplastic samples, with a similarity of 40.97%. Meanwhile, the rest had similarities of 35.05, 34.08 and 33.47%, respectively.

The microplastics found are derived from plastics or important components for the manufacture of nylon and fibers. Zhang et al. [32] reported that cellophane microplastic is the most prevalent in the digestion of fish, and that they are mostly blue and transparent fibers. Similarly, Huang et al. [33] found cellophane-type microplastics in fishes from the Zhanjiang mangrove in China. Likewise, Feng et al. [15] also reported cellophane as a predominant microplastic in fish from the Haizhou Bay in China.

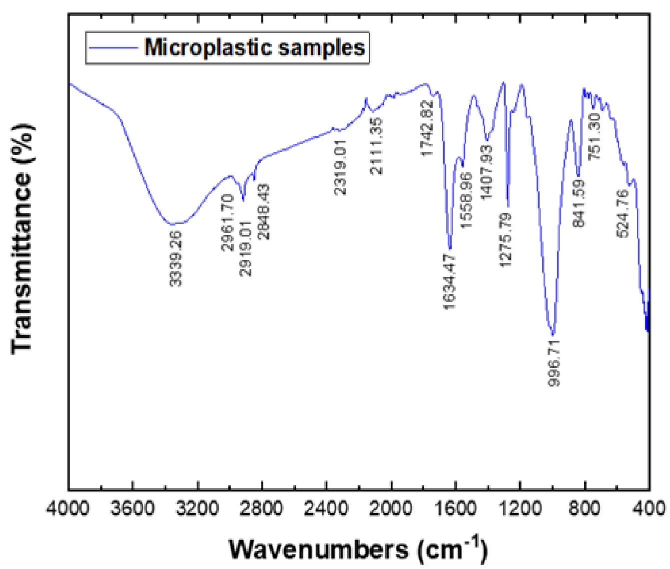

Figure 5 FTIR spectrum of microplastic samples

Kumar et al. [18] investigated the microplastic presence in the species *Rastrilleger kanagurta* and *Epinephalus merra* in two landings in India. The microplastic particles found were fibers (80%) fragments (20%) of the polyethylene and polyethylene type. In the same way, Koongolla et al. [17] evaluated microplastic contamination in 24 species of fishes from the Gulf of Beibu in China. The results revealed microplastics in the form of transparent fibers that were mostly polyester (44%), nylon (38%), polypropylene (6%), polyethylene (6%) and acrylics (6%).

Hossain et al. [16] evaluated the presence of microplastics in fishes such as *Harpadon nehereus*, *H. translucens* and

Sardinella gibbosa of North Bay of Bengal. The microplastics found were in the form of fibers, particles and fragments that were mostly polyamide and polyethylene terephthalate. Maaghloaud et al. [19] also studied the presence of microplastics in three pelagic species (*Scomber spp*, *Truchurus truchurus* and *Sardinas pilchardus*) from the central Atlantic area. The results showed microplastics of the type polyamide, acrilic and polystyrene. Already, Sfriso et al. [20] studied microplastic contamination in benthic invertebrates of the Ross Sea in Antarctica. The study revealed that 83% of the twelve species analyzed contained microplastics, and these were mainly nylon and polyethylene.

Other research studied and identified microplastic contamination in seas and seagrass beds. Thus, Jiang et al. [40] investigated microplastic contamination in Nordic seas in Greenland, and the results showed microplastics in the form of fibers and fragments, mainly of the polyester and polyethylene type. Meanwhile, Jones et al. [41] conducted a study on the seagrass beds of Deerness Sound, Orkney - Scotland. The results of the samples (sediments, seagrass and seawater) analyzed showed particles of microplastics with an average size of 0.95 mm, and these particles were in the form of fibers, flakes and fragments that were identified as polyethylene, polypropylene, polyamide, polyetherethane, polyester, polystyrene and polyethylene.

V. Conclusions

The research showed the presence of microplastics in the species *Chelon Labrosus*, highlighting its emerging threat. The most significant results were:

1. The microplastics found in *Chelon labrosus* are black, reddish and transparent fibers, and a transparent fragment. Microplastics in the form of fibers predominated in the samples analyzed.

2. FTIR analyses showed 04 types of microplastics, which were cellophane, polyvinylpyrrolidone, poly (4-methycaprolactam) and poly (2, 2, 2-trifluoroethyl vinyl ether).

The amount of microplastics found in the *Chelon labrosus* species indicates contamination of the water and marine species in the study site. This contamination allows us to take the necessary measures to control the informal dumps in the area and the discharge of wastewater, and thus improve the aquatic ecosystem and consequently the life of the species that are mostly consumed by the population.

Acknowledgment

The authors thank the Universidad César Vallejo (UCV) and the Universidad Nacional de Ingeniería (UNI) for providing us with their laboratories for the experimental development of this research.

References

[1] N. Laskar and U. Kumar, "Plastics and microplastics: A threat to environment," Environ. Technol. Innov., vol. 14, p. 100352, 2019.

[2] J. Góngora, "La industria del plástico en México y el mundo," Comer. Exter., vol. 64, no. 5, pp. 6–9, 2014.

[3] M. O. Rodrigues, N. Abrantes, F. J. M. Gonçalves, H. Nogueira, J. C. Marques, and A. M. M. Gonçalves, "Impacts of plastic products used in daily life on the environment and human health: ¿What is known?," Environ. Toxicol. Pharmacol., vol. 72, no. July, p. 103239, 2019.

[4] C. Giacovelli, Plásticos de un solo uso: una hoja de ruta para la sostenibilidad, ONU Medio. 2018.

[5] E. Rojo-Nieto and T. Montoto, Basuras marinas, plásticos y microplásticos. 2017.

[6] D. B. Daniel, S. N. Thomas, and K. T. Thomson, "Assessment of fishing-related plastic debris along the beaches in Kerala Coast, India," Mar. Pollut. Bull., vol. 150, no. July, p. 110696, Jan. 2020.

[7] C. Martin, "Plastic world," Curr. Biol., vol. 29, no. 19, pp. R950–R953, oct. 2019.

[8] S. Krishnakumar, S. Anbalagan, K. Kasilingam, P. Smrithi, S. Anbazhagi, and S. Srinivasalu, "Assessment of plastic debris in remote islands of the Andaman and Nicobar Archipelago, India," Mar. Pollut. Bull., vol. 151, no. December 2019, p. 110841, 2020.

[9] P. L. Forsberg, D. Sous, A. Stocchino, and R. Chemin, "Behaviour of plastic litter in nearshore waters: First insights from wind and wave laboratory experiments," Mar. Pollut. Bull., vol. 153, no. October 2019, p. 111023, 2020.

[10] S. Gangadoo et al., "Nano-plastics and their analytical characterisation and fate in the marine environment: From source to sea," Sci. Total Environ., vol. 732, p. 138792, Aug. 2020.

[11] S. L. Wright, R. C. Thompson, and T. S. Galloway, "The physical impacts of microplastics on marine organisms: a review.," Environ. Pollut., vol. 178, pp. 483–492, 2013.

[12] M. Eriksen et al., "Plastic Pollution in the World's Oceans: More than 5 Trillion Plastic Pieces Weighing over 250,000 Tons Afloat at Sea," PLoS One, vol. 9, no. 12, pp. 1–15, 2014.

[13] W. C. Li, H. F. Tse, and L. Fok, "Plastic waste in the marine environment: A review of sources, occurrence and effects," Sci. Total Environ., vol. 566–567, pp. 333–349, 2016.

[14] F. M. Baalkhuyur, M. A. Qurban, P. Panickan, and C. M. Duarte, "Microplastics in fishes of commercial and ecological importance from the Western Arabian Gulf," Mar. Pollut. Bull., vol. 152, no. January, p. 110920, 2020.

[15] Z. Feng et al., "The accumulation of microplastics in fish from an important fish farm and mariculture area, Haizhou Bay, China," Sci. Total Environ., vol. 696, p. 133948, 2019.

[16] M. S. Hossain et al., "Microplastics in fishes from the Northern Bay of Bengal," Sci. Total Environ., vol. 690, pp. 821–830, 2019.

[17] J. B. Koongolla et al., "Occurrence of microplastics in gastrointestinal tracts and gills of fish from Beibu Gulf, South China Sea," Environ. Pollut., vol. 258, p. 113734, 2020.

[18] V. E. Kumar, G. Ravikumar, and K. I. Jeyasanta, "Occurrence of microplastics in fishes from two landing sites in Tuticorin, South east coast of India," Mar. Pollut. Bull., vol. 135, no. June, pp. 889–894, 2018.

[19] H. Maaghloud et al., "Ingestion of microplastics by pelagic fish from the Moroccan Central Atlantic coast," Environ. Pollut., vol. 261, 2020.

[20] A. A. Sfriso et al., "Microplastic accumulation in benthic invertebrates in Terra Nova Bay (Ross Sea, Antarctica)," Environ. Int., vol. 137, no. January, p. 105587, 2020.

[21] INVEMAR – Instituto de Investigaciones Marinas y Costeras, "Protocolo De Muestreo Y Análisis De Microplásticos En Aguas Marinas Superficiales, Sedimentos De Playas Y Tracto Digestivo De Peces." Santa Marta, Colombia, p. 21, 2017.

[22] L. G. A. Barboza et al., "Microplastics in wild fish from North East Atlantic Ocean and its potential for causing neurotoxic effects, lipid oxidative damage, and human health risks associated with ingestion exposure," Sci. Total Environ., vol. 717, p. 134625, 2020.

[23] H. Nie, J. Wang, K. Xu, Y. Huang, and M. Yan, "Microplastic pollution in water and fish samples around Nanxun Reef in Nansha Islands, South China Sea," Sci. Total Environ., vol. 696, p. 134022, 2019.

[24] L. Su et al., “The occurrence of microplastic in specific organs in commercially caught fishes from coast and estuary area of east China,” J. Hazard. Mater., vol. 365, no. July 2018, pp. 716–724, 2019.
[25] T. S. Galloway, M. Cole, and C. Lewis, “Interactions of microplastic debris throughout the marine ecosystem,” Nat. Ecol. Evol., vol. 1, no. 5, pp. 1–8, 2017.
[26] M. Lehtiniemi, S. Hartikainen, P. Näkki, J. Engström-Öst, A. Koistinen, and O. Setälä, “Size matters more than shape: Ingestion of primary and secondary microplastics by small predators,” Food Webs, vol. 17, p. e00097, 2018.
[27] J. Procter, F. E. Hopkins, E. S. Fileman, and P. K. Lindeque, “Smells good enough to eat: Dimethyl sulfide (DMS) enhances copepod ingestion of microplastics,” Mar. Pollut. Bull., vol. 138, no. July 2018, pp. 1–6, 2019.
[28] M. S. Savoca, C. W. Tyson, M. McGill, and C. J. Slager, “Odours from marine plastic debris induce food search behaviours in a forage fish,” Proc. R. Soc. B Biol. Sci., vol. 284, no. 1860, 2017.
[29] C. van der Lingen, “Effect of particle size and concentration on the feeding behaviour of adult pilchard Sardinops sagax,” Mar. Ecol. Prog. Ser., vol. 109, no. 1, pp. 1–13, 1994.
[30] R. Qiao et al., “Accumulation of different shapes of microplastics initiates intestinal injury and gut microbiota dysbiosis in the gut of zebrafish,” Chemosphere, vol. 236, p. 124334, 2019.
[31] C. Lefebvre, C. Saraux, O. Heitz, A. Nowaczyk, and D. Bonnet, “Microplastics FTIR characterisation and distribution in the water column and digestive tracts of small pelagic fish in the Gulf of Lions,” Mar. Pollut. Bull., vol. 142, no. March, pp. 510–519, 2019.
[32] D. Zhang et al., “Microplastic pollution in water, sediment, and fish from artificial reefs around the Ma’an Archipelago, Shengsi, China,” Sci. Total Environ., vol. 703, p. 134768, Feb. 2020.
[33] J.-S. Huang et al., “Microplastic accumulation in fish from Zhanjiang mangrove wetland, South China,” Sci. Total Environ., vol. 708, p. 134839, Mar. 2020.
[34] T. Romeo, B. Pietro, C. Pedà, P. Consoli, F. Andaloro, and M. C. Fossi, “First evidence of presence of plastic debris in stomach of large pelagic fish in the Mediterranean Sea,” Mar. Pollut. Bull., vol. 95, no. 1, pp. 358–361, 2015.
[35] P. Battaglia, C. Pedà, S. Musolino, V. Esposito, F. Andaloro, and T. Romeo, “Diet and first documented data on plastic ingestion of Trachinotus ovatus L. 1758 (Pisces: Carangidae) from the Strait of Messina (central Mediterranean Sea),” Ital. J. Zool., vol. 83, no. 1, pp. 121–129, 2016.
[36] K. Jabeen et al., “Microplastics and mesoplastics in fish from coastal and fresh waters of China,” Environ. Pollut., vol. 221, pp. 141–149, 2017.
[37] F. M. Baalkhuyur et al., “Microplastic in the gastrointestinal tract of fishes along the Saudi Arabian Red Sea coast,” Mar. Pollut. Bull., vol. 131, no. December 2017, pp. 407–415, 2018.
[38] L. Zhu, H. Wang, B. Chen, X. Sun, K. Qu, and B. Xia, “Microplastic ingestion in deep-sea fish from the South China Sea,” Sci. Total Environ., vol. 677, pp. 493–501, 2019.
[39] C. A. Peters, P. A. Thomas, K. B. Rieper, and S. P. Bratton, “Foraging preferences influence microplastic ingestion by six marine fish species from the Texas Gulf Coast,” Mar. Pollut. Bull., vol. 124, no. 1, pp. 82–88, 2017.
[40] Y. Jiang, F. Yang, Y. Zhao, and J. Wang, “Greenland Sea Gyre increases microplastic pollution in the surface waters of the Nordic Seas,” Sci. Total Environ., vol. 712, p. 136484, 2020.
[41] K. L. Jones, M. G. J. Hartl, M. C. Bell, and A. Capper, “Microplastic accumulation in a Zostera marina L. bed at Deerness Sound, Orkney, Scotland,” Mar. Pollut. Bull., vol. 152, no. December 2019, p. 110883, 2020.