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Microplastic ingestion by Atlantic chub mackerel (*Scomber colias*) in the Canary Islands coast

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ABSTRACT

In recent years, due to the increasing concerns about their negative impact on wildlife and possible toxicity to living organisms (including humans), microplastics have become the subject of intense investigations. In the ocean, microplastics can be easily ingested by numerous marine organisms because of their small size (< 5 mm). The Northwest African upwelling system is an important fishery area, and the present study is the first one in the region to reveal the presence of microplastic particles in the digestive tract of Atlantic chub mackerel (*Scomber colias*). From the 120 examined fish gastrointestinal tracts, 78.3% contained some type of microplastics, 74.2% contained fibres, 17.5% plastic fragments, and 16.7% paint. More studies are needed on fish, but *S. colias* is a candidate for being a good indicator of microplastic contamination in the region.

1. Introduction

Microplastics (MPs) were first described more than 40 years ago (Carpenter et al., 1972; Shiber, 1982, 1987), but since the beginning of the new millennium, they have become the object of intense investigations (Andrady, 2011; Avio et al., 2016; Barboza and Garcia Gimenez, 2015; Ivar Do Sul and Costa, 2014; Lusher, 2015; Shim and Thomposon, 2015; Thompson et al., 2004), owing to the increasing concerns about their negative impact on wildlife and their toxicity on living organisms, including humans (Wright et al., 2013). Here, we consider microplastics as any plastic particles smaller than 5 mm (secondary or primary), according to the current globally accepted definition (Arthur et al., 2009; GESAMP, 2015). Industrial and fishing activities and indiscriminate disposal of waste material lead to direct or indirect transfer of plastic litter to the marine environment. The most common types of microplastics found in the oceans are fragments of larger plastics, microparticles from cosmetic products, synthetic fibres from washing laundry, and resin pellets from the plastic industry that were lost during production (Veiga et al., 2016). Although wastewater treatment plants are able to filter most of the microplastics and plastic debris (Mason et al., 2016; Talvitie et al., 2017), a considerable amount of microplastics still enter aquatic ecosystems (Browne et al., 2011, 2007; Correia Prata, 2018; Fendall and Sewell, 2009; Mason et al., 2016). Moreover, plastics that enter river systems - directly or indirectly - will eventually end up in the sea (Lebreton et al., 2017).

Due to their small size and abundance, microplastics are potentially consumed by a wide range of organisms. Ingestion has been observed in several invertebrate and vertebrate species, including fish (reviewed in Ivar Do Sul and Costa (2014), Lusher (2015) and Rezania et al. (2018)). However, most of the research on invertebrates is restricted to controlled laboratory experiments (Phuong et al., 2016). Microplastics can be ingested directly or indirectly as a result of eating lower trophic-level organisms that have consumed microplastics themselves (Browne et al., 2008; Cole et al., 2011; Nelms et al., 2018).

Once ingested, microplastics may be egested or retained. They could also block the digestive tract, causing pseudo-satiation and leading to decreased food consumption; or they could get absorbed by the gut or be translocated into other tissues (Derraik, 2002; Jovanović, 2017; Wang et al., 2016). Browne et al. (2008) observed that microplastics ingested by *Mytilus edulis* were translocated from the gut into the circulatory system and persisted there for several weeks. Microplastic ingestion in *Mytilus edulis* is commonly studied, and the transference of microplastics from *M. edulis* to higher trophic levels has also been observed (Farrell and Nelson, 2013). The implication for the rest of the

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Table 1
Literature review. We conducted an ISI Web of Science search (October 30, 2018) with TOPIC = microplastic* AND fish* AND ingestion*, in English, for the dates 1900–2018. We selected articles that reported the ingestion of microplastics in wild-caught fish or bought in fish markets, not the experiments carried out in the laboratory.

Location	Digestion	Sample size (n)	Species	Fish with MPs (%)	Average MPs/fish	Predominant color (%)	Predominant type (%)	Reference
North Pacific Gyre[a]	No	670	6 species	35%	5.9	58% white	94% fragments	Boerger et al. (2010)
North Pacific Gyre	No	141	27 species	9.2%	1.2	N/A	56% fragments	Davison and Asch (2011)
North Sea, Atlantic[b]	10% KOH	1203	7 species	2.6%	N/A	N/A	Fibres N/A	Foekema et al. (2013)
English Channel	No	504	10 species	36.5%	1.9	45% black	68% fibres	Lusher et al. (2013)
Portuguese coast, Atlantic	No	263	26 species	19.8%	1.40	N/A	66% fibres	Neves et al. (2015)
Gulf of Mexico	No	419	44 freshwater species	8.2%	N/A	N/A	Fragments	Phillips and Bonner (2015)
Gulf of Mexico	No	116	8 marine species	10.4%	N/A	N/A	Filaments	Phillips and Bonner (2015)
Eolian Islands, Mediterranean Sea[c]	No	123	*3 species*	18.2%	N/A	N/A	N/A	Romeo et al. (2015)
Spain, Atlantic and Mediterranean	1 M NaOH	212	3 species	17.5%	1.56	51% black	71% fibres	Bellas et al. (2016)
Norwegian coast	No	302	*Gadus morhua*	3%	1.77	N/A	N/A	Bråte et al. (2016)
Balearic Islands, Mediterranean Sea	No	337	*Boops boops*	57.8%	3.75	N/A	100% fibres	Nadal et al. (2016)
South Africa urban harbour	No	70	*Mugil cephalus*	73%	5.1	White and clear	51% fibres	Naidoo et al. (2016)
Tokio Bay	10% KOH	64	*Engraulis japonicus*	77%	2.3	N/A	86% fragments	Tanaka and Takada (2016)
North and Baltic Sea[c]	No	290	5 species	5.5%	1.44	N/A	N/A	Rummel et al. (2016)
Balearic Islands, Mediterranean Sea	No	125	*Galeus melastomus*	16.8%	N/A	42% transparent	86% filaments	Alomar and Deudero (2017)
Turkish waters, Mediterranean Sea	35% H_2O_2	1337	28 species	58%	2.36	Blue	70% fibres	Güven et al. (2017)
North Sea, Atlantic	10% KOH	400	4 species	0.25%	N/A	Transparent	Spherical particles	Hermsen et al. (2017)
China	30% H_2O_2	378	21 species	100%	N/A	Transparent	Fibres	Jabeen et al. (2017)
		108	6 species	95.7%				
Northeast Atlantic, Scotland	No	128	3 species	47.7%	1.8	43% black	82% fibres	Murphy et al. (2017)
	No	84	9 species	2.4%				
Texas Gulf coast	No	1381	6 species	42.4%	1.93	Purple/blue	86.4% fibres	Peters et al. (2017)
Argentina, Ro de la Plata estuary	30% H_2O_2	87	11 species	100%	19	Blue	96% fibres	Pazos et al. (2017)
Paje River, Brazil[c]	No	48	*Hoplosternum littorale*	83%	4.4	N/A	47% fibres	Silva-Cavalcanti et al. (2017)
Western English Channel	No	347	23 species	2.9%	1.2	83% blue	83% fibres	Steer et al. (2017)
Estuaries, Brazil	No	2233	69 species	9%	1.05	N/A	90% fibres	Vendel et al. (2017)
	No	84	9 species	2.4%				
Goiana Estuary, Brazil	No	552	*Cynoscion acoupa*	51%	3.03	44% blue	99.9% fibres	Ferreira et al. (2018)
Adriatic Sea	10% KOH	533	*Solea solea*	95%	1.6	N/A	72% fragments	Pellini et al. (2018)
Southeast Pacific Ocean[b]	No	292	7 species	2.1%	N/A	N/A	Fibres N/A	Ory et al. (2018)
Hong Kong east coast	30% H_2O_2	30	*Mugil cephalus* culture	16.7%	0.2	33% blue	100% fibres	Cheung et al. (2018)
	30% H_2O_2	30	*Mugil cephalus* wild	60%	4.3	44% green	60% fibres	
Sydney Harbour, Australia[a]	No	24	*Acanthopagrus australis*	25%	1.6	N/A	83% fibres	Halstead et al. (2018)
		45	*Mugil cephalus*	64%	4.6			
		24	*Gerres subfasciatus*	21%	0.2			
Spanish coast, Mediterranean Sea	No	105	*Sardina pilchardus*	15.2%	0.21	N/A	83% fibres	Compa et al. (2018)
		105	*Engraulis encrasicolus.*	14.3%	0.18			
Mondego estuary, Portugal	10% KOH	40	*Dicentrarchus labrax*	23%	0.30	47% blue	96% fibres	Bessa et al. (2018)
		40	*Diplodus vulgaris*	73%	3.14			
		40	*Platichthys flesus*	13%	0.18			
Adriatic Sea, Mediterranean Sea	30% H_2O_2	20	*Chelon auratus*	95%	9.5	N/A	75.6% filaments	Anastasopoulou et al. (2018)
		20	*Chelon auratus*	95%	9.5			
		20	*Solea solea*	100%	7.3			
Adriatic Sea, Mediterranean Sea	30% H_2O_2	30	*Mullus surmuletus*	70%	1.8	N/A	97.7% filaments	Anastasopoulou et al. (2018)
		30	*Pagellus erythrinus*	50%	1			
		30	*Sardina pilchardus*	37%	0.9			
Ionian Sea, Mediterranean Sea	30% H_2O_2	25	*Mullus barbatus*	32%	0.5	N/A	79% filaments	Anastasopoulou et al. (2018)
		19	*Pagellus erythrinus*	42%	0.8			
		36	*Sardina pilchardus*	47%	0.8			
[a]Canary Island, North Atlantic	10% KOH	120	*Scomber colias*	78%	2.77	55% blue	74% fibres	Present work

[a] Includes natural fibres.
[b] Fibres not account.
[c] Includes micro and macroplastics.

food web, including humans, is concerning (Farrell and Nelson, 2013; Setälä et al., 2014). There are an increasing number of studies that reveal microplastic ingestion in various fish species in different parts of the world. We have conducted a literature review of microplastic studies in fish and have found that ingestion has been reported in demersal, pelagic, estuarine and freshwater species including species of commercial importance (Table 1). Davison and Asch (2011) estimates the ingestion rate of plastic debris by mesopelagic fish in the North Pacific to be from 12,000 to 24,000 tons per year.

In addition, persistent organic pollutants (POPs) such as polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and dichlorodiphenyltrichloroethane (DDTs) can be adsorbed onto plastics, mainly due to their greater affinity for the hydrophobic surface of plastics compared to seawater (Wang et al., 2016). Rochman et al. (2013) found greater concentrations of PCBs and polybrominated diphenyl ethers (PBDEs) in fish fed with marine plastic than those fed with virgin plastic particles, which indicates that plastic litter serves as an accumulation point and a pathway for the adsorbed POPs into the food web. PCBs can lead to reproductive disorders, alter hormone levels, and cause harmful effects on even low-level marine organisms (Derraik, 2002).

Atlantic chub mackerel *Scomber colias* (Gmelin, 1789) is a coastal pelagic species present in the Atlantic Ocean and the Mediterranean and Black Sea. Previously cited as *Scomber japonicus*, it has been demonstrated that there are morphological and genetic differences between the species, the classification now being accepted as *S. colias* in the Atlantic and *S. japonicus* in the Indo-Pacific. *S. colias* attain first sexual maturity (50% of individuals) at 20 cm of total length (TL) in the first year of life (Lorenzo Nespereira and González Pajuelo, 1993). It is an important fishery resource in the Canary Islands, with an estimated biomass in the Canary archipelago of 38,000 tones (Lorenzo Nespereira and González Pajuelo, 1993). It is the most important resource of the traditional purse seine fleet, accounting for about 60% of the total coastal pelagic catch (Lorenzo and Pajuelo, 1996). Studies carried out in Gran Canaria (Canary Islands) showed that *S. colias* is mainly planktivorous, with mysids being an important component in their diet.

In the present work, we aim to (1) assess, for the first time, the ingestion of microplastics in the coastal pelagic fish (*Scomber colias*) in the Canary archipelago; (2) determine if there are differences in the number of microplastics in the digestive tracts of fish from two different fishing areas: Lanzarote and Gran Canaria; and (3) analyse the types of plastic particles found and their possible sources.

2. Materials and methods

2.1. Fish sampling and laboratory analysis

The fish were bought from artisanal fishing fleets in Gran Canaria and Lanzarote (Fig. 1). In the Canary Islands, Atlantic chub mackerel are fished with purse-seine nets at a depth of 40–50 m, and fish are lured with light (Castro, 1995). To determine microplastic ingestion, we applied a slightly modified methodology recommended by MSFD GES Technical Subgroup on Marine Litter and MSDF Technical Subgroup on Marine Litter (2013). Each specimen was weighed and the total length (TL) was measured before dissection. Gastrointestinal tracts were removed, rinsed and stored in 70% ethanol. The digestive tract content was removed and treated with 10% KOH for 24 h at 60° in order to degrade as much organic matter as possible (Dehaut et al., 2016).

After digestion, the remaining material was filtered using a 50 μ m zooplankton mesh and visually examined under the stereomicroscope for at least 10 min. All potential microplastic particles were photographed and measured. Items were classified according to size, texture and shape into fragments, fibres, lines, paint and films. The fibres were distinguished from lines by being smaller and more flexible than the lines derived from fishing nets. Microplastic particles were determined by visual inspection, and in case of doubt, FTIR (Perkin Elmer spectrometer, model FTIR Spectrum BX) was used to confirm the material composition (Supplementary Material Figs. 1–7). In the case of fibres, no micro-FTIR inspection was performed, and they were visually determined according to the homogeneous color, brightness and absence of cellular structures. However, in particles smaller than 500 μm, and particularly in fibres, the visual determination error can reach 70% (Lusher et al., 2017). For fibres, therefore, it is not possible to determine with certainty whether they are synthetic or natural (e.g. cotton, linen, manila, kenaf, sisal rope, silk, wool, cellulose) (Halstead et al., 2018). Here, 27 non-fibre particles were smaller than 500 μm in size, so there could also be an error associated with their visual determination.

The stomach content filtration and final sample observation were performed under a laboratory fume hood, and all material and working places were cleaned with alcohol in order to reduce any air-born fibre contamination. During the entire process (extraction, digestion, filtration and visual examination), cotton lab coats were worn to prevent contamination of the samples. A petri dish with clean 50 μ m mesh was placed near the stereomicroscope during the visual inspection as contamination control. If any fibres were found in the control, the sample was discarded. During the analysis, only one control was contaminated with fibres, and that sample was discarded because we could not determine if the fibres present were due to air borne contamination.

2.2. Statistical analysis

Data normality were analysed by the Shapiro-Wilk test, and data homoscedasticity was assessed graphically. Since the distribution of data was not normal, the Wilcoxon-Mann-Whitney test was applied to determine the significant differences in microplastic ingestion (items/fish) among the fishing areas. The results were represented in box plots. Statistical analysis and graphics were performed with the R statistical software (R Core Team, 2017) and its extension, RStudio.

3. Results

Overall, 120 specimens of *Scomber colias* were studied: 60 from fish markets of Gran Canaria and 60 from Lanzarote. The total length of fish ranged from 15 to 44 cm, and wet weight ranged from 30 to 830 g. A total of 94 individuals (78.3%) had microplastics in the digestive tract (Fig. 2). A percentage of 74.2% of the sampled fish (89 individuals) had ingested fibres, 17.5% (21 individuals) fragments, 16.7% (20 individuals) paint, 3.3% (4 individuals) lines and 1.7% (2 individuals) films (Figs. 2 and 3).

The average number of microplastics ingested by all the sampled fish was 2.17 ± 2.04 items per fish, (mean ± SD). Of the 96 fish that ingested microplastics, an average of 2.77 ± 1.91 items per individual (mean ± SD) was found, ranging from 1 to 9 items. Significant differences were found in the number of items per individuals (total sampled) among fishing zones ($p < 0.01$). The average number of microplastics per fish in Lanzarote was 2.55, and in Gran Canaria, it was 1.78. The median values were 2 and 1 for Lanzarote and Gran Canaria, respectively (Fig. 4).

From the 260 microplastics found, 193 were fibres (74.23%), 31 were fragments (11.93%), 30 paint chips (11.54%), 4 lines (1.54%) and 2 films (0.77%) (Fig. 5). The size (maximum length) of the microplastics found ranged between 0.035 and 29.5 mm, with a median of 0.9 mm. Only 7 items (4 fibres and 3 lines) had a maximum length higher than 5 mm (Fig. 3).

In the plastic debris ingested, the most frequent colors were blue (55%) and black or dark (23.5%). If we analyse only the fibres, the most frequent colors were blue (51.8%) and black or dark (30.8%). In the other types of plastic debris (fragments, paint, lines and films), blue was also the most frequent (64.2%), followed by white or light (13.4%) (Figs. 6 and 7).

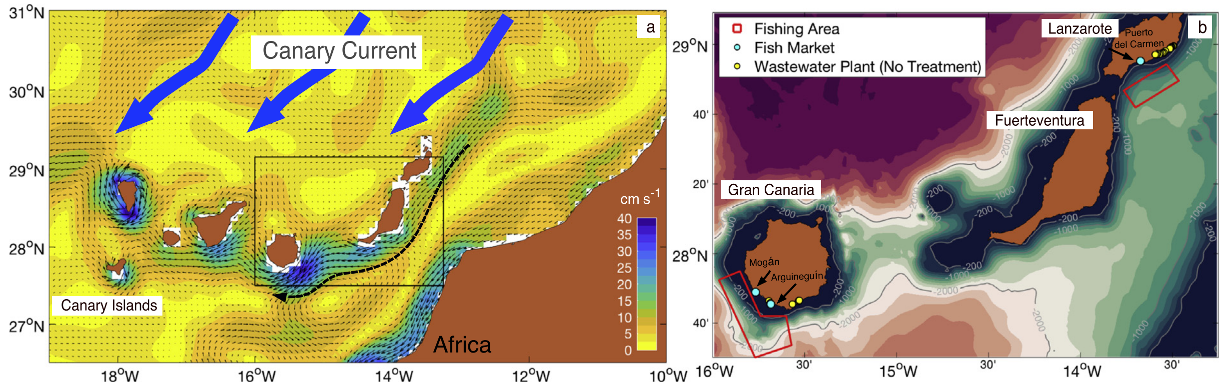


Fig. 1. a) Canary basin circulation (depth-averaged annual mean of 2016 for the upper 40 m) based on model data from the high resolution (1/12°) global analysis and forecasting system PSY4V3R1 version 3.1 of NEMO ocean model (Madec and NEMO-Team, 2008) provided by the Copernicus Marine Environment Monitoring Service (CMEMS). Currents are shown as a vector velocity field (shades of colors are cm^{-1}). A zoom in panel (b) is indicated with a black rectangle. b) Bathymetric map with indication to the fishing areas south of Gran Canaria and Lanzarote (red rectangles), wastewater discharges without treatment prior to water disposal (yellow circles) (GRAFCAN Cartográfica de Canarias IDECanarias, 2018) and fish markets (cyan circles). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

4. Discussion

The percentage of fish that ingested microplastics was higher than the percentages reported in most other studies of demersal and pelagic fish (Table 1). However, recent studies in estuaries, bays and enclosed seas show percentages of microplastic intake similar to those found in the present work (Table 1). For instance, MP was found in 57% of bogue from the Mediterranean Sea, in 95% of flatfish from the Adriatic Sea, and in 77% of the Japanese anchovy from Tokyo Bay (Table 1). In addition, microplastic ingestion was reported in 73% of the two banded seabreams in the Mondego estuary, and in 100% of fish from the Río de la Plata estuary. High incidence was also found in fish purchased from markets, with MP in almost 100% of the fish studied from the Shanghai market, and 60% of mullets from the fishery markets of Hong Kong (Table 1).

Rochman et al. (2015) studied the incidence of anthropogenic debris in fish purchased at fish markets in Indonesia and California. The study demonstrated the presence of anthropogenic debris in 28% of fish purchased in Indonesia and 25% of fish purchased in California markets. Differences were observed between the types of debris found in both areas, in California 80% were fibres, while in Indonesia 100% were plastic particles. Compared to our results, in the Canary Islands a higher incidence of anthropogenic debris was found and the composition was similar to that found in fish from California, with a predominance of textile fibres.

Atlantic chub mackerel is one of the most important coastal pelagic fishing resources in the Canary Islands. Its low price and its availability throughout the year make it one of the most consumed fish in the region. Although in the case of Atlantic chub mackerel, traditionally the gut is not consumed, there is great concern about the potential risks to humans associated with the transfer of chemical pollutants presents in MP, via diets containing fish (Rochman et al., 2015).

Here, most of the microplastics found were fibres, consistent with the majority of the published studies (Table 1). According to the types of plastic particles found, we speculate on possible sources. Most of the fibres are washed out from sewage. Washing clothes has been shown to

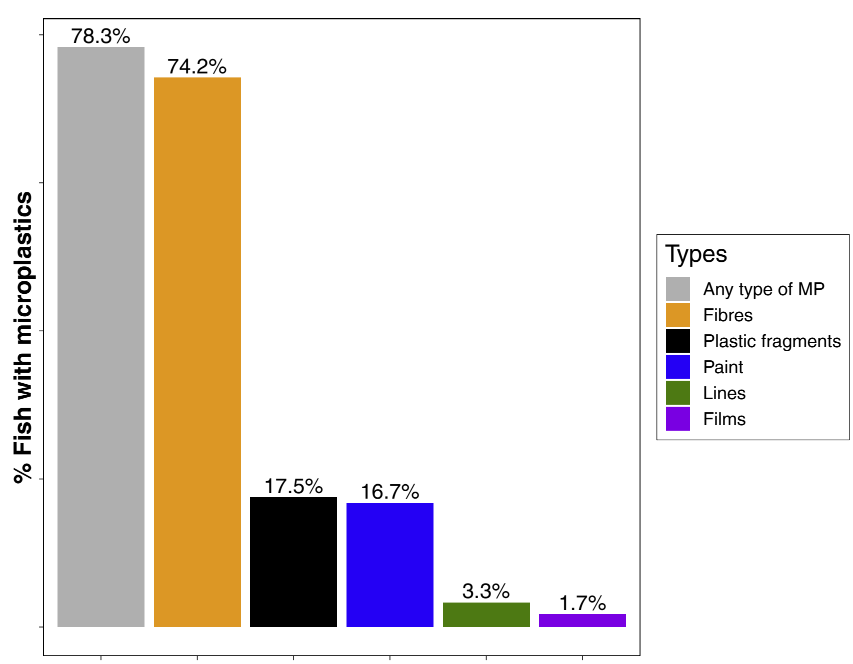


Fig. 2. Percentage of fish with microplastics in the gastrointestinal content.

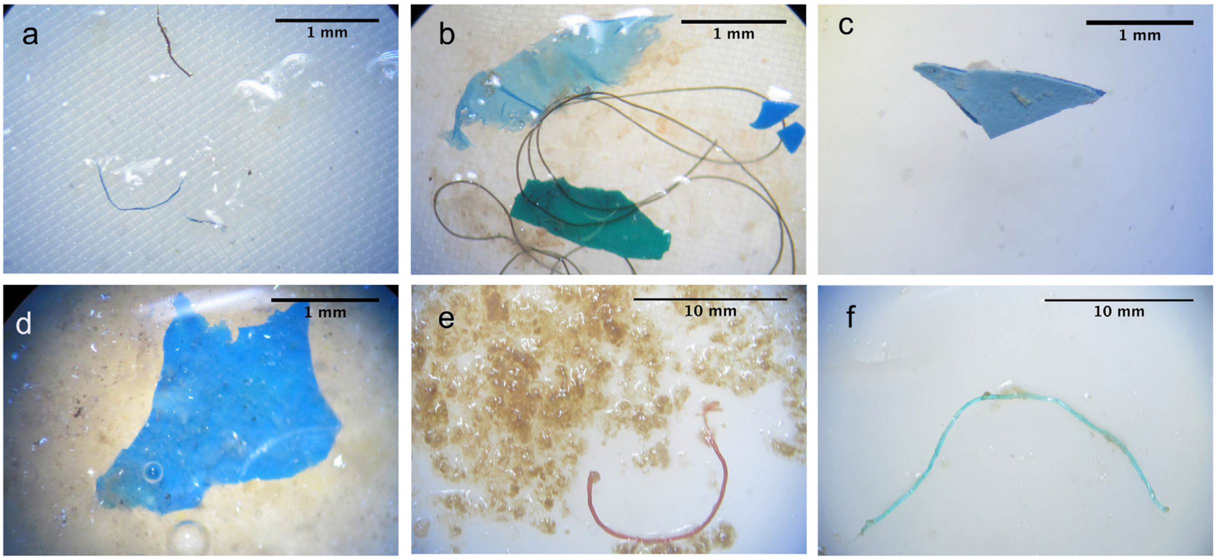


Fig. 3. Microplastics found in the gastrointestinal contents of fish purchased from fish markets in Gran Canaria and Lanzarote. a) Fibres. b) Film, fragments and line found in one fish. c) Plastic fragment. d) Chip paint. e) Red line from fishing gear. f) Green line from fishing gear. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

release thousands of synthetic fibres into the sea through wastewater discharges (Browne et al., 2011; Napper and Thompson, 2016). Paint and lines could come from the fishing activity. Of the debris found, 4 were "lines" probably originating from fishing gear, in the case of this type of debris, the ingestion could have occurred during capture with purse seine. However, the fragments and films are from undetermined sources, from land and sea.

While the present study was carried out in the coastal waters of the Canary Islands, located in the North Atlantic Ocean, the fishing areas were close to urban areas. This could determine the high incidence of microplastics in the gastrointestinal content of Atlantic chub mackerel. In the Canary Islands, sewage, after treatment in wastewater treatment plants (WTPs), is discharged directly to the sea. According to the official data of the Canary Islands Government (http://visor.grafcan.es/visorweb/) (GRAFCAN Cartográfica de Canarias IDECanarias, 2018), there are 20 wastewater effluents in Gran Canaria and 31 in Lanzarote,

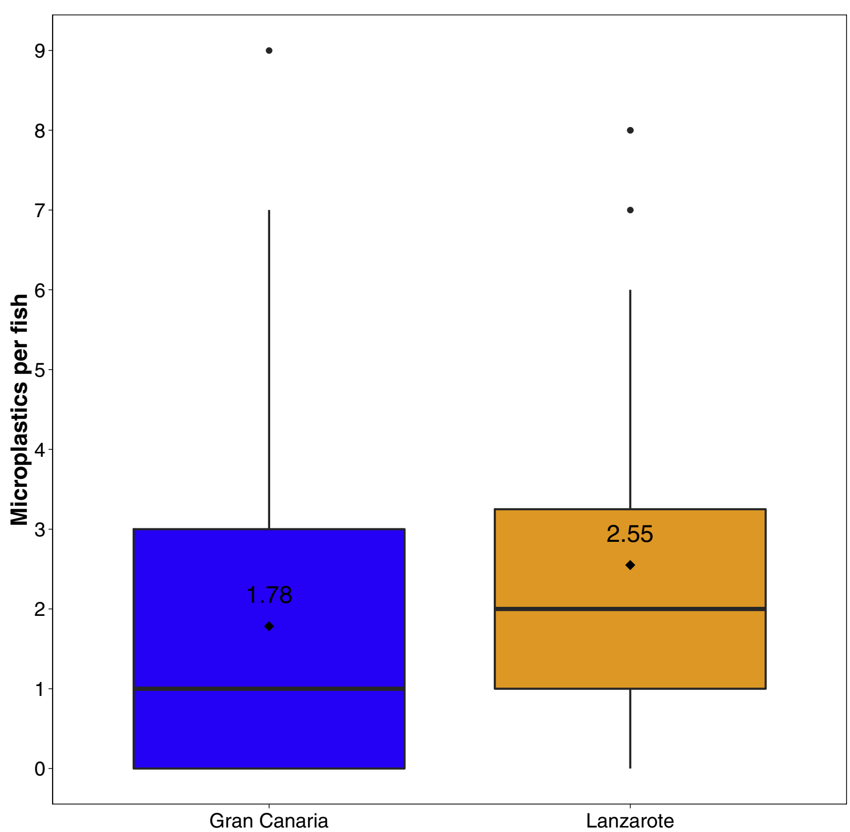


Fig. 4. Microplastics per fish collected from Lanzarote and Gran Canaria. The point and the number in the box represent the mean microplastics per fish. The thick central line of each box designates the median, the box height shows the interquartile range, and the whiskers indicate the lowest and the highest values.

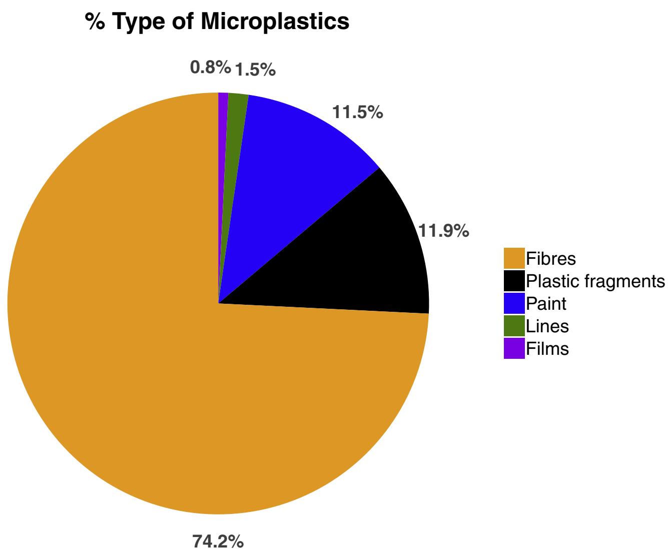


Fig. 5. Percentage of each type of microplastics found.

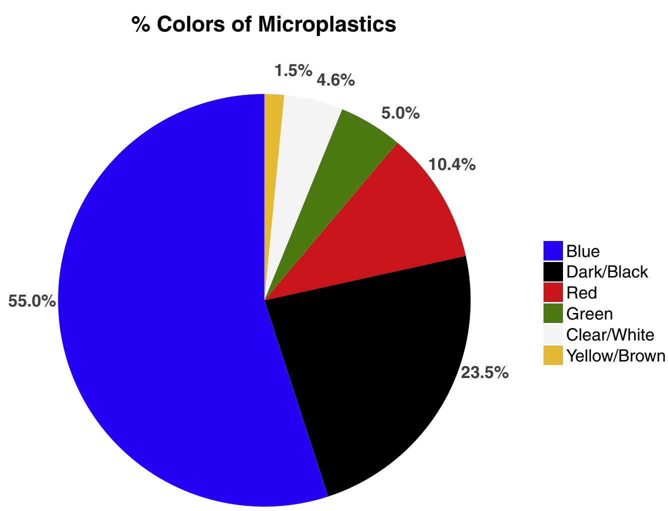
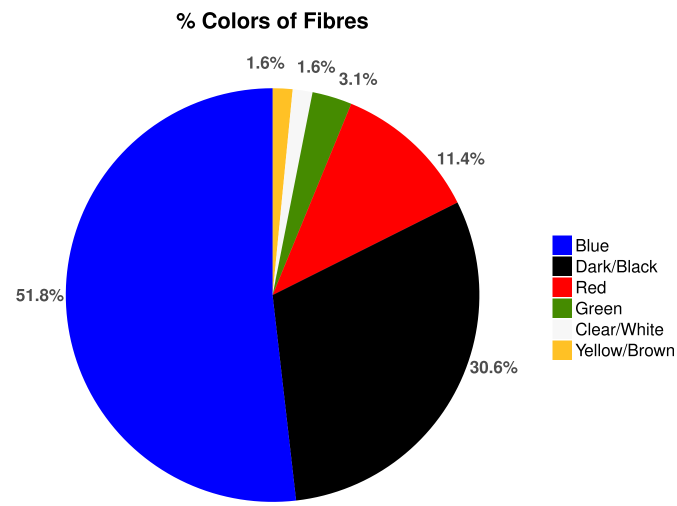
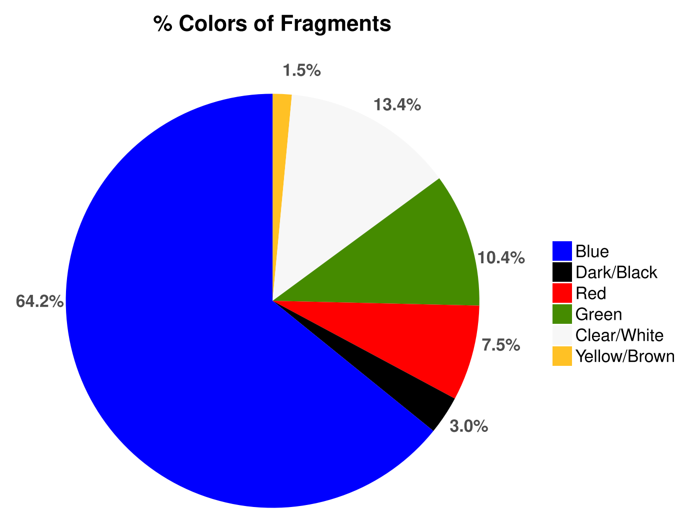


Fig. 6. Percentage of colors of total microplastics found in the stomach content. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)



(a) Color of Fibres



(b) Color of Fragments, Lines, Films and Paint

Fig. 7. Percentage of colors of (a) fibres and (b) fragments, lines, films and paint.

located less than 10 km from fishing areas. Of these discharges, 6 in Gran Canaria and 22 in Lanzarote do not have treatment, or data are not known because they do not have the valid legal authorization (Fig. 1b). In addition, untreated wastewater is occasionally discharged to the sea during heavy rain.

These submarine discharges could be a source of pollution, especially of synthetic fibres, and this could be the reason for the difference in the amount of fibres found in the fish from Lanzarote compared to Gran Canaria. Talvitie et al. (2017) determined that about 98% of the plastics debris are removed in the pre-treatment phase. However, other authors argue that wastewater discharges represent a source of microplastics in aquatic ecosystems (Browne et al., 2011; Correia Prata, 2018; Estahbanati and Fahrenfeld, 2016; Mason et al., 2016; Murphy et al., 2016). Though a major part of microplastics are removed in WTPs due to the large volume that is processed every day, sewage effluents are discharged from approx. 50,000 up to nearly 15 million particles to the environment (Mason et al., 2016).

Although the high incidence of fibres, similar to that found in estuaries or areas with high anthropogenic pressure (Pazos et al., 2017), points to a local source of pollution, we cannot ensure its origin without an ad hoc experimental design assessing the nature and quantity of microplastics released by each of the WTPs discharges along the eastern coasts of Lanzarote and Gran Canaria. In addition to the hypothesis of the local sources of fibres being products of WTPs discharges, we have also inspected the mean ocean circulation in the region of study based on modeling data. This suggests that a relatively strong current (see black arrow in Fig. 1) connecting the east coasts of Lanzarote, Fuerteventura and Gran Canaria might be causing a downstream cumulative effect between the islands. In this case, due to the cumulative effect, fish from Gran Canaria would be contaminated with more fibres than fish from Lanzarote; however, our results indicate, counterintuitively, the opposite. The findings of this work highlight the complexity of this polluted system, stressing the need for further ad hoc studies to determine the origin of microplastics that enter the ocean, primarily due to the release of untreated wastewater discharges, from the islands.

In the microplastics found in the present work, the predominant color both in the fibres and other plastic particles was blue. Other authors reported similar results (Bessa et al., 2018; Boerger et al., 2010;

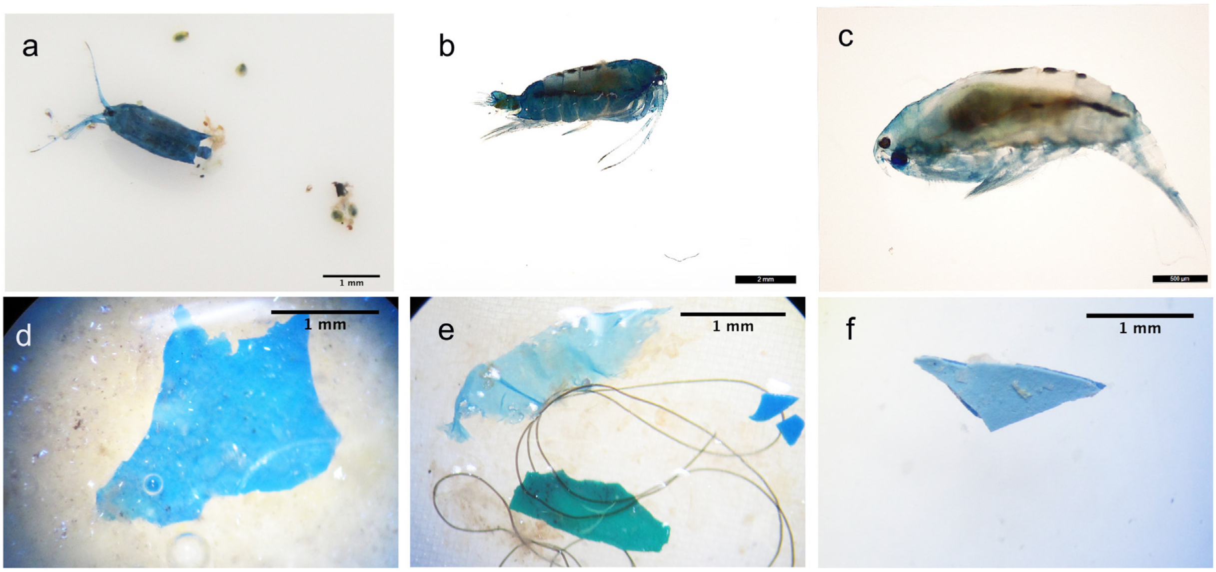


Fig. 8. Copepods of the genus *Labidocera* (a-c) compared with blue microplastics found in fish (d-f).

Davison and Asch, 2011; Ferreira et al., 2018; Güven et al., 2017; Pazos et al., 2017; Peters et al., 2017). Ory et al. (2017) argued that the high incidence of blue color could be due to mistakenly-ingested microplastics that bear resemblance to their natural prey - for instance, some species of blue copepods. In samples collected with a manta net in the surface waters off the Canary Islands, a high percentage of blue copepods (*Labidocera* sp.) were found (unpublished data) (Fig. 8), which could support this hypothesis.

The blue paint chips found here are likely to be fragments of fishing vessel coating, and ingestion could also occur during capture (net feeding). Rummel et al. (2016) also found red and green fragments that were identified as chips from the research on vessel coating. The study excluded these results because they were attributed to post-capture feeding. Even if they are due to post-capture feeding, we have not excluded such data from the results in the present study as they might be important for future studies. It is necessary to investigate whether this is the case, or if contamination is caused by ship painting in coastal areas.

5. Conclusions

1. The present study shows that Atlantic chub mackerel caught in the coastal waters of Canary Islands have a high incidence of microplastics in the gastrointestinal content (78%).
2. Future studies are needed to determine the fish species affected by microplastics, which among them could serve as indicator species, and how microplastics affect fish physiology and health.
3. It is necessary to carry out studies to investigate the different stages of wastewater processing as well as submarine effluents to determine the impact of WTPs as sources of microplastics, mainly synthetic fibres.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.marpolbul.2018.12.022.

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