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Ingestion of microplastics by demersal fish from the Spanish Atlantic and Mediterranean coasts

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ABSTRACT

Microplastic pollution has received increased attention over the last few years. This study documents microplastic ingestion in three commercially relevant demersal fish species from the Spanish Atlantic and Mediterranean coasts, the lesser spotted dogfish *Scyliorhinus canicula*, the European hake *Merluccius merluccius* and the red mullet *Mullus barbatus*. Overall 212 fish were examined, 72 dogfish, 12 hakes and 128 red mullets. The percentage of fish with microplastics was 17.5% (15.3% dogfish, 18.8% red mullets and 16.7% hakes), averaging 1.56 ± 0.5 items per fish, and the size of the microplastics ranged from 0.38 to 3.1 mm. These fish species are used currently as biomonitors for marine pollution monitoring within the Spanish Marine Pollution Monitoring Programme (SMP), and may be as well suitable candidates for monitoring spatial and temporal trends of ingested litter. The data presented here represent a baseline for the implementation of the Marine Strategy Framework Directive descriptor 10 in Spain.

1. Introduction

Over recent decades, plastic wastes have been found in the marine environment worldwide, as a direct consequence of industrial activities, consumption habits and a poor waste management (Jambeck et al., 2015). Several studies have demonstrated that low density plastics (e.g. polypropylene or polyethylene) are dominant in the top layers of the water column, although buoyant plastics may suffer biofouling, making them eventually sink (Andrady, 2011; Zettler et al., 2013, Cózar et al., 2015). On the other hand, high density plastics like polyvinylchloride (PVC), polyester or polyamides, usually sink to the sea bottom (Barnes et al., 2009; Andrady, 2011). Plastics are degraded in oceanic and coastal environments into smaller pieces mainly by mechanical erosion, due to the action of winds and waves, by physical abrasion against particles of sediment, or by solar radiation; whereas chemical degradation is slow (Moore, 2008; Barnes et al., 2009). Erosion and fragmentation is greater on beaches due to solar radiation and the action of waves, whereas fragments floating on the surface or below the photic zone will degrade much slower because of the lower temperature and the attenuation of solar UV radiation (Andrady, 2015).

Plastics are considered chemically inert but the organic compounds used as additives to modify the properties of the original polymers can be harmful to living organisms, affecting their endocrine systems and therefore their reproductive capacity (Talsness et al., 2009; Lithner et al., 2011). In addition plastics have the capacity to concentrate organic contaminants like polycyclic aromatic hydrocarbons (PAH), polychlorinated biphenyls (PCB) and dichlorodiphenyltrichloroethane (DDT), depending on the type of polymer (Rios et al., 2007; Heskett et al., 2012). In this regard, some studies have speculated about a possible pathway of environmental pollutants into the marine food web by plastic ingestion (Moore, 2008; Teuten et al., 2009; Cole et al., 2011).

The implementation of the European Commission's Marine Strategy Framework Directive (2008/56/EC, MSFD) has prompted the efforts of specialists to create a common framework for the monitoring of the impact of marine litter in European seas (MSFD, Descriptor 10: *Properties and quantities of marine litter do not cause harm to the coastal and marine environment*). During the MSFD implementation process, member states have recognized the lack of an indicator to assess the impact of microlitter in biota (MSFD, Descriptor 10. Indicator 10.1.3. *Trends in the amount, distribution and, where possible, composition of microparticles -in particular microplastics-*), which has become a research priority.

Although there is still debate, microplastics, first described by Thompson et al. (2004), may be defined as plastic particles smaller than 5 mm in diameter (Arthur et al., 2009). This term includes primary microplastics, i.e. plastic particles that were produced in small size to be used in plastics production (resin pellets), cleaning, cosmetic and medical products, and secondary microplastics, resulting from the fragmentation of larger items (Thompson et al., 2004; Cole et al., 2011). Recent studies have demonstrated that microplastic pollution is widespread

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in the marine environment, from the sea surface to the bottom, even in the deep-sea or in Polar Regions, and continues to rise (Lusher, 2015).

The impacts of macroplastics by ingestion, smothering or entanglement have been well documented for a variety or marine species, which has led to the consideration of plastics as hazardous materials (Rochman et al., 2013). Different studies have shown the obstruction and damage of digestive tracts or even animals starving to death caused by stomachs filled with plastic (reviewed by Kühn et al., 2015). However, due to methodological difficulties in their quantification, the impact of microplastics in marine organisms is not well known. Because of their small size, microplastics may be ingested by marine organisms, whichever are their feeding mechanisms, and may enter their circulatory system and accumulate in different types of tissues, as has been proven in laboratory experiments (Browne et al., 2008). Laboratory studies also indicate that microplastics may have the ability to enter and propagate through the marine food web (Farrell and Nelson, 2013; Setälä et al., 2014). However, the impact of microplastics on natural populations is still not well understood (Murray and Cowie, 2011; Lusher et al., 2013).

The aim of this study was to investigate microplastic ingestion in demersal fish species from different Atlantic and Mediterranean Spanish marine regions. To this end, abundance of microplastics ingested by the commercially important species: *Scyliorhinus canicula*, *Merluccius merluccius* and *Mullus barbatus*, was calculated. The lesser spotted dogfish *S. canicula* (Linnaeus, 1758) is found from the uppermost slopes off the coast of Norway to Senegal, including the Mediterranean and the Adriatic Seas. It is found primarily over sandy, gravely, or muddy bottoms at depths down to 400 m, and preys on a wide range of organisms including polychaetes, crustaceans, molluscs, cephalopods and other fish (Rodríguez-Cabello et al., 2007). The European hake *M. merluccius* (Linnaeus, 1758) is found from the coasts of Norway and Iceland to Mauritania including the Mediterranean Sea, from 30 to 500 m depth, and may have nocturnal migrations to surface waters. Juvenile individuals are usually found in muddy bottoms on the continental shelf whereas adults are found on the shelf slope. It is an opportunistic predator that feeds mostly on fish, but also on other organisms such as molluscs or crustaceans (Murua, 2010). The red mullet *M. barbatus* (Linnaeus 1758) is found in sandy and muddy bottoms in depths down to 200 m, from Scandinavia to Senegal and also in the Mediterranean and Black Seas. They mainly feed on polychaetes but crustaceans may also form part of their diet (Bautista-Vega et al., 2008).

2. Materials and methods

Fish were collected during the bottom trawl surveys "DEMERSALES 2014", "ARSA 2014" and "IBERIANMULLUS 2014", conducted by the Spanish Institute of Oceanography (Instituto Español de Oceanografía, IEO) at four sampling areas: i) the Galician coast; ii) the Cantabrian coast (N-NW Spain, NE Atlantic Ocean), at depths from 46 to 302 m; iii) the Gulf of Cadiz (SW Spain, NE Atlantic Ocean), at depths from 25 to 487 m; iv) and the Spanish Mediterranean coast (NE-E and SE Spain, W Mediterranean Sea), at depths from 33 to 90 m (Fig. 1). Trawling operations were carried out during daylight at a speed of 2.5–3 knots, using a baka 44/60 (DEMERSALES), a baka 40/60 (ARSA) and a GOC73 (IBERIANMULLUS) trawl gears. Dogfish (33.3 $\pm$ 2.2 cm) were collected in the three Atlantic areas, while hakes (33.5 $\pm$ 2.1 cm) were only captured in the Gulf of Cadiz. Red mullets (16.8 $\pm$ 1.6 cm) were sampled from five subareas within the Mediterranean waters: Barcelona, Cartagena, Málaga, Mahón and Ciutadella (Table 1).

Fish were frozen, transported to the laboratory and stored at −20 °C until further laboratory analysis. Subsequently, each fish was defrosted and dissected from the upper part of the oesophagus to remove the stomach, according to methods published elsewhere (Claessens et al., 2013; Lusher et al., 2013; Rocha-Santos and Duarte, 2015). Stomachs

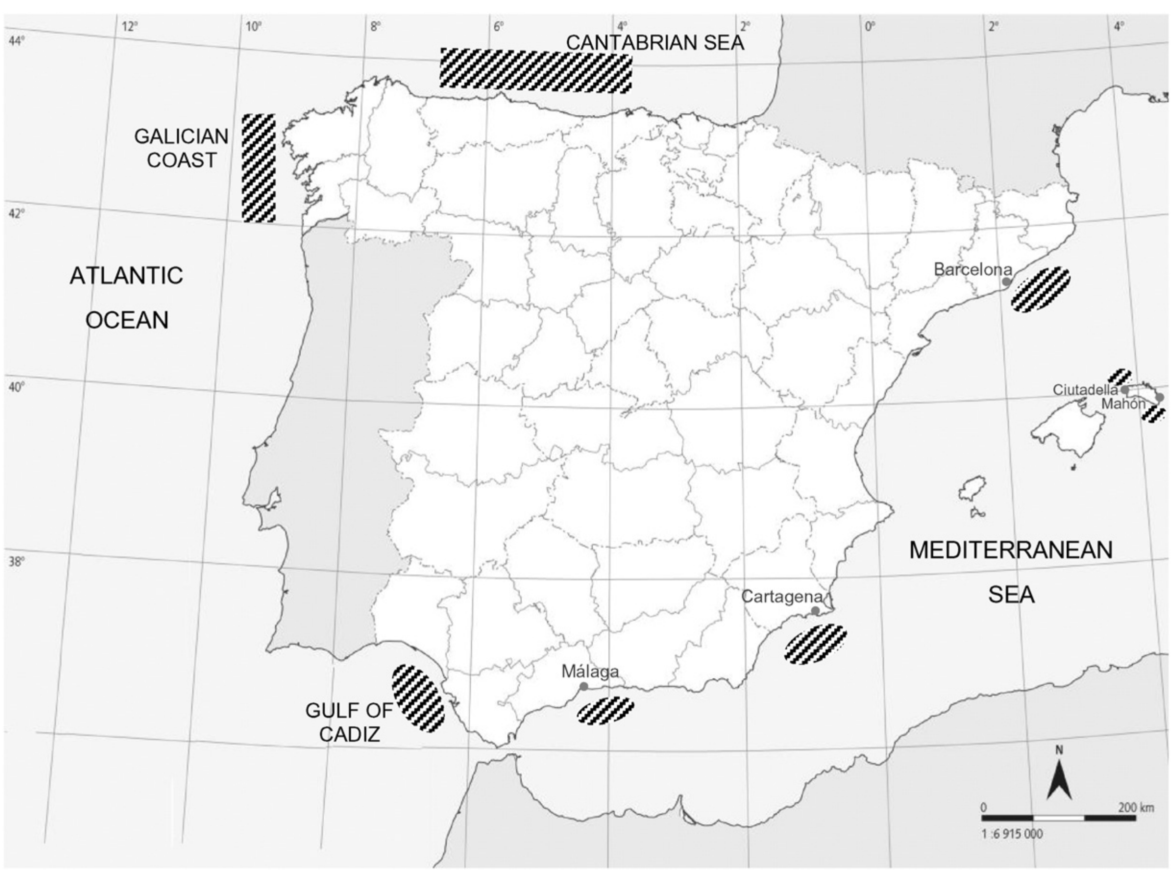

Fig. 1. Map of the Spanish coast showing the location of the sampling areas.