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# Potential microplastics impacts on African fishing resources

Masiá Paula [1], Mateo Juan L. [1], Arias Andrés [1], Bartolomé Marlene [1], Blanco Carmen [1], Erzini Karim [2], Le Loch Francois [3], Mve-Beh Jean-Herve [3, 4], Powers Deborah [2], Rodriguez Noemi [1], Schaal Gauthier [3], Machado-Schiaffino Gonzalo [1], Garcia-Vazquez Eva [1, *]

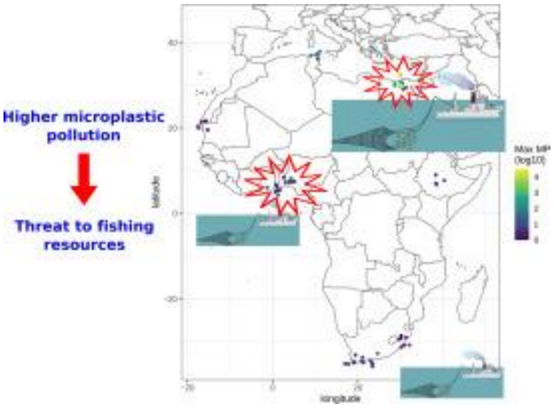
[1] University of Oviedo, 33071 Oviedo, Spain
[2] Centro de Ciências do Mar (CCMAR), Universidade do Algarve, 8005-139 Faro, Portugal
[3] University of Brest, CNRS, IRD, Ifremer, LEMAR, F-29280 Plouzane, France
[4] Laboratoire d'Hydrologie et d'Ichtyologie, IRAF, CENAREST, Libreville, Gabon

* Corresponding author : Eva Garcia-Vazquez, email address : egv@uniovi.es

## Abstract :

Microplastic (MP) pollution is increasing worldwide and affecting aquatic fauna in different ways, which endangers current aquatic resources in a still unknown extent. MP-induced threats to marine fauna are critical for developing countries, where waste treatment may be not optimal and coastal communities rely heavily on marine resources for dietary protein. In this study, we assess the importance of MP pollution for African fishing resources. A new meta-database was created from published studies, containing 156 samples with more than 6200 individuals analysed for microplastic content from African and adjacent waters. A combination of research landscape analysis and rank analysis served to identify main research targets and to determine regional fishing resources especially affected by MP. A network of relevant terms showed fish health as a concern in Mediterranean waters, environmental pollution in freshwater and an emphasis on plastic items in South Africa. MP contents in fishing resources from Nile countries and the Gulf of Guinea, followed by Tunisia, are significantly higher than in other regions. Some of the most exploited species are among the most polluted ones, highlighting the threat of MP pollution in valuable but already compromised African fishing resources. Large geographic gaps with almost absent data about MP in aquatic fauna were revealed, especially in freshwater and in East African coasts. These results emphasize the importance of increasing the coverage of MP pollution in African fishing resources, and improving plastic waste management in the continent.

## Graphical abstract



## Highlights

► Microplastics are emerging contaminants that endanger aquatic resources. ► There is a lack of studies about microplastics in specific areas like Africa. ► Meta-database of 156 samples of fishing organisms from quality publications ► High microplastic pollution in Nile countries, Gulf of Guinea and Tunisia fish ► Some of the most fished African species are highly microplastic-polluted. ► African fishing resources can be threatened by microplastics in some regions.

**Keywords** : Biodiversity threats, Fisheries, Meta-analysis, Plastic pollution, Research landscape

## 1. Introduction

Plastic debris has become globally ubiquitous, being one of the biggest hazards for the environment, especially for marine ecosystems (Derraik, 2002). In modern societies plastic seems to be essential, because packaging is responsible for half of the world's plastic waste (Ritchie et al., 2018). The amount of waste generated and accumulated in the ecosystem is huge, so this material has been proposed as a geological marker of Anthropocene strata in marine sedimentary deposits (Zalasiewicz et al., 2016). The way plastic pollution affects ecosystems, and especially marine wildlife, undermines the United Nations Sustainable Development Goal #14 "Life Below Water" (https://www.globalgoals.org/14-life-below-water, accessed July 2021), and is indeed an increasing concern in the scientific community (e.g., Gall & Thomson, 2015; Provencher et al., 2017). One of the aspects related with plastic litter that has recently raised scientific and societal concern is aquatic microplastic pollution (Lim, 2021).

Microplastics (MP hereafter) are small fragments of plastics (< 5mm), originated from the fragmentation of bigger pieces of plastic (secondary MP), or directly produced of this size (primary MP) for different uses (Arthur et al., 2008). Since the first reports of MP pollution in the Sargasso Sea (Carpenter & Smith, 1972), this problem has become a serious environmental threat. Nowadays MP can be found even in the most pristine and remote ecosystems, from Polar regions (Cozar et. al., 2017; Peeken et al., 2018) to coral reefs (Hall et al., 2015; Huang et al., 2021), and from the deep-sea floor (Van Cauwenberghe et al., 2013; Woodall et al., 2014) to the atmosphere (Allen et al., 2019). MP entering the ocean come from multiple sources like landfills, paint and coating, wastewater treatment plants, fishing and aquaculture, atmospheric transport and others (Naper & Thompson, 2016; Boucher & Friot, 2017; Lusher et al., 2017; Gaylarde et al., 2020; Hale et al., 2020; Masiá et al., 2021a). Once in the ocean, the fate of MP is determined by multiple factors like hydrodynamic, wind-driven processes and others (Zhang, 2017), which tend to accumulate in oceanic gyres (Eriksen et al., 2013). Large amounts of MP in aquatic habitats are associated to stormwater and flood events (Veerasingam et al., 2016). Rivers are one of the main sources of MP in the marine environment (e.g. Schmidt et al., 2017; Meijer et al., 2021). Moore et al. (2011) estimated a load of 2 billion particles over 3 days for South California rivers; Mani et al. (2015) calculated a daily average load of 191 million particles of MP transported from the Rhine River into the North Sea. Meijer et al. (2021) emphasized the high plastic load of small urban rivers compared to rivers of predominant cultivated lands; for example the small Ciliwung River in Indonesia would emit more plastic into the ocean than the 200-fold larger Rhine River. Although marine settings, as the final sink of MP, are currently subjects of most studies on plastic pollution, freshwater ecosystems are equally threatened because of this ubiquitous pollutant (Rochman, 2018). Rivers, lakes, reservoirs are also MP sinks and temporary reservoirs, and even pristine mountain springs have MP coming from the atmosphere and deposited by rainfall (Wang et al., 2021).

MP have been broadly studied worldwide, but their prevalence and influence on aquatic ecosystems and organisms remain largely understudied in developing countries, where improving plastic (including MP) waste management is urgently needed. Here we will focus on Africa for several reasons. First is the current and predicted increase of plastic and MP load by 2050. Meijer et al. (2021) modelled the global emission of plastics into the ocean and, from their results, Africa is not the principal emitter at a continent level, but some African countries like those located around the Gulf of Guinea, South Africa or Morocco would contribute more than any European country to the ocean plastic load. The risk will likely increase the next years. Van Wijnen et al. (2019) estimated that, although *per capita* plastic and MP emissions of African countries are now below those of East Asia, the Organisation for Economic Co-operation and Development (OECD) and Latin American countries, under the scenario of “Business as usual” (same population, trade and waste treatment trends as today) they will become the second MP exporters by 2050, above Latin America and OECD countries and approaching East Asian emissions. Only in an “environment profits” scenario of solid waste collection rate of 90% and an efficient wastewater treatment plants (WWTP) removal rate of 95% will African countries remain in the same regional position as they are today (van Wijnen et al., 2019). Today, this scenario looks like a difficult goal. In South African rural areas, households frequently discharge wastewater directly to rivers, increasing MP - especially fibres from clothes (Verster & Bouwman, 2020). The same issue has been reported in other African countries, such as Ghana (Ampofo, 2015; Yeboah, 2020). Shabaka et al. (2020) reported the highest amounts of MP in fish worldwide from Egyptian waters, classified by Alimi et al. (2021) amongst the most MP-polluted in Africa.

The second reason is the coverage of MP data in aquatic environments is poor in Africa, thus we need studies providing a global view of what is known already and what is needed to know yet, to prioritize future efforts. Despite being the third largest continent and containing potentially some the most heavily affected regions in the world, studies addressing microplastic pollution are relatively scarce, at least in comparison with other continents. In a recent review, Alimi et al. (2021) found a variable proportion of aquatic organisms, between 5 and 100% depending on the species and location, to contain MP in African waters. Different toxic products have also been found associated with MP in this continent, like POPs and heavy metals (Alimi et al., 2021). These authors reported studies on MP only from 11 of the 54 countries in the continent, highlighting the need of more studies about this hot pollution topic in Africa. Similarly, Savoca et al. (2021) found large coastal regions with no data about plastic and/or MP ingestion in marine fish: in the Atlantic, between South Africa and the south of Gulf of Guinea; in the Indian Ocean, all the coast from the north of Tanzania to the Red Sea, including the Gulf of Aden. Most studies have targeted Northern African countries situated in the Mediterranean Sea (e.g., Abidli et al., 2018; Toumi et al., 2019; Maaghloud et al., 2020; Tata et al., 2020), and South Africa (e.g., Nel & Froneman, 2015; Naidoo & Glassom, 2019; Dahms et al., 2020; Preston-Whyte et al., 2021). Studies focused on western and central African countries are scarce, with a few exceptions in Nigeria (e.g. Adeogun et al., 2020; Akindele et al., 2020), Ghana (e.g. Adika et al., 2020) and Guinea (Lourenço et al., 2017), while there is a general lack of such information for eastern Africa.

Reviews covering MP in Africa focused principally on environmental and ecological threats so far (e.g. Alimi et al., 2021; Savoca et al., 2021), but MP threats on fisheries is an aspect yet to be explored. Another reason to investigate the status of MP pollution in African fish is many African countries rely on fisheries for protein supply and employment (Belhabib et al., 2015a; FAO, 2020). The risk of stock depletion due to overfishing and climate change is a serious threat for the nutrition of many Africans (Golden et al., 2016, Cheung et al, 2016). If MP damages aquatic organisms in any way, fishing resources are exposed to an additional threat that needs to be known. The problem is not only local. Current globalization of fisheries and fish trade extends the potential impact of MP pollution of African fish to a worldwide scale. Since 1960, fishing fleet from the EU, Asia and Russia increased their fish catches from African waters considerably (Belhabib et al., 2015b), with some species highly exploited (e.g. Alder & Sumaila, 2004; Belhabib et al., 2019). As an example, nowadays EU fleets fish territorial waters of 13 African countries using active bilateral fishing agreements (of the total number of 14 that the EU has active worldwide); in these Sustainable Fisheries Partnership Agreements, EU vessels have access to exclusive fishing zones of those countries (Johnson et al., 2021). Thus, Asia and Europe should also be interested in the status of MP pollution of African fish stocks.

Feeding behaviour and other biological features determine the degree of exposure of marine animals to different types of plastic polymers (Wright et al., 2013). Filter-feeding organisms or sediment-feeders that do not catch food actively can accumulate high loads of MP in their tissues reflecting environmental MP pollution. For example, mussels ingest so easily many MP particles that they have been proposed for MP biomonitoring (Kazour & Amara, 2020), while holothurians concentrate plastics and their pseudofeces are MP hotspots (Bulleri et al., 2021). The position in the food web can also determine how much MP an organism takes. MP enter the food web from low levels like zooplankton, that may eat MPs because they are small, abundant and of different colours so may be taken as food (Setälä et al., 2014). MP are then transferred up the food web, from low to intermediate trophic level organisms (Farrell & Nelson 2013; Setälä et al., 2014; Welden et al., 2018), up to top predators (Erikkson & Burton, 2003; Nelms et al., 2018). In a recent meta-analysis, Savoca et al. (2021) found that predatory fish are commonly found to consume plastics, top predators having a higher risk for their higher mobility and multiplied probability of encountering plastic from many locations; either via food and/or gills.

Although researchers discuss the real level of threat posed by MP to the aquatic community, unambiguous evidences of MP being dangerous for aquatic animals are growing (Lim, 2021; Parker et al., 2021). Sublethal effects of MP exposure in zooplankton include alterations in swimming capacity and feeding behavior, changes in enzyme activity, neurotoxic effects and oxidative stress (Cole et al., 2015; Gambardella et al., 2017). Adverse effects of MP on fish have been proved under laboratory conditions, at different levels and in many species (Wang et al., 2020; Parker et al., 2021). To cite a few, in zebrafish *Danio rerio*, MP cause reproductive problems, metabolic toxicity and disorders, oxidative damage and inflammation, oxidative stress, and neurotoxicity (Zhao et al., 2020; He et al., 2021; Sheng et al., 2021). In commercially important species such as the gilt-head sea bream *Sparus aurata*, MP contribute to cellular stress and disrupts social and feeding behaviour (Rios-Fuster et al., 2021). In the European sea bass *Dicentrarchus labrax* MP cause neurotoxicity, lipid peroxidation, enzyme activity changes, and enhance the uptake and accumulation of mercury in brain and muscle (Barboza et al., 2018), as well as oxidative stress (Zitouni et al., 2020). Ding et al. (2018) found that MP cause inhibition of acetylcholinesterase activity in *Oreochromis niloticus* brain, thus neurotoxicity, and metabolic alterations; antioxidant capacity (SOD, catalase etc.) is depressed after exposure to high concentrations of MP (Hamed et al., 2020). Persistent anemia in juveniles of this species is MP concentration and exposure time-dependent, increasing mortality risks (Hamed et al., 2019); the same happens with innate immunity depression and liver damage in *Oncorhynchus mykiss* (Hodkovicova et al., 2021). At realistic exposure levels –similar to those that can occur in many coasts, polystyrene particles induce DNA degradation in the commercial mussel *Mytilus* *galloprovincialis* (Masiá et al., 2021b). Moreover, there are also signals of harmful effects of MP on wild fish. In the Mediterranean Sea, the content of MP in *Sardina pilchardus* is positively associated with the prevalence of parasites (Pennino et al., 2020). In addition to their direct effects, MP are vectors of toxic compounds, such as Bisphenol A (Lithner, 2019), persistent organic pollutants (POPs), antibiotics and pesticides (De Sá et al., 2018), that can be assimilated and bioaccumulated by aquatic organisms causing further damage (Bakir et al., 2014; Tourinho et al., 2019). Therefore, MPs are a threat for fish population health, and consequently fishing and aquaculture resources. Moreover, although the consequences of consumption of MP-polluted seafood for human health are yet to be fully understood (Carbery et al., 2018; Prata et al., 2020), MP might be a problem for human consumers too.

This study aims to recognize gaps in the knowledge on MP pollution in African fish and invertebrates important for fisheries, with the following objectives: (i) Summarise the current research landscape of MP pollution in exploited aquatic African species; (ii) Identify threats derived from MP pollution for fishing resources of different regions and fish groups; (iii) From the results of i) and ii), suggest research and management priorities principally focused on commercially important species. For this, we analysed state-of-the-art literature using network clustering, created a metadata set, and from MP pollution, current conservation status of the species, and catch data, established a rank of impacted resources. From current knowledge about the relative MP pollution of African waters (Alimi et al., 2021), we expected African fisheries of the East Mediterranean and Nile basin regions to be the most threatened by this emerging pollutant.

## 2. Materials and methods

### *2.1 Literature review*

We followed PRISMA-based approach for literature revision (Preferred Reporting Items for Systematic reviews and Meta-Analyses; Moher et al., 2009). Databases used in scientific literature search included Google Scholar, PubMed and Web of Science. The following terms were employed: “Africa”, “microplastics”, “aquatic”, “organisms”, “fish”, “Indian Ocean”, "Atlantic Ocean" "Mediterranean sea", using AND (for "Africa" and "microplastics") and AND/OR boolean operators in the search engines. In boolean logic (algebra used to create true/false statements), using AND we will retrieve articles that contain together the words indicated, while with AND/OR we will retrieve articles containing at least one of the terms indicated. After searching the abstracts, publications specifically addressing microplastics in Africa and surrounding waters, sediments and organisms were retained and reviewed in greater detail. Not relevant articles, and papers whose quality was judged as not sufficient, that is, those not meeting the selection criteria, were excluded (see below). Finally, only studies with data expressed in convertible units were retained for the database and quantitative analysis (Supplementary Table 1).

Selection criteria were:

a) Peer-reviewed studies (either articles or published theses).

b) Studies conducted on Africa and adjacent waters, allowing sampling points in south European and southwest Asian waters (e.g. Turkey, Lebanon, Red Sea) because many aquatic organisms are highly mobile in their planktonic larvae or adult phase.

c) Studies on aquatic animals of relevance for fisheries; either directly consumed species, species used as bait, and/or preys of commercial species.

d) Studies disclosing geographical information i.e. where the samples were taken from (geographical coordinates).

e) Studies disclosing the number and/or concentration of microplastics in organisms and/or water and/or sediment.

f) Articles stating the measure units of MP e.g., number of microplastics per individual (MP.ind$^{-1}$) or per weight unit.

### 2.2. Meta-database creation

The majority of studies reporting units of MP content provided data expressed in MP.ind$^{-1}$ thus this unit was chosen to represent MP pollution in organisms. A few articles reported data in organisms as MP.weight$^{-1}$. Those articles were retained to construct the meta-database when the data could be transformed into MP.ind$^{-1}$, for example when individual weight was disclosed. Data not convertible in standard units were excluded.

From each article, information about MP content, standard deviation, author, year of publication and coordinates of the sampling sites were extracted into a database generated in a spreadsheet, organized by population samples – each sample corresponding to a species, location and year. Samples size was also recorded. For each species, taxonomy was aligned with the World Register of Marine Species WoRMS, accessible at www.marinespecies.org; WoRMS Editorial Board, 2021). FishBase (https://www.fishbase.se/search.php; Froese and Pauly, 2021), WoRMS and relevant literature (for invertebrates) were employed to retrieve relevant information about the biology and life history of the species.

Information about fishing captures was extracted from FAO (Food and Agriculture Organization of the United Nations) statistics website (FAO, 2021); annual catch from 2018, an intermediate year in the series of analyzed articles. When a species is produced from extractive fisheries and aquaculture in a country (e.g. *Oreochromis niloticus* in Egypt) we used the total production (extractive fisheries + aquaculture) because aquaculture waters can be MP-polluted (Reinold et al., 2021). FAO aquaculture data are in http://www.fao.org/fishery/statistics/global-aquaculture-production/en, and capture data (extractive fisheries) in http://www.fao.org/fishery/statistics/global-capture-production/query/es, accessed in August 2021. Some countries report data to the FAO by the common or by the generic name. Matching species of our list allocated to this type of data are marked in the dataset like the maximum catch, since it is possible that those labels contain a mixture of species.

Species conservation status in a region (if available) or global was extracted from the International Union for Conservation of Nature IUCN webpage (https://www.iucnredlist.org/es; accessed in July 2021). Data were geographically coded considering six main areas, according with the main basins in Africa: Northwest, NW

(Atlantic Ocean from Morocco and surrounding waters up to Portugal, to Liberia); Gulf of Guinea, GG; southern Africa (from Angola to Tanzania around Cape of Good Hope), SA; Nile basin countries from river heads to the mouth and surrounding waters, NB; eastern part of the Mediterranean Sea, EM; west Mediterranean Sea, WM. The division between east and west Mediterranean was the strait of Sicily.

The following data were extracted and codified per population sample (Supplementary Table 2):

- Authors
- Publication year
- Permanent digital object identifier (DOI)
- Coordinates of the sampling site. Latitude and longitude.
- Country
- Local ecosystem. Local sampling area (specific estuary, coast zone, river sector, lake etc.)
- Geographical region as explained above: EM, GG, NB, NW, SA, WM.
- Species, scientific name
- Species, common name
- Sample size, as number of individuals analysed
- Trophic level. Values between 2 (herbivores) and 5 (top predators)
- Feeding behaviour. Filter or sediment-feeding (2), Active feeding (1)
- Dispersal capacity. 1-3 for Sedentary, Migratory, Highly migratory
- Main environment type. 1-3 for Marine, Brackish water, Freshwater. For diadromous species the habitat they are fished from was considered.

- Annual species catch (in tonnes) per country (the lowest geographical level available in FAO database), which indicates the value of that species as a fishing resource for that country.

- Species conservation status (SCS). 1 to 6 for Least concern, Data deficient, Near Threatened, Vulnerable, Endangered, Critically endangered. For precautionary approach, not evaluated species were treated as Data deficient.

- Mean MP.ind$^{-1}$ and its standard deviation.

- Maximum MP.ind$^{-1}$.

### *2.3. Data analysis*

#### 2.3.1. Analysis of research landscape

To understand the main issues investigated so far about MP in African species we performed a cluster analysis of key terms based on the keywords of the articles (following Klingerhöfer et al., 2020), adding the abstracts to increase the number of eligible terms if words related with fisheries did not appear as keywords. A network-based map was constructed using the open source software VOSwiever v.1.6.15 (van Eck & Waltman, 2010). Common uninformative terms like mean, percentage, density, location or specimen, and synonymous or redundant terms, were removed from the selected list to create the network.

We applied the following settings: binary counting; variable number of minimum occurrences of a term; variable percentage of most relevant terms selected. The clustering method employed was association strength, with these settings: merging small clusters and a minimum cluster size of three.

#### 2.3.2. Global overview of the metadata

The global variation of the metadata was visualized employing a principal component analysis (PCA) that helped to understand possible associations between the functional diversity of the species analyzed, their conservation status, location (defined by latitude and longitude of the sampling points), and MP pollution (maximum and mean MP.ind$^{-1}$). Life history and functional traits considered were trophic level, dispersal capacity (= mobility, adding one point to the fish scores for clear shorter distances of adult mobility of the invertebrate species found in this study), feeding behavior, and the environment the species was sampled from (brackish water, freshwater, marine). We used the correlation option, thus only one variable of each pair with $r > 0.8$ in pairwise correlations was retained. The scatter plot of PC 1 and 2 was constructed with biplots where the loadings were represented by diagonals of length proportional to their relative weight. Components with Eigenvalue > 0.7 were considered.

A map showing the location of the samples and the maximum number of MP per individual was constructed using R (R Core Team, 2021) and the package ggplot2 (Wickham, 2016).

### 2.3.2. Analysis of MP threat in exploited species

In experimental settings and in observational data from the wild, the damage caused by MP in fish increases with MP concentration (e.g. Hamed et al., 2020; Pennino et al., 2020). Thus we can reasonably assume that organisms carrying more MP will be more negatively impacted than those carrying less MP. We considered two scenarios, one taking into account only the MP pollution and another considering the conservation status of the exploited species. In the first scenario (Scenario 1) we used MP.ind$^{-1}$ as a proxy of the possible population threat posed by MP. Two values were employed: *MPmax* (maximum number of MP.ind$^{-1}$) that is available for all the samples, and *MPmean* (mean number of MP.ind$^{-1}$) that is available for a proportion of the compiled samples.

In Scenario 2 we assumed that the negative impact of MP would be higher in already stressed vulnerable or endangered populations. Experiencing multiple environmental stressors translates to decreased survival (Lange & Marshall, 2017), epigenetic changes (Ardura et al., 2018), decreased fitness (Petitjean et al., 2019), and other negative effects depending on the species. Although the effect of the exposure to multiple stressors can be either synergistic or antagonistic, depending on the stressors and the species (Petitjean et al., 2019), for precautionary approach here we have considered a multiplicative effect, which explains synergistic effects of multiple stressors in other studies (e.g. Ardura et al., 2018). The threat was estimated in this scenario multiplying *MPmax* or *MPmean* by IUCN conservation status (see SCS above). This new index was called "Microplastics conservation threat" = *MPct*, as:

$MPct$ = [SCS] * [MP.ind$^{-1}$]

Focusing on fishing resources, populations in potential risk were identified using rank analysis in the two scenarios. First we ranked the population samples by the MP threat variable for each scenario. In Scenario 1 we ranked the population samples by *MPmax* (all the samples had this datum), then by *MPmean* (to distinguish between populations with the same maximum) as a proxy of the relative impact of MP on a species. In Scenario 2 we ranked the population samples by the index *MPct* calculated with *MPmax*, then calculated with *MPmean*. The global risk to fishing resources derived from MP in a region was estimated from the mean rank of the samples from that region. Although fishing statistics is missing for some species and countries, all the populations considered in this study are exploited (by commercial, subsistence and/or recreational fisheries, harvesting for bait, etc.).

Focusing on fishing production, we analysed the potential impact of MP on commercial fisheries only for the species with FAO catch data. Since FAO statistics are given by country, in case of multiple samples of a species from a country we have used the most polluted sample as a country's representative, by precautionary approach. The two scenarios were visualized plotting cumulative species production in the country on MP contamination indices. Highly exploited species (contributing more to the total catch) are seen as a gap in the plot, and their relative position on the X-axis indicates how much MP-polluted or threatened they are. The potential impact on the fisheries of a region was estimated from the distribution of regional samples in rank quartiles Q1, Q2, Q3 and Q4 from highest to lowest threat (= position in the rank).

Metadata were explored first using a Principal Component Analysis, with correlation option and considering only variables with pairwise r < 0.8 (disregarding one variable of each pair with r ≥ 0.8). Non-parametric statistics was preferred due to large data dispersion. Differences between Scenario 1 and Scenario 2 ranks were estimated from two-sample paired Wilcoxon test and sign test. Differences in mean ranks (between regions, between environments) were estimated using Kruskal-Wallis test and post-hoc pairwise Mann-Whitney. Comparison among regions for the potential impact of MP on fisheries was done using contingency statistics (contingency Chi Square and exact Fisher tests), employing Cramer’s V to estimate effect size. When significant, stepwise post-hoc contingency tests were conducted to determine groups of regions differently impacted. Although not optimal method, a complementary multiple regression model was run to further support Kruskal-Wallis results, with organism MP pollution as dependent and the rest of factors related with MP content as independent variables. Standard significance level was adopted at $p < 0.05$, applying Bonferroni correction for multiple comparisons whenever relevant. Free software PAST v.3 (Hammer et al., 2001) and ©Meta-Mar V2.7.0 (available at https://www.meta-mar.com/, accessed August 2021) was employed.

*2.4. Publication bias*

The metadata analysed quantitatively in this study were obtained from 156 population samples published in 32 articles (Figure 1). For relatively small number of articles we would expect publication bias, but articles did not compare samples from different regions, nor of different environments, so fail-safe number - the number of papers that would need to be published with non-significant results to change the mean effect size to a non-significant result- could not be calculated for differences among regions in a standard way. We have considered pairs of articles reporting mean MP.ind$^{-1}$ and extracted a subset of random sample pairs of similar trophic level and the same type of organism (fish, bivalve) from regions significantly different for MP pollution, as long as possible without repeating samples in different pairs. We used environment as moderator. Trophic level was taken into account for its implication in the level of plastic ingestion (Savoca et al., 2021). To test publication bias in the inferred differences between environments we employed mean MP.ind$^{-1}$ data from a subset of papers, selecting fish of similar trophic level inhabiting in different environments within the same region from each paper. Differences among regions occurring, we used as moderator the mean MP.ind$^{-1}$ of the region. Fail-safe numbers robust to publication bias are larger than 5n + 10 (Rosenberg, 2005). Standardized mean differences (between environments and between regions) were also estimated in the partial datasets to confirm (or disconfirm) rank analyses.

## 3. Results

### *3.1. Research landscape of MP pollution in exploited African species*

#### 3.1.1. Literature review

Using the search terms reported above, a total of 609 scientific articles and theses were identified. From those, duplicated articles and articles not located in the geographical region of interest were discarded. After this selection, a total of 67 studies were retrieved and completely analysed (Suppl. Table 1), dating from 2012 to 2021 and starting in 2015 for organisms (although publication year filters were not applied in the search). These articles were employed for qualitative analysis and to study the research landscape. From those, only a total of 32 articles (47.8%) contained standardized units of microplastics content in organisms, representing a total of 156 population samples. They were employed to create a meta-database and evaluate the threat potentially derived from MP for African fisheries (Figure 1). It is worth noting that, despite of the use of the word “Africa” with “AND” Boolean in the bibliographic search, a part of the 67 selected studies reported data from south European (33.3%) or west Asian (3.2%) waters in the vicinity of Africa.

The number of publications meeting the required standards for qualitative (n = 67) and quantitative analysis (n= 32) increased significantly (significant slopes with $r^2 > 0.87$, $p < .001$ for 8 d.f. in the two cases) since 2011, the year of the first article retained in this study (Figure 2).

### 3.1.2. Research landscape based on cluster analysis of keywords

The keywords of the articles retained for analysis did not contain any relevant term directly related with fishing and fisheries. This result confirmed the opportunity of our study focused on the potential impact of MP on fisheries. With the settings chosen in the cluster analysis of keywords (a minimum number of four occurrences, 60% of relevant terms retained and removing uninformative words), a final group of 15 relevant terms were selected for the network map, organized in three different clusters: red, green and blue (Figure 3). The red cluster contained the relevant terms "South Africa", "Plastic pollution" and three artificial materials (rayon, polyethylene and polypropylene). The green cluster was formed by the terms "Mediterranean Sea", "MP particles", "MP ingestion", "Marine environment" and "Oxidative stress". Finally, the blue cluster joined the scientific name of Nile tilapia (*Oreochromis niloticus*), an important freshwater fish crucial for aquaculture in Africa and worldwide, with the words "Pollution", "Trophic level" and "Sediment" (Figure 3). These keyword clusters would represent the three most studied ecosystems and the foci of the studies carried out in each one. The terms pollution, sediments and trophic level clustered together with Tilapia in the blue cluster, which was organized around pollution in general. In the green cluster (at right in the map of terms, Figure 3) the terms microplastic particles, marine environment, microplastic ingestion and oxidative stress joined the term Mediterranean Sea, invoking problems (ingestion, stress) for the fish. Finally, the red cluster (upper left in Figure 3) contained terms descriptive of MPs like rayon, fiber, polyethylene, together with South Africa and plastic pollution; in this cluster plastic waste would be the core. In other words, MP studies on African freshwaters are focused on more general pollution issues, while those carried out in the Mediterranean Sea focus on the impact of MP fish health, and the main focus of studies in South Africa would be general plastic and MP waste.

### 3.1.3. Meta-database created from the articles retained for quantitative analysis

The data collected from the 32 articles retained for quantitative analysis are detailed in Supplementary Table 2. A total of 156 population samples summing at least 6212 aquatic animals (sample size was not displayed in three cases) from 101 species were compiled in the database: 15 invertebrates and 86 fishes (Table 1). Invertebrates included Polychaete worms used as bait, like *Diopatra* or *Glycera* (Cunha et al., 2005; Watson et al., 2017), commercial bivalves and freshwater snails locally eaten in African countries (like *Lanistes varicus*; Eneji et al., 2008). Mean sample size was 40.6 individuals/sample (standard deviation SD = 53.2).

The taxonomic catalogue comprised five species of polychaetes (36 individuals from five population samples), eight bivalves (338 individuals from nine samples), two gastropods (73 individuals from two samples), five species of Elasmobranchii (246 individuals from seven samples) and 81 of Actinopterygii (5534 individuals from 134 samples). Studies were clearly biased towards Perciformes, which represented the majority of species and samples (Table 1).

The geographical distribution of the samples gathered in the database (Figure 4) showed a quite uneven coverage of African waters. Many population samples were from Mediterranean (39 EM and 16 WM samples) and Atlantic areas at the north and northwest of Africa (48 NW), many of them sampled from neighbouring south European waters. Most of the species sampled from south European waters have high dispersal capacity and  can visit neighbouring African waters in their lifetime, thus we kept them in the database. Data were also relatively abundant in South Africa (21 SA samples), then the Gulf of Guinea (18 GG) and finally the Nile basin (14 NB samples): four from Ethiopia and ten from Egypt. A large proportion of coasts in the east and southwest Africa were not covered with the data obtained in this study (Figure 4). Only 37 population samples (23.7% of the total number of samples) were from freshwater or brackish water, and the rest were marine species – this could be expected since three search terms contained ocean or sea names (Supplementary Table 2). The majority of samples from the Nile basin (Ethiopia and Egypt) were from freshwater or brackish water, and several samples from Gulf of Guinea were taken from (fresh) municipal waters in Nigeria.

Regarding functional traits (Supplementary Table 2), the bivalves of this study are all filter-feeders, and the rest of invertebrates except the active feeders apple snail *Lanistes varicus* and the blood worm *Glycera alba*, are principally sediment- or deposit- feeders. All the fish species here analysed are active feeders. Trophic levels of the studied invertebrates ranged from 2 in filter-feeding bivalves and the snails to 2.5 in several polychaetes. In the fish trophic levels ranged from 2 in the herbivorous Nile tilapia *Oreochromis niloticus* (Perciformes) to 4.9 (±0.2) in the deep-water Cape hake *Merluccius paradoxus* (Gadiformes), or 4.5 in the John dory *Zeus faber* (Zeiiformes) and torpedo ray *Torpedo torpedo* (Torpediniformes) (Supplementary Table 2).

For the conservation status according to the IUCN the majority of species in the database were of Least Concern (78.7%) or Data Deficient/Not Evaluated (13.2%). Exceptions were ten species (Supplementary Table 2): five catalogued as Vulnerable (*Sardinella maderensis* from Ghanaian waters, *Squalius acanthias* from Italy, *Cyprinus carpio* from Ethiopia, *Trachurus trachurus* from Portugal and *Oreochromis mossambicus* from South Africa); four Near Threatened (*Dentex angolensis* from Ghana, *Raja asterias* from Portugal, *Sciaena umbra* from Turkey and *Argyrozona argyrozona* from South Africa); one Critically Endangered (*Polyprion americanus* from Portugal).

### 3.1.4. Metadata overview

The diversity of life history, ecosystem function and regions in the dataset is visually represented in the PCA scatter plot of Figure 5. Maximum and mean MP.ind$^{-1}$ being highly correlated (pairwise r = 0.96 > 0.80), we retained only maximum MP.ind$^{-1}$ (the index *MPmax*) in the PCA. This variable was located in the same quadrant of Nile basin and Gulf of Guinea regions together with the variable Environment, opposite to northwest region, suggesting spatial variation of fish pollution data. Dispersal capacity and feeding behaviour in opposite directions (Figure 5) is explained because deposit- and filter-feeders are sedentary invertebrates, all the fishes here being active feeders. Higher trophic levels (predators) corresponded to highly migratory fish species in the dataset; accordingly, these variables were in the same quadrant.

The six main components accounted for 75.2% of the total variance (Table 2). Main loadings were the environment, trophic level and Gulf of Guinea region in PC1; feeding behaviour, and northwest and Nile basin regions in PC2; *MPmax*, Nile basin and Gulf of Guinea regions in PC3; three regions in PC4, PC5 and PC6. These results point at the important geographical and functional variation in the database.

### *3.2. MP threat on fish resources from African and surrounding waters*

#### 3.2.1. Overview of MP threat indices in the meta-database

To assess MP pollution threat in the populations directly or indirectly related with fishing resources compiled in this study we employed two indices, *MPmax* and *MPct* (MPmax*SCS). They provided similar but not identical results (Supplementary table 3), due to the species with conservation issues and also to the data deficient species. Differences in the population rank between the two measures were significantly different (sign test with r = 110, $p < 0.001$; Wilcoxon test with W = 6425, normal approx. $z = 4.04$, $p < 0.001$). For example, the species catalogued as vulnerable *Squalus acanthias* moved up in the list from the 99th for *MPmax* to the 36th position for *MPct*. However, the rank change depended on the level of MP pollution. When no MP were found in a sample, indeed its position did not move whatever the index employed (e.g. Portuguese *Solea solea* and *Torpedo torpedo*, the 153rd and 154th respectively, same positions for the two indices). Similarly, some vulnerable very highly MP-contaminated species advanced only a few positions in the rank, like *Sardinella maderensis* sampled from

Ghanaian waters from the 14th for *MPmax* to the 7th for *MPct*. These results also showed that the quantity of MP and the conservation category were independent in the metadata set analysed here.

### 3.2.2. Differences in MP threat between regions, taxonomic groups and environment types

PCA suggested spatial difference in the fish MP content (Figure 4), and rank analysis confirmed that MP pollution threat was not equal in all the regions. The first observation was that samples from the Nile Basin ranked higher, in average position, for both *MPmax* and *MPct* than the rest of samples; while samples taken at the northwest of Africa were apparently cleaner, followed by samples from the West Mediterranean (Table 3). For *MPmax* rank regions were highly significantly different to each other (Kruskal-Wallis tie corrected Hc = 65.93, $p < 0.001$), as well as for *MPct* (Hc = 55.89, $p < 0.001$). Applying Bonferroni correction for multiple comparisons, post-hoc pairwise Mann-Whitney tests revealed significant differences between Northwest samples and the rest of regions for *MPct*, and the same except West Mediterranean ones for *MPmax* (Supplementary table 4a). Nile basin samples differed significantly from all the rest of regions, for the two indices (Supplementary tables 4a and b). Some differences between indices could be expected because the regions differed in the proportion of samples catalogued by IUCN differently of Least Concern (Table 3).

Invertebrates were less represented in the dataset than fish. There was no clear trend in the difference between fish and invertebrates of the same region for *MPmax* pollution. The latter were apparently more polluted than fish in northwest samples (Table 3), especially two bivalves from Portugal in the 24th and 31st positions and two of Mauritania in the 39th and 40th (Supplementary Table 3) and slightly more (East Mediterranean, South Africa) or less polluted (Gulf of Guinea) in other regions. Statistics comparing taxonomic groups will not be performed here for the scarce number of invertebrate samples retrieved in this study, with no one with MP data in Nile basin nor in West Mediterranean region. Only two species of bivalves in our list had FAO production data in 2018 (Supp. Table 2): *Mytilus galloprovincialis* in Greece (89th and 67th in *MPmax* and *MPct* rank respectively, Supp. Table 3), *Cerastoderma edule* in Portugal (26th and 24th in *MPmax* and *MPct*) and *Mytilus galloprovincialis* in South Africa (60th for *MPmax* and 70th for *MPct*). Besides, in decreasing *MPct* pollution order (Supp. Table 3), we found the following molluscs: Lebanese red thorny oyster *Spondylus spinosus* (23rd), South African black mussel *Choromytilus meridionalis* (25th), Portuguese furrow shell *Scrobicularia plana* (31st), South African ribbed mussel *Aulacomya atra* (45th), Mauritanian clam *Pelecyora isocardia* (39th) and blood cockle *Senilia senilis* (40th), and Nigerian apple snail *Lanistes varicus* (53rd) and red-rimmed melania *Melanoides tuberculata* (98th); and the Mauritanian polychaetes *Glycera alba* (44th), *Diopatra neapolitana* (63rd), *Neanthes acuminata* (66th) and *Scolelepis squamata* (109th) (Suppl. Table 3). With so few samples in the dataset, these data do not allow to obtaining robust conclusions about edible molluscs and fishing bait polychaetes being more or less endangered than fish by MP pollution. The same could be applied to feeding behaviour because its variation in the dataset was due only to invertebrate species in this dataset.

The type of environment (freshwater, marine, brackish) seemed related with the MP pollution in the PCA. To clarify this point and check if freshwater and brackish species would be more or less threatened by MP than marine fish in this study, we did a Kruskal-Wallis analysis for *MPmax* and *MPct* rank positions. Results were significant for *MPmax* (Hc = 10.65, $p = 0.004$) with a significant difference between freshwater and marine samples in post hoc Mann-Whitney test (Supplementary table 4C). Similar results were found for *MPct* (Hc = 11.39, $p = 0.003$; post-hoc tests in Supplementary table 4D). Freshwater samples had a mean of 49.3 (SD 39.8) and 47.2 (37.4) for *MPmax* and *MPct* respectively; these values were 72.2 (41.7) and 76.8 (43.4) for brackish water samples, and 84.3 (44.8) and 84 (44.7) for marine samples. Then, although being not very robust for data dispersal and use of dummies, we did an exploratory multiple regression analysis in order to see if significant difference among regions and environments was still maintained considering also other factors that vary in the dataset and can be related with MP pollution from the literature: trophic level, feeding behaviour, dispersal capacity. Regions were treated as in the PCA (0-1 dummies) and west Mediterranean was excluded to prevent the dummy trap. For this we worked on *MPmax* because conservation status is not an intrinsic trait of the organisms. We obtained a significant multiple R = 0.498 with adjusted multiple $R^2$ = 0.202 (not adjusted 0.248) and $p$ = 0.002. Factors explaining significantly *MPmax* were Environment (t = 3.47, $p$ < 0.001) and Nile basin region (t = 5.308, $p$ < 0.001; see Supplementary Table 5A). From these results, the results obtained from Kruskal-Wallis would be confirmed after controlling the rest of variables. In our specific dataset, freshwater species would be more threatened by MP pollution than marine and brackish water ones, and populations inhabiting the Nile basin region would be more endangered than the rest.

### 3.2.3. Publication bias

Quantitative analyses on metadata encompass a risk of publication bias. Here the subset of publications with mean MP.ind$^{-1}$ for species of similar trophic level inhabiting different environments within the same region was reduced to eight (see Supplementary table 2): Digka et al. (2018) and Guven et al. (2017), east Mediterranean; Adu-Boahen et al. (2020) and Adeogun et al. (2020), Gulf of Guinea; Merga et al. (2020) and Shabaka et al. (2020), Nile basin; Neves et al. (2015), northwest; Naidoo et al. (2020), South Africa. Indeed the difference between environments in this subset was significant and occurred in the same direction of more polluted marine species (p < 0.001 for both fixed and random effects, Supplementary table 5B), confirming the exploratory results above based on all the data. The publication bias risk estimated for the present analysis was low because Rosenberg (2005) fail-safe N was Ng = 60.76, far over the threshold of 50 for 8 publications (Rosenberg, 2005). However, this quantitative analysis has to be taken just as exploratory because the data are highly dispersed, with substantial regional differences in the number of samples and types of organisms (vertebrates, invertebrates, migratory, sedentary etc.) between regions.

For differences among regions, the subset of publication pairs with mean MP.ind$^{-1}$ for pairs of species of the same type of organism and similar trophic level inhabiting the same environment in significantly different regions was: Adika et al. (2020) and Bessa et al. (2018); Sparks and Immelman (2020) and Bellas et al. (2016); Naidoo et al. (2020) and Neves et al. (2015); Sparks and Immelman (2020) and Neves et al. (2015); Lourenço et al. (2017) and Sparks (2020); Abidli et al. (2021) and Shabaka et al. (2020); Sparks & Immelman (2020) and Shabaka et al. (2020); Shabaka et al. (2020) and Bellas et al. (2016); Guven et al. (2017) and Neves et al. (2015); Digka et al. (2018) and Lourenço et al. (2017); Avio et al. (2015) and Bessa et al. (2018); Avio et al. (2015) and Neves et al. (2015); Gianni et al. (2019) and Neves et al. (2015). The difference between regions was highly significant for either fixed or random effects ($p < 0.001$ in both cases, Supplementary table 5C). Publication bias could be discarded in this meta-dataset, with Ng = 3672.8 >> 170 (= 5*32+10) robust fail-safe number (Rosenberg, 2005). As in the previous analysis these results could be considered exploratory because, although apparently very safe for the Ng, articles (and sample pairs) are often of different years, but there are no evidences of MP pollution stability in these regions over time.

### 3.2.4. MP threat to commercial fisheries

Next we focused on commercially exploited fish stocks with production records in FAO statistics (94 samples of the meta-dataset), to evaluate the relative MP threat in different countries (Supplementary table 6). The big picture was similar, with the Egyptian population *Oreochromis niloticus* providing the largest gap in cumulative catch while ranking very high in the two MP pollution indices considered, and other highly fished South African species like *Merluccius capensis* and *M. paradoxus* ranking very high too. In contrast, highly fished species from European waters like Spanish *Engraulis encrasicolus* and *Merluccius merluccius* occupied clearly lower positions in the MP pollution rank (Figures 6 and 7).

As in the previous analysis some species changed their position using different indices. When SCS was taken into account (Figure 7), populations from European countries obtained generally lower rank scores – interpreted as relatively less threatened – than when using only MP contents (see Supplementary table 6). In contrast, some African species like the vulnerable *Oreochromis mossambicus* from South Africa moved from the 73rd to the 36th position in the *MPmax* and *MPct* ranks respectively (Supplementary table 6). With *MPmax* South African *Merluccius capensis* occupied the 25th place in the pollution rank and *M. paradoxus* the 27th (Figure 6); while with *MPct* their positions were 29th and 20th respectively (Figure 7), due to the status of *M. paradoxus* as data deficient (SCS = 2). *Sardinella maderensis* and *S. aurita* from Ghanaian waters, highly contaminated in the data compiled in our study, occupied respectively positions 11th and 14th in *MPmax* rank and 5th and 15th in *MPct* rank (Supplementary table 6), because *S. maderensis* is vulnerable. As in the whole dataset, the rank provided by the two indices in this subset of samples with FAO data was significantly different (Wilcoxon test with W = 2477.5, $z = 3.88$, $p < 0.001$), sign test with r = 69, $p < 0.001$.

Differences among regions regarding the level of MP pollution in commercial fish were quite obvious in the quartile analysis (Figure 8). Population samples from the Nile basin, the Gulf of Guinea and South Africa were principally located in Q1 and Q2 (first quartiles in pollution), while the populations located at the northwest were located in Q3 and principally Q4. Samples from Mediterranean regions were more or less in the middle, the west Mediterranean region containing more Q1 when using *MPmax* than when *MPct* is employed (Figure 8). The differences between regions regarding their distribution among fish pollution quartiles were statistically significant, for both *MPmax* (contingency Chi Square = 84.5, 15 d. f., $p < 0.001$, Cramer's V = 0.53) and *MPct* (contingency Chi Square = 73.6, 15 d.f., $p < 0.001$, Cramer's V = 0.51).

Stepwise post-hoc test (Supplementary figure 1) showed that the group of regions comprising the Nile countries and the Gulf of Guinea were not significantly different to each other for any index. Northwest samples were located at the least polluted edge of the figure with the two indices, being grouped with west Mediterranean samples using *MPct*. The relative position of South African, east and west Mediterranean samples, in the middle of the regional set, changed depending on the index employed (Supplementary figure 1). The whole picture showed a potential of MP threat lower and higher for northwest and Nile basin and Gulf of Guinea fish stocks, respectively, than in the other regions considered.

The analysis so far refers to the fishing stocks samples were taken from. Another proxy of the relative impact of MP on fisheries is the proportion of the region catch represented by Q1 population samples, choosing *MPct* to take into account conservation status. With the metadata employed here, Q1 population samples represented the majority of catch (of the species with MP data) of Nile basin, near 40% of South Africa's and one quart of Gulf of Guinea's while they were represented less than 6% of the catch in the rest of regions (Table 4). Consistently with the results found for the fish stocks, fisheries of Nile basin would be more affected than those of other regions.

Some species located in the Q1 (Suppl. Table 6 and Figures 6 and 7) are very important for African fisheries, like *Oreochromis niloticus* for Egypt, or *Merluccius capensis* and *M. paradoxus* for South Africa and may have importance for other countries too. EU fleet fishes Cape hakes, within multi species Sustainable Fisheries Partnership agreements between African countries and the EU (https://knowledge4policy.ec.europa.eu/publication/eu-sustainable-fisheries-partnership-agreements_en, accessed on August 2021). Small pelagics fished off Northwest and West Africa, like *Sardinella* species, are caught for use as fish meal and fish oil in China and other countries like Turkey.

## 4. Discussion

### *4.1. Research landscape of MP in aquatic exploited species: conservation issues*

This study, based on a database generated from solid peer-reviewed publications, revealed issues of microplastic pollution of importance for African fisheries, that had not been a main focus in the research landscape until now. A novelty of our study was considering conservation status in an index of MP threat, *MPct*. Rank results changed, significantly, using that index – some populations advanced many positions regarding those occupied when using only MP pollution indices. We were able to identify already vulnerable populations that carry important levels of MP burden, like *Sardinella maderensis* from Ghana (Supplementary Table 3). It is clear that conservation issues are important because without healthy stocks and populations fisheries sustainability is just impossible. Many studies report adverse effects of MP on aquatic species (e.g. De Sá et al., 2018; Parker et al., 2021), thus persistent exposure to plastics and MP (alone or with adhered toxic substances) surely threatens fished stocks. Populations double-threatened by MP and other conservation problems affecting the species should be treated with special care when designing fishing management plans. In the example above *Sardinella aurita* is classified as Least Concern by IUCN, and is also less MP-contaminated than *S. maderensis*. MP pollution could be considered an additional stress factor of already vulnerable species and populations.

The impressive progression of studies about MP in in Figure 2 shows the special interest on fishing resources in Africa. The amount of data will no doubt keep growing, given the dependence on fish as protein supply in many African countries (e.g., Golden et al., 2016; FAO, 2020). Studies warn about the risk of malnutrition in some regions derived from expected stock depletion following climate change (Golden et al., 2016), in addition to overfishing that is already a big problem there (e.g., Lazar et al., 2018). Microplastic pollution is an important stressor whose effects are concomitant with those of climate change due to the global greenhouse gas emissions during plastic lifecycle (e.g. Shen et al., 2020). The potential synergistic effects between climatic factors and toxicological ones, including MP pollution, on African fisheries targeted species, deserve further interest to be able to anticipate the future of marine subsidies to local communities. Moreover, some highly MP-polluted species like the *Sardinella* species of Gulf of Guinea (Adika et al., 2020) and Egypt (Shabaka et al., 2020) are highly migratory (see Supplementary Table 2), thus MPs could eventually reach other regions along North and West African coasts transported by these fish.

### *4.2. Threats to fishing resources and consumers*

One may wonder if the level of MP found in African fish and invertebrates is high enough to endanger fishing resources. High contents of MPs would imply a higher toxicological and physiological risk (Barboza et al., 2018; Wang et al., 2020; Rios-Fuster et al., 2021), and even medium concentrations can harm some species (e.g. Masiá et al., 2021b). Although the amount of MP an organism can take naturally from the environment without health danger is still unknown and likely different in different species (e.g. Hale et al., 2020), some signs point at the populations considered in this study are affected already. Following with the example of *Sardinella maderensis* that has a high MP load in Ghana (40 MP.ind$^{-1}$), Adika et al. (2020) found it exhibits a lower condition factor that less MP-polluted species in the same area, perhaps linked in a way with its higher MP pollution as suggested by the authors. They recognize a direct cause-effect cannot be ensured from their observational data (Adika et al., 2020), thus more studies are needed to demonstrate how much MP could affect fishing stocks. Pennino et al. (2020) found a higher parasite load in anchovies and sardines with higher MP contents in the gastrointestinal tract, in a range of 1.14 (± 0.14) to 2.00 (± 0.58) MP.ind$^{-1}$. East Mediterranean sardines of the same species included in our study had higher MP contents of 1.8 to 3.75 MP.ind$^{-1}$ (Guven et al., 2017; Digka et al. 2018) – in contrast with less contaminated sardines from west Mediterranean Spanish (1.4 MP.ind-1, Compa Ferrer et al., 2016) and northwest Portuguese coasts (0-0.14 MP.ind-1, Neves et al., 2015). Although not analysed in these studies, if MP and parasite load were correlated sardines of the latter areas would have a lower infestation levels than those of the East Mediterranean, and surely more in Alexandria waters where the load in *Sardinella aurita* is higher than 1000 MP.ind$^{-1}$ (Shabaka et al., 2020). It is clear that more studies about the effect of MP ingestion in fish are needed. In any case, although this cannot be generalized to the whole regions because the samples analysed did not cover them all, it seems that some fish from the Nile basin and waters near Nile River mouth, and also of Gulf of Guinea countries may be especially affected by microplastic pollution.

Another doubt emerging from our study is how the MP load found in fishing resources could affect human consumers. African fishing resources are very diverse comprising a large variety of species (e.g. Nunoo et al., 2009; Belhabib et al., 2015a, 2019), and there is an increasing demand of fish for local consumption (e.g. Zhou & Staatz, 2016; Tran et al., 2019). For the scarcity of studies in humans about this topic, and the novelty of this emerging pollutant, it is still early to affirm that eating MP-polluted fish encompasses a health risk for human consumers (e.g. Lehner et al., 2019; Rubio et al., 2019). However, reviewing the effects of MP and nanoplastic ingestion in mammalian models, Rubio et al. (2019) pointed at a significant risk of carcinogenesis after long-term (chronic) exposure to low-doses of these particles, as well as at thyroid endocrine disruption, damage in the intestinal barrier function, inflammatory responses and other adverse effects. The potential effects of consuming MP-polluted fish would be higher in populations reliant on fish for protein supply, as those from countries around the Gulf of Guinea (Belhabib et al., 2015a; Golden et al., 2016; FAO, 2020). Precisely the Gulf of Guinea contains some of the most MP-polluted fish in our study (Adika et al., 2020); here and in Egypt it is possible that those MP contained by fish arrive to humans via seafood, depending on how fish are consumed; eating them entire would encompass more risk of MP ingestion than if they are cooked eviscerated.

### *4.3. Regional differences in African aquatic resources for MP pollution*

The large-scale comparison among regions using rank tests and meta-analysis with a partial dataset confirmed the expectations of risk in fish production of Nile countries. A 95% of the stocks analysed from that region did occupy positions in the Q1 of MP threat. MP pollution was enormous in the Egyptian coast, with extremely high MP values found by Shabaka et al. (2020) in Alexandria. It could happen to be the result of a single study in an exceptionally polluted but small area; however, other results from Nile countries would support a general very high MP pollution of fish in the region, not only in Alexandria. Fish MP content in River Nile species (Khan et al., 2020), and in an Ethiopian lake far upstream (Merga et al., 2020) was lower than that of Alexandria fish but also very high and in Q1.

Thus, based on three different studies from geographically separated locations, MP seems to be a serious threat for fish in River Nile countries.

Regional comparisons served to detect another potential MP hotspot: the Gulf of Guinea, where the high concentration of MP in the coast and in freshwater bodies was comparable to that found in Nile River populations. This region was not especially highlighted as a MP hotspot in other studies (Alimi et al., 2021). However, MP content in the two *Sardinella* species commented above and *Dentex angolensis* from Ghana coast (Adika et al., 2020) was comparable to that found in some species fished in Alexandria like *Atherina boyeri* (Shabaka et al., 2020). Moreover, invertebrates from River Osun (Akindele et al., 2020) and several fish from Eleyele Lake in Nigeria (Adeogun et al., 2020) were located in Q1 of MP pollution, with MP contents comparable to those found in Khan et al. (2020) and Merga et al. (2020) on Nile countries. Thus Gulf of Guinea fisheries could be considered another resource affected by MP menace.

Tunisia could be considered another country with MP threat for fish. Two studies reporting MP in Tunisian fish are included in our study. Zitouni et al. (2020) found an intermediate level of MP in the marine comber *Serranus scriba*, but fish inhabiting brackish waters like the mullet *Liza aurata* and the Salema porgy *Sarpa salpa* are more polluted (Abidli et al., 2021), being in Q1 in our analysis at levels similar to some Egyptian or Ghanaian coastal fish.

The metadata of other African countries like South Africa and Mauritania seem to point at a lower MP threat for fisheries, at least if compared with the hotspots named above. Notwithstanding it, important fishing resources like Cape hakes (*Merluccius capensis* and *M. paradoxus*) and the carpenter seabream *Argyrozona argyrozona* (Sparks & Immelman, 2020) are in Q1 in our list, and others like the round herring *Etrumeus whiteheadi*, the anchovy *Engraulis encrasicolus* (Bakir et al., 2020), the Cape horse mackerel *Trachurus capensis* and the Cape gurnard *Chelidonichthys capensis* (Sparks & Immelman, 2020), and the freshwater Mozambique Tilapia *Oreochromis mossambicus* (Naidoo et al., 2020) are in Q2. Relatively high levels of MP have been also found in South African molluscs, especially in the black mussel *Choromytilus meridionalis* (Sparks, 2020), and in Mauritanian blood cockle *Senilia senilis*, the saltwater clam *Pelecyora isocardia* and some polychaetes employed as bait (Lourenço et al., 2017). Thus MP could be also considered a threat for South African fishing resources, while more studies are needed about Mauritanian fish.

Regarding possible differences between taxonomic groups, our results are not informative about the importance of the trophic level and the feeding behaviour to MP content. The invertebrates analysed in our study, of low trophic level, are sedentary thus constantly exposed to the pollution of the residence area; blue mussels have even been proposed for MPs biomonitoring (Kazour & Amara, 2020). However, no clear conclusions can be driven from our meta-analysis regarding preferential MP accumulation in invertebrates than in fish in the same area, principally because the number of invertebrates analysed was too small for robust analysis. With similar proportions of fish of different trophic levels in Q1, our results would not disagree with high MP content in highly mobile predators proposed by Savoca et al. (2021), consistent with the bioaccumulation of MPs at higher trophic levels (Cresson et al., 2014); nor with the opposite explanation of a higher MP load in herbivorous and planktivorous fish proposed by Abidli et al. (2021), related with a dilution of MPs going up the trophic web (Diepens & Koelmans, 2018).

### *4.4. Considerations for management*

The causes of MP pollution in African aquatic organisms were not the focus of our research, but our study may contribute to some discussions. Our results suggested higher MP threat in marine than in freshwater species in Egypt, although lagoon fish contained more MP than marine samples in Tunisia in our metadata. A great proportion of MP pollution is associated with rivers (e.g. Jambeck et al., 2015; Schmidt et al., 2017; Meijer et al., 2021), but they are not the only source of MP. Amongst others, large ports and fishing activities contribute significantly to MP input (e.g. Masiá et al., 2021a), coastal landfills and wastewater treatment plants (e.g. Kazour & Amara, 2020), urban concentrations when waste management is inadequate (e.g. Jambeck et al., 2015), and more. The Mediterranean Sea contains what has been defined as a “microplastics soup” (Suaria et al., 2016), comparable to the concentrations found in oceanic gyres and with a high concentration offshore Egyptian coasts (Cózar et al., 2015). Being River Nile an important source of MP (Schmidt et al., 2017), all the rest of factors from industrial discharges to urban sources in this heavily populated sea will explain the results found by Shabaka et al. (2020) in coastal fish. A little bit at north in the East Mediterranean, some fish from Turkey (Guven et al., 2017) and Greece (Miliou et al., 2016) are also in Q1. Dominant deep and surface currents (El-Geziry and Bryden, 2010) will transport MPs from Nile River to Turkish and Greek waters, which could explain general pollution accumulated in the area. In addition, inefficient wastewater treatment that would multiply the expected MP load in suburban Greek areas (Mourgkogiannis et al., 2018). Similar concomitance of MP sources would explain the results found in Tunisia. The most polluted fish found by Abidli et al. (2021) inhabit a lagoon bounded by six cities, with industrial discharges and four harbours; this explains the difference between fish caught in that lagoon and those sampled from less polluted Tunisian open waters (Zitouni et al., 2020).

As a final remark, from the management point of view, the treatment of plastic waste is still a challenge to be addressed. African countries being important plastic consumers, and sources to the marine environment, to increase recycling rate and improve waste management are priorities in Africa (Verster et al., 2017; Verster & Bouwman, 2020). Moreover, Africa is importing large quantities of primary polymers and plastic products, estimated as more than 230 Mt at continental level between 1990 and 2017 (Babayemi et al., 2019). Indeed African societies and local managers are the only entitled to prioritize their research needs that may be very different in each country and region; amongst them, it seems that looking into the control of plastic pollution and microplastics is already in the agenda. Actions like taxing plastic imports (OECD, 2018) have been already successfully taken in some African countries, and could be expanded continent-wide. Circular economy is the priority sought by economists and social scientists to stop plastic entering the environment (Garcia-Vazquez et al., 2021). Rethinking plastic management (production, consumption and waste management) is urgent; perhaps tax incentives for plastic recyclers to acquire new equipment and improve their activity could enhance circular economy in Africa (Babayemi et al., 2019). In the view of the potential risk posed by microplastics to other important economic sectors like fisheries, we would totally align with this view.

### *4.5. Limitations of this study*

A technical problem of this study was the use of indices based on the number of MP per individual instead of MP concentration. For a similar tolerance to MP, it is logical to think that the same number of MP particles will affect more intensely a small fish than a big fish. However, if we had chosen MP concentration (per fish weight) instead of MP.ind$^{-1}$, the number of studies retained would have been much smaller than the already small number used in the present study. As pointed out by other authors, efforts to employ standardized methodologies and units are strongly recommended for the study of fish MP (Alimi et al., 2021; Parker et al., 2021).

Indeed the scarcity of data from African waters, highlighted by Alimi et al. (2021), is a problem for a meta-analysis and has impeded a formal approach employing the totality of the metadata in this study, for their irregular distribution and dispersion across taxonomic groups and functional traits. Precisely the enormous gaps in the current knowledge of MP pollution in Africa and African organisms (Alimi et al., 2021), is one of the reasons to choose this continent for this study. To put Africa in the centre of research foci is important to encourage more efforts, collaborations and investment in research in that continent, where aquatic resources in essential biodiversity hotspots like the Eastern Arc (Tanzania/Kenya), the Moroccan coast in the West Mediterranean basin, Madagascar or West African forests (Myers et al., 2000) seem to be still underexplored for MP pollution. The scarcity of studies in freshwater species is especially concerning. Fish populations are declining in rivers impacted by mining, industry and agriculture pollution in combination with the impact of large dams on hydrology (e.g. Jackson et al., 2016); plastic and MP pollution may be an added stressor contributing to endangering native freshwater fish fauna.

The measure of conservation status could be also improved. To represent conservation status we employed here a globally accepted index such as IUCN classification in the Red List (IUCN, 2021). However, being principally global, this index does not contemplate all the fish populations case by case. It is possible that some local populations are endangered while the global species is not. For an accurate evaluation of conservation risks populations should be evaluated individually, for estimating MP or any other threat.

Another limitation of this study was the literature search itself. It was based on English words and peer-reviewed publications. Allowing more flexible use of reports and unpublished theses (less strict quality filters), and doing the search in various languages, could help to retrieve more data –although perhaps less reliable if they are not peer-reviewed. Although the purpose of our study was not an exhaustive compilation of MP data, a larger number of entries in the database could allow testing hypotheses about the relation between trophic level and MP, relative MP pollution in invertebrates versus vertebrates, and others.

Finally, we have not included an analysis of the type of materials in the different regions and species. Although this information would be very interesting, the volume of individual and species data is quite scarce because most studies analyse only a part of the plastic items found and do not distinguish between species. Alimi et al. (2021) have reviewed the type of materials in African organisms at continent level and concluded that polystyrene followed by polypropylene are the most abundant polymers, according to the relative global plastic demand (Geyer et al., 2017). This issue deserves further exploration in future analyses.

### *4.6. Research gaps and recommendations*

i) We have seen here very long coastlines where we could not find data of organism MP for our database, like the greatest part of East African coastal waters, and the long zone between South Africa and the Gulf of Guinea in the west. The geographical coverage of MP content in

African aquatic resources should be expanded urgently, taking into account the richness of fish diversity of African rivers and lakes and the dependence of many populations on their supply. Research on freshwater organisms is strongly encouraged.

ii) Precautionary approach would recommend expanding studies of MP in fish caught or produced in Nile River countries and Gulf of Guinea, in order to see if MP pollution is as high as suggested from this study.

iii) Conservation status should be analysed at regional and local levels and considered in estimates of MP threat, because MP pollution may represent an added stress in already compromised populations.

iv) Here we have seen many studies focused on fish that are caught by European and other international fleets and exported to Europe and Asia. However, given the diversity of African fishing resources, expanding the study of MP to the locally consumed species of interest for African populations could be considered a priority.

v) Many of the species analysed contain high levels of MP but their physiological, genetic and physical impacts are still unknown. More studies on the effect of MP pollution in fishing resources are needed. A combination of experimental, observational and meta-analysis could help in this purpose.

vi) One of the main difficulties of this study was the impossibility of using all the articles retrieved because they measured MP pollution in organisms in different ways so results were not comparable. Employing standardized measures of MP content in future studies to enable comparisons with existing works is strongly recommended.

## 5. Conclusions.

i) From the results of research landscape analysis based on available data, it can be concluded that current MP pollution studies in Africa are focused on general environmental pollution in freshwater, while the focus in Mediterranean waters would be fish health and in South Africa plastic contamination.

ii) Rank analysis from a new meta-database has identified Nile countries, especially Egyptian waters, and the Gulf of Guinea as hotspots of fish microplastic pollution, while fish from northwest African waters are apparently less contaminated in our data.

iii) Several species in the first quartile of MP-pollution rank are also highly fished, thus based on our meta-analysis MP could be considered a threat to fishing resources.

iv) Although MP content was generally higher in the marine species here considered, some populations from brackish water are among the most polluted. Single factors cannot explain the levels of MP in African fish and aquatic invertebrates with the present data; concomitant factors like river plastic load, industry, maritime activity and incorrectly treated urban wastewater would most likely explain MP load.

v) We encourage monitoring of MPs in exploited aquatic species, especially from freshwater where published studies are scarce. Improving plastic waste management in African countries is revealed as a priority to avoid MP-pollution stress to be added to populations whose conservation status is already compromised.

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**Figure legends**

**Figure 1.** Flow of literature analysis showing the analysed publications.

**Figure 2.** Cumulative number of scientific articles reporting microplastics in African waters that meet the selection criteria employed in this study for qualitative (analysed for research landscape) and quantitative analysis (employed to create the database).

**Figure 3.** Network map created from significant terms of keywords of the 67 articles meeting quality criteria in this study. Colors represent clusters of terms most frequently associated in the reviewed articles. VOSviewer software was employed.

**Figure 4.** Geographical location of the samples analysed. Colour intensity is proportional to the maximum amount of microplastics per individual in each population sample.

**Figure 5.** Scatter plot representing Principal Components Analysis of the variables considered in this study. Diagonals are proportional to the relative weight of each variable. Constructed with PAST software (Hammer et al., 2001).

**Figure 6.** Plot of the cumulative fish catch on the rank of fish MP pollution measured from the maximum number of MP.ind-1. Each point represents a population sample. Populations contributing significantly to the catch in each pollution quartile are indicated, identified from country and species with label size proportional to the catch and the position in the pollution rank in parentheses.

**Figure 7.** Plot of the cumulative fish catch on the rank of fish MP pollution measured from the index *MPct*, where MP.ind$^{-1}$ is weighed by the conservation status. Each point represents a population sample. Species contributing significantly to the total catch in each pollution quartile are indicated (in parentheses is its position in the pollution rank).

**Figure 8.** Proportion of samples from each considered region in microplastics pollution quartiles (Q1 to Q4 from most to least polluted). Results are given for *MPmax* and *MPct* indices (the latter considers population conservation status).

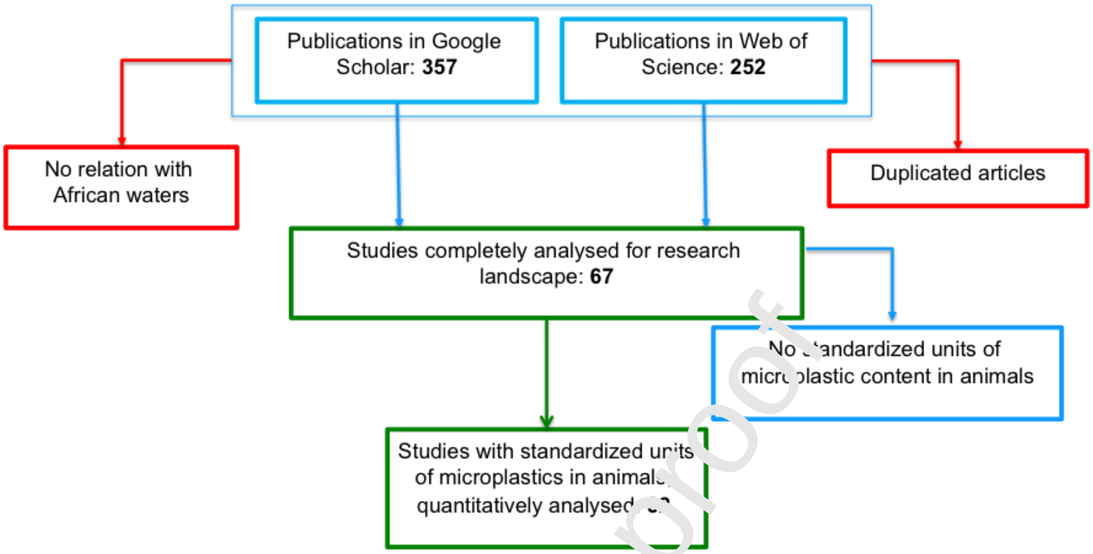
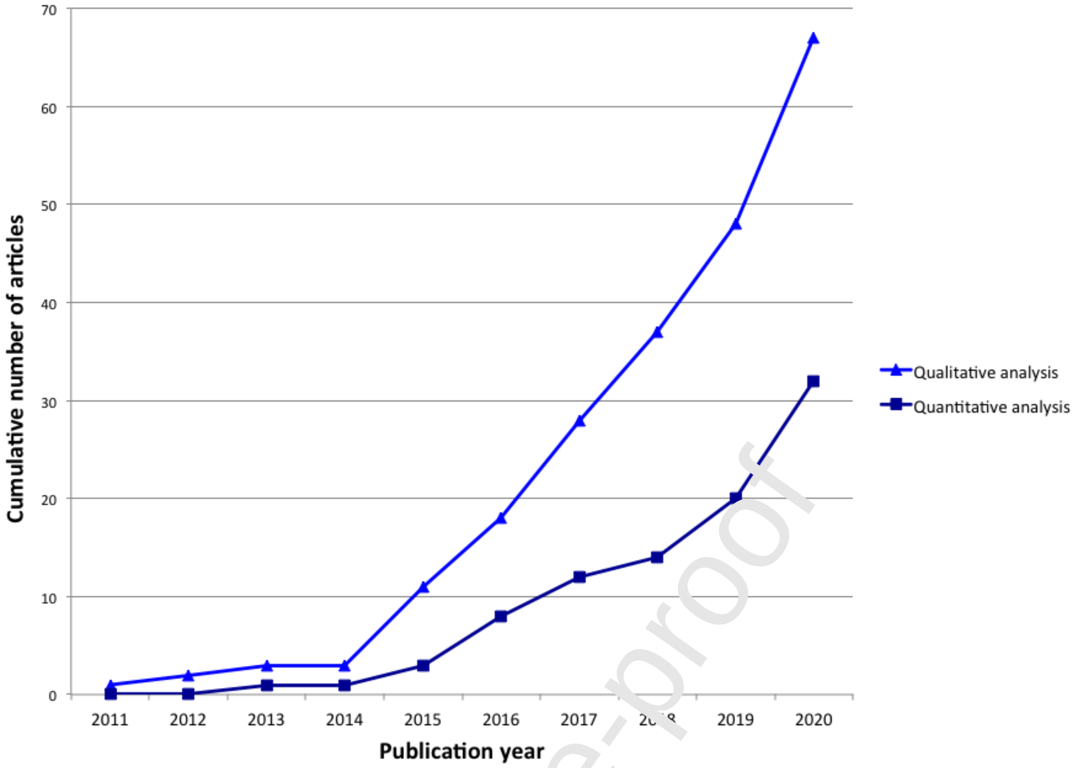

Publications in Google Scholar: **357**
Publications in Web of Science: **252**
No relation with African waters
Duplicated articles
Studies completely analysed for research landscape: **67**
No standardized units of microplastic content in animals
Studies with standardized units of microplastics in animals, quantitatively analysed: [illegible]

Fig. 1


70
60
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30
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10
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Cumulative number of articles
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2019
2020
Publication year
Qualitative analysis
Quantitative analysis

Fig. 2

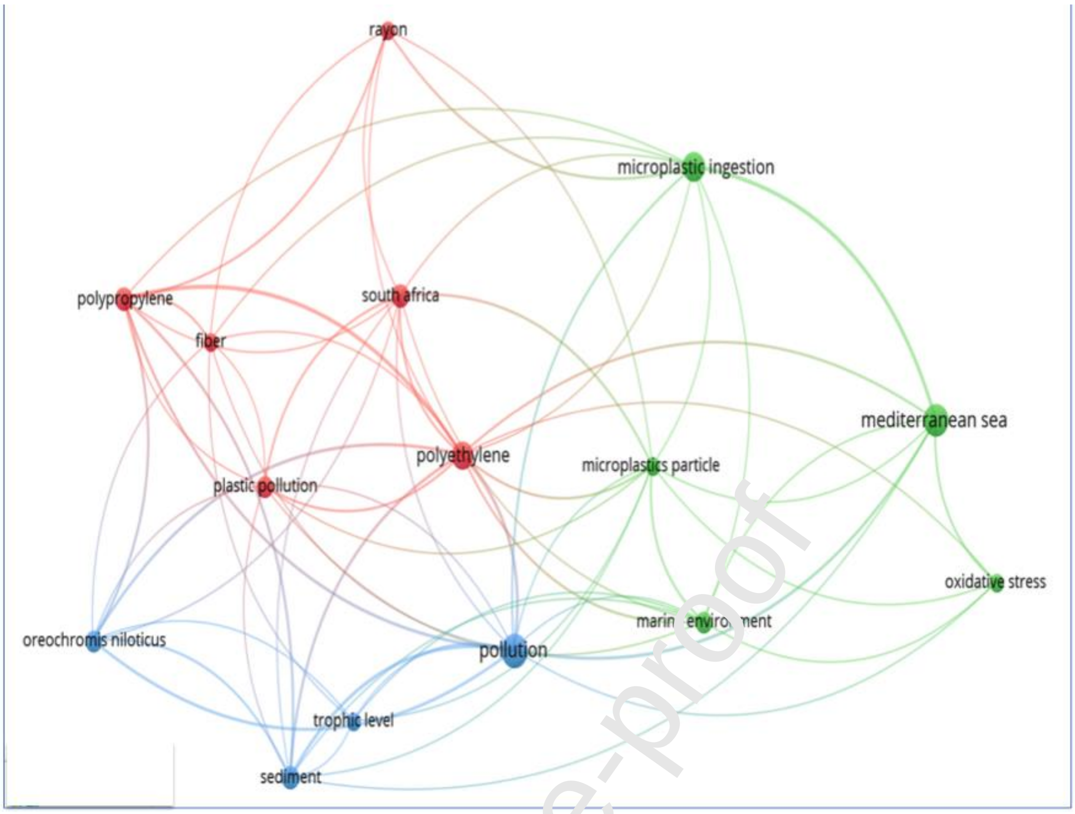

rayon
microplastic ingestion
polypropylene
south africa
fiber
mediterranean sea
polyethylene
microplastics particle
plastic pollution
oxidative stress
marine environment
oreochromis niloticus
pollution
trophic level
sediment

Fig. 3

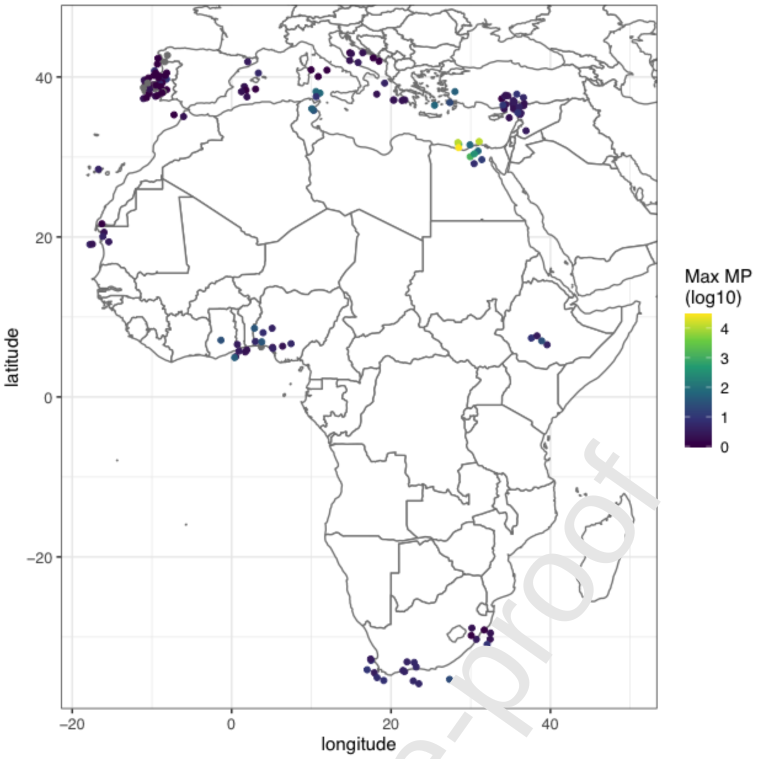


Fig. 4

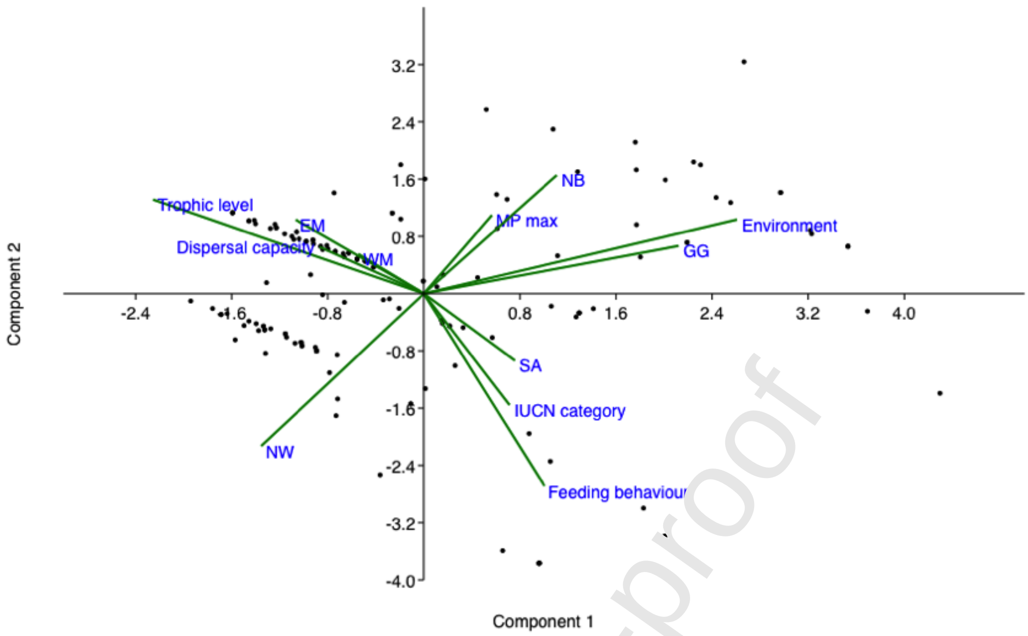
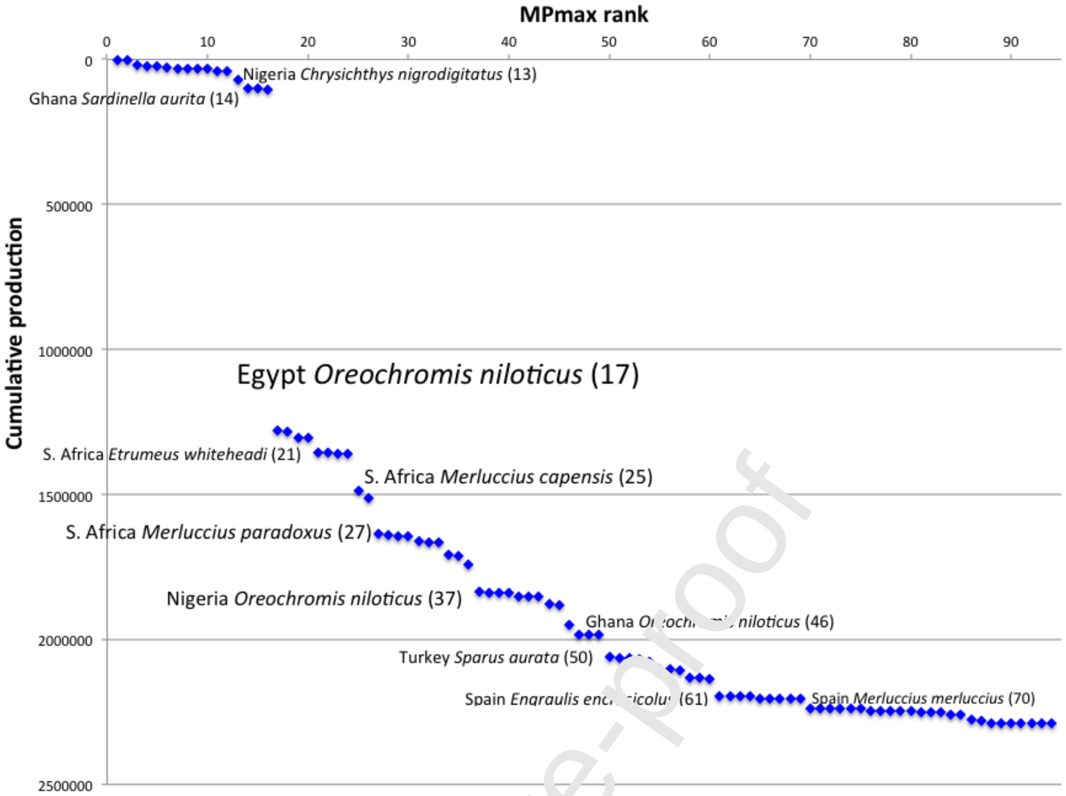

Component 2
Component 1
3.2
2.4
1.6
0.8
-0.8
-1.6
-2.4
-3.2
-4.0
-2.4
-1.6
-0.8
0.8
1.6
2.4
3.2
4.0
Trophic level
EM
Dispersal capacity
WM
NB
MP max
Environment
GG
SA
IUCN category
NW
Feeding behaviour

Fig. 5


MPmax rank
0
10
20
30
40
50
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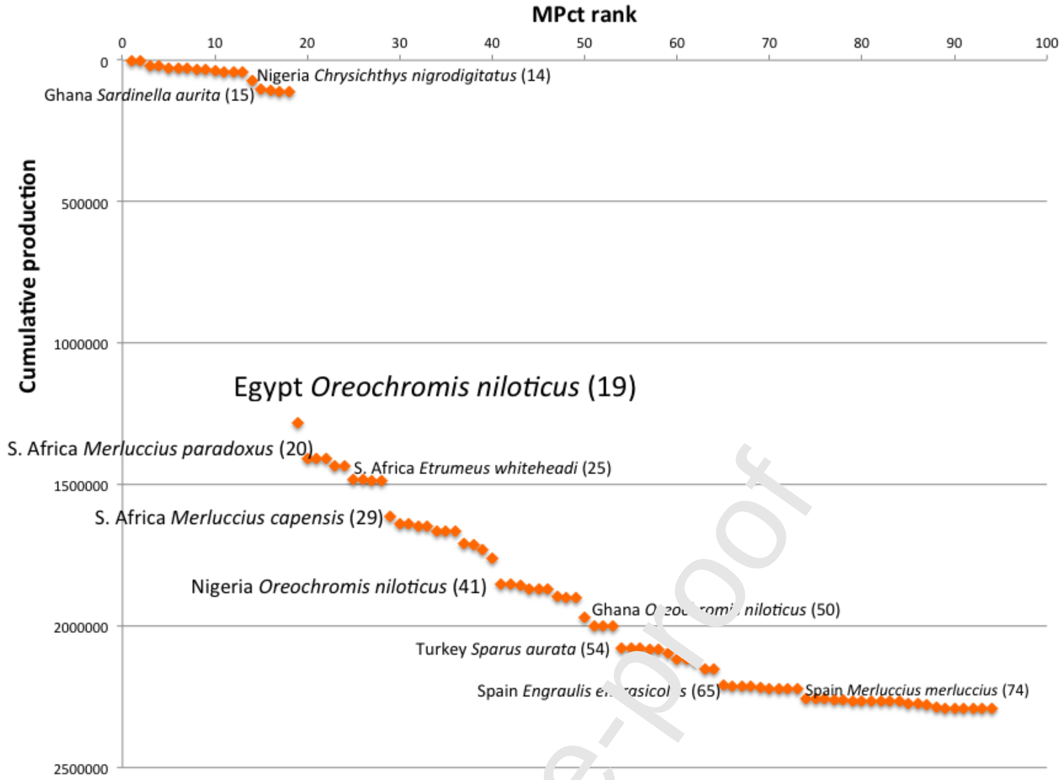
70
80
90
Cumulative production
0
500000
1000000
1500000
2000000
2500000
Nigeria *Chrysichthys nigrodigitatus* (13)
Ghana *Sardinella aurita* (14)
Egypt *Oreochromis niloticus* (17)
S. Africa *Etrumeus whiteheadi* (21)
S. Africa *Merluccius capensis* (25)
S. Africa *Merluccius paradoxus* (27)
Nigeria *Oreochromis niloticus* (37)
Ghana *Oreochromis niloticus* (46)
Turkey *Sparus aurata* (50)
Spain *Engraulis encrasicolus* (61)
Spain *Merluccius merluccius* (70)

Fig. 6


MPct rank
0
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Nigeria *Chrysichthys nigrodigitatus* (14)
Ghana *Sardinella aurita* (15)
Egypt *Oreochromis niloticus* (19)
S. Africa *Merluccius paradoxus* (20)
S. Africa *Etrumeus whiteheadi* (25)
S. Africa *Merluccius capensis* (29)
Nigeria *Oreochromis niloticus* (41)
Ghana *Oreochromis niloticus* (50)
Turkey *Sparus aurata* (54)
Spain *Engraulis encrasicolus* (65)
Spain *Merluccius merluccius* (74)

Fig. 7

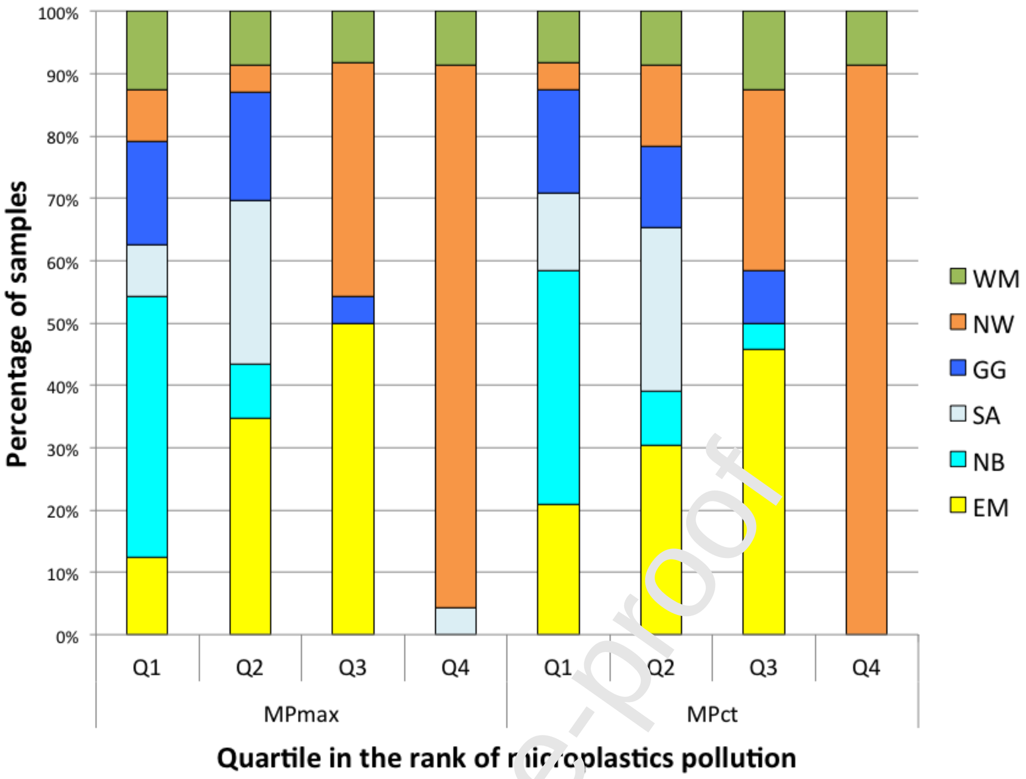

Percentage of samples
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Q1
Q2
Q3
Q4
Q1
Q2
Q3
Q4
MPmax
MPct
Quartile in the rank of microplastics pollution
WM
NW
GG
SA
NB
EM

Fig. 8

Table 1. Number of species, population samples and individuals analysed for microplastics content in the studies considered for the meta-database. Results presented by taxonomic group.

| Phylum | Class | Order | Number of species | Number of samples | Number of individuals |
|---|---|---|---|---|---|
| Annelida | Polychaeta | Eunicida | 1 | 1 | 4 |
| | | Phyllodocida | 3 | 3 | 24 |
| | | Spionida | 1 | 1 | 8 |
| Mollusca | Bivalvia | Arcida | 1 | 1 | 20 |
| | | Cardiida | 2 | 2 | 20 |
| | | Mytilida | 3 | 4 | 248 |
| | | Pectinida | 1 | 1 | 30 |
| | | Venerida | 1 | 1 | 20 |
| | Gastropoda | Architaenioglossa | 1 | 1 | 40 |
| | | Caenogastropoda | 1 | 1 | 33 |
| Chordata | Actinopterygii | Eupercaria incertae sedis | 2 | 3 | 11 |
| | | Anabantiformes | 1 | 1 | 1 |
| | | Atheriniformes | 1 | 1 | 7 |
| | | Aulopiformes | 1 | 1 | 99 |
| | | Characiformes | 1 | 1 | 1 |
| | | Cichlidae | 1 | 1 | 38 |
| | | Clupeiformes | 7 | 17 | 1185 |
| | | Cypriniformes | 2 | 2 | 180 |

| | | | | |
|---|---|---|---|---|
| | Gadiformes | 3 | 10 | 256 |
| | Lophiiformes | 1 | 1 | 2 |
| | Mugiliformes | 3 | 7 | 327 |
| | Perciformes | 45 | 75 | 3084 |
| | Pleuronectiformes | 4 | 4 | 45 |
| | Scorpaeniformes | 4 | 5 | 188 |
| | Siluriformes | 4 | 4 | 109 |
| | Zeiformes | 1 | 1 | 1 |
| Elasmobranchii | Carcharhiniformes | 2 | 4 | 201 |
| | Rajiformes | 1 | 1 | 7 |
| | Squaliformes | 1 | 1 | 9 |
| | Torpediniformes | 1 | 1 | 29 |

Table 2. Principal Component (PC) Analysis showing eigenvalues, percentage of variance explained by each component, and loadings of the variables considered. The three highest loadings are marked in bold. *MPmax* = maximum number of MP.ind$^{-1}$. NW northwest, SA South Africa, EM east Mediterranean, NB Nile basin, GG Gulf of Guinea, WM west Mediterranean.

| | **PC 1** | **PC 2** | **PC 3** | **PC 4** | **PC 5** | **PC 6** |
|---|---|---|---|---|---|---|
| Eigenvalue | 2.1 | 1.7 | 1.5 | 1.4 | 1.3 | 1.1 |
| % variance | 17.2 | 13.9 | 12.4 | 11.9 | 10.4 | 9.4 |
| **Loadings** | | | | | | |
| *MPmax* | 0.116 | 0.224 | **-0.513** | 0.315 | 0.036 | 0.027 |
| Trophic level | **-0.46** | 0.268 | 0.182 | 0.065 | 0.221 | 0.205 |
| Dispersal capacity | -0.177 | 0.133 | 0.36 | 0.325 | -0.183 | 0.196 |
| IUCN category | 0.145 | -0.317 | 0.161 | 0.099 | 0.201 | 0.222 |
| Environment | **0.532** | 0.211 | 0.2721 | 0.015 | 0.141 | 0.023 |
| Feeding behaviour | 0.205 | **-0.548** | -0.259 | -0.165 | 0.002 | -0.195 |
| NW | -0.276 | **-0.434** | 0.087 | **0.468** | 0.282 | -0.16 |
| SA | 0.155 | -0.191 | -0.01 | -0.129 | **-0.37** | **0.754** |
| EM | -0.218 | 0.211 | -0.139 | **-0.631** | **0.315** | -0.011 |
| NB | 0.226 | **0.338** | **-0.437** | **0.347** | 0.118 | 0.085 |
| GG | **0.433** | 0.136 | **0.453** | -0.006 | 0.134 | **-0.247** |
| WM | -0.111 | 0.113 | 0.01 | 0.013 | **-0.713** | **-0.411** |

Table 3. Summary of organism microplastics pollution by region. N, number of population samples; n = sample size; Conservation issues = percentage of samples with conservation status (in the IUCN Red List) different of Least Concern; Inv, invertebrates; SD, standard deviation. *MPmax* and *MPct* are maximum number of MP.ind-1 and MPmax*SCS, respectively. SCS = species conservation status from IUCN. EM, East Mediterranean; GG, Gulf of Guinea; NB, Nile basin; NW, Northwest; SA, South Africa; WM, West Mediterranean.

| | | | | **Mean rank position (SD)** | | **N** | | **Mean *MPct* rank (SD)** | |
|---|---|---|---|---|---|---|---|---|---|
| **Region** | **N** | **Mean n (SD)** | **Conservation issues** | *MPmax* | *MPct* | Fish | Inv | Fish | Inv |
| EM | 39 | 46.7 (46.8) | 7.7% | 76.9 (29.0) | 74.8 (31.4) | 37 | 2 | 76.9 (30.9) | 60 (52.3) |
| GG | 18 | 19.9 (22.7) | 16.7% | 58.7 (37.3) | 60.7 (40.4) | 16 | 2 | 60.2 (41.4) | 65.5 (31.8) |
| NB | 14 | 31.8 (29.9) | 0 | 14.2 (14.8) | 17.2 (18.7) | 12 | 0 | No invertebrates | |
| NW | 48 | 17.4 (24.8) | 31.2% | 114.8 (35.2) | 109.9 (39.9) | 39 | 9 | 98.5 (27.5) | 54.2 (27.7) |
| SA | 21 | 67.3 (68.9) | 28.6% | 58.8 (33.7) | 55.4 (27.8) | 18 | 3 | 58.2 (29.1) | 46.7 (22.5) |
| WM | 16 | 85.3 (92.3) | 0 | 75 (48.2) | 79.9 (48.5) | 16 | 0 | No invertebrates | |

Table 4. Total catch of the species considered in each country, per region, and proportion of that catch in Q1 pollution rank measured from *MPct*.

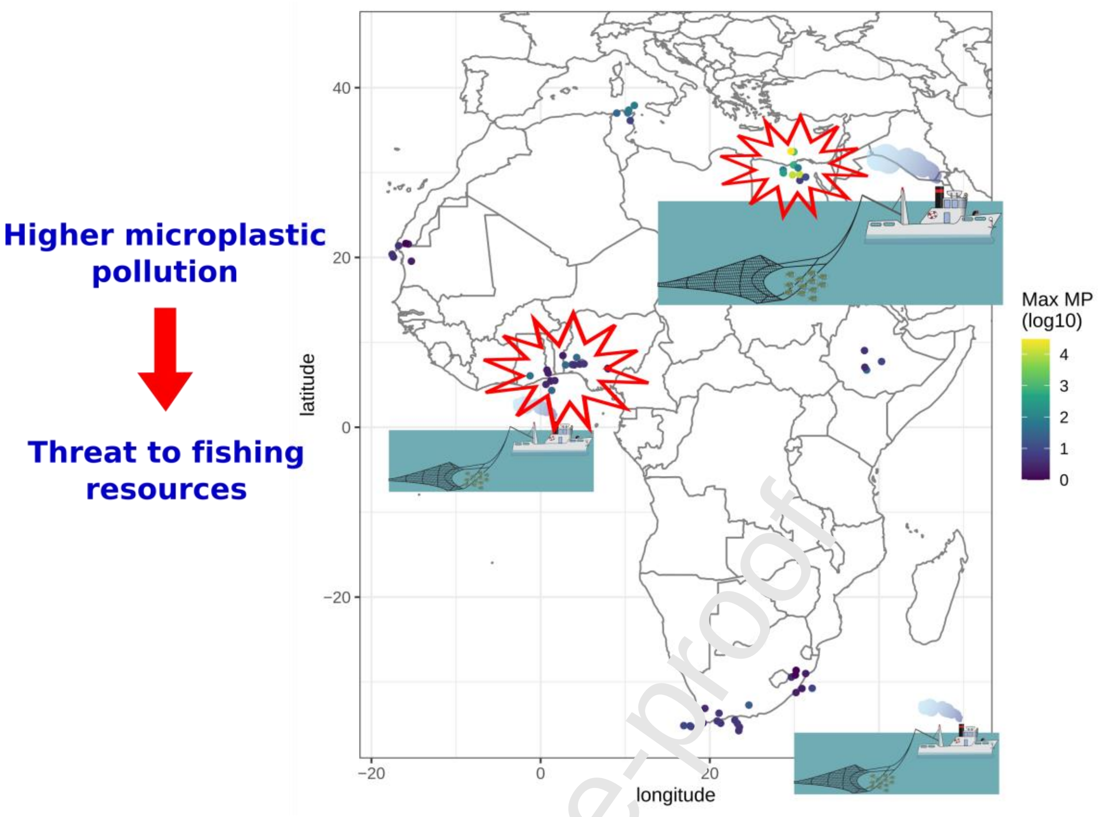
| **Region** | **Catch of the species considered in this study** | **Proportion of MPct Q1 catch** |
|---|---|---|
| East Mediterranean | 200594 | 2.6% |
| Gulf of Guinea | 270162 | 25% |
| Nile basin | 1259980 | 97.1% |
| Northwest | 132600 | 3.5% |
| South Africa | 442682 | 38.7% |
| West Mediterranean | 98717 | 5.5% |

**Declaration of interests**

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Declarations of interest: none



Graphical abstract

## Highlights

1. Microplastics are emerging contaminants that endanger aquatic resources
2. There is a lack of studies about microplastics in specific areas like Africa.
3. Meta-database of 156 samples of fishing organisms from quality publications
4. High microplastic pollution in Nile countries, Gulf of Guinea and Tunisia fish
5. Some of the most fished African species are highly microplastic-polluted
6. African fishing resources can be threatened by microplastics in some regions