ISPRA
Istituto Superiore per la Protezione e la Ricerca Ambientale

Sistema Nazionale per la Protezione dell'Ambiente

Marine Litter: studio e monitoraggio delle microplastiche in ambiente marino

WORKSHOP

ATIA ISWA ITALIA — Ordine degli Ingegneri della Provincia di Roma — AIDIC

INQUINAMENTO DA MICROPLASTICHE NELLE ACQUE: STATO ATTUALE E STRATEGIE FUTURE

Prospettive professionali ed industriali

www.isprambiente.gov.it/it marco.matiddi@isprambiente.it

ISPRA-Italian National Institute for Environmental Protection and Research

MARINE STRATEGY FRAMEWORK DIRECTIVE

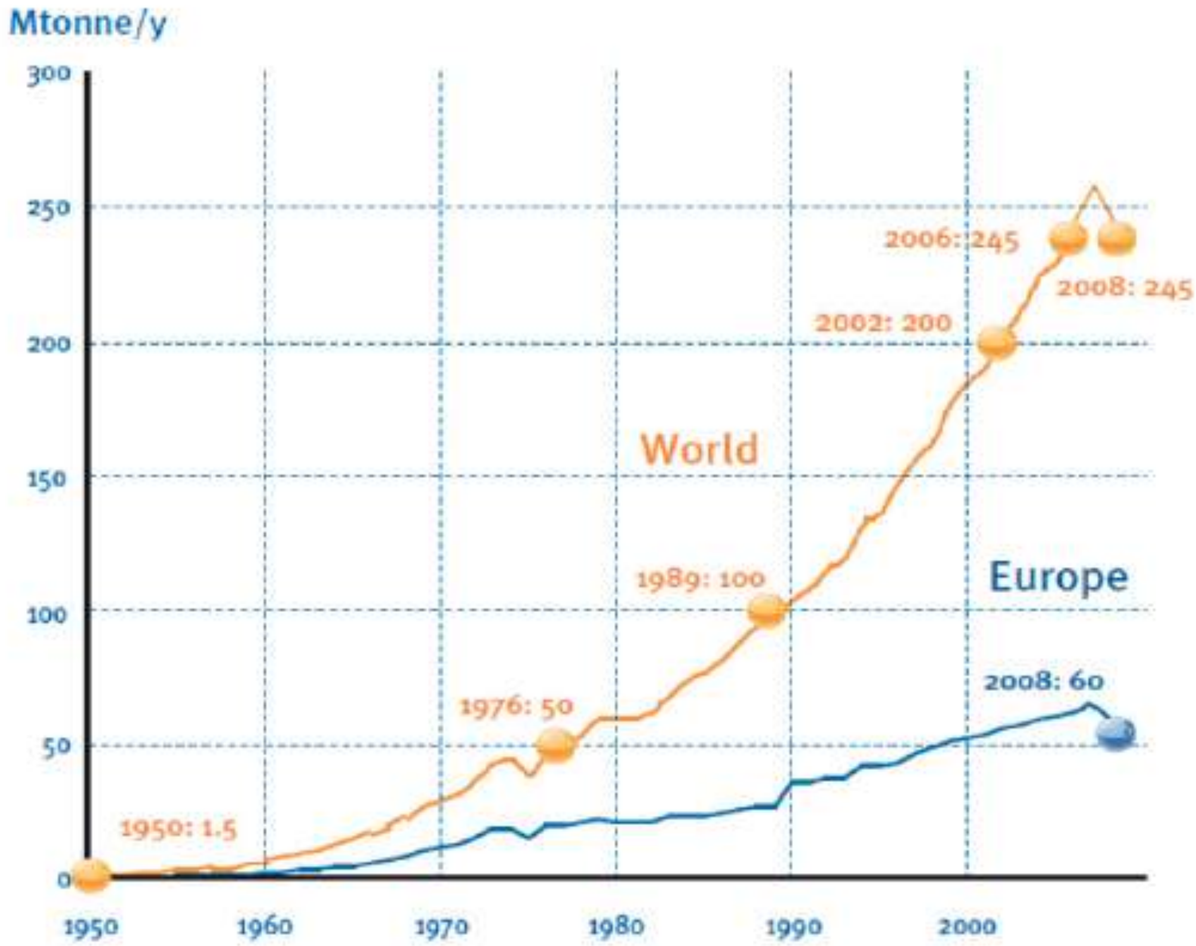
DESCRIPTOR 10: MARINE LITTER

✓Valutazione dello stato del mare attraverso 11 Descrittori

La Direttiva è stata recepita in Italia nel 2010, sono già 12 anni che viene attuata da noi di ISPRA insieme alle Agenzie Regionali per la protezione dell’ambiente e sotto il coordinamento dell’Autorità competente, oggi MASE


MARINE LITTER:
any persistent, manufactured or processed solid
material discarded, disposed of or abandoned in
the marine and coastal environment

Produzione di plastica



Includes Thermoplastics, Polyurethanes, Thermosets, Elastomers, Adhesives, Coatings and Sealants and PP-Fibers. Not included PET-, PA- and Polyacryl-Fibers

1953

- **Ziegler** sintetizza il **polietilene (PE)**

1954

- **Natta** sintetizza il **polipropilene (PP) isotattico**

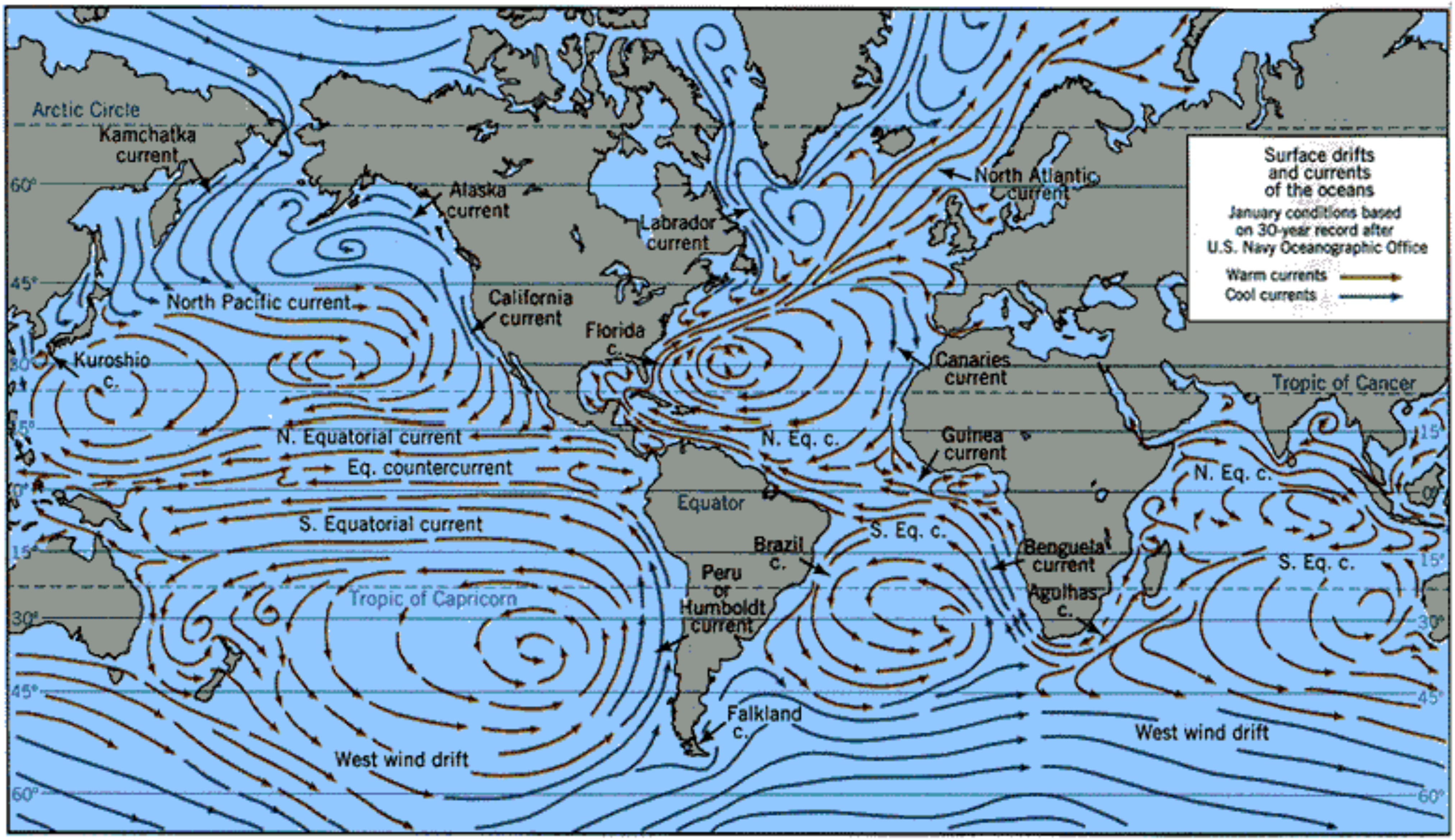
1963

- Ziegler & Natta vincono il **Nobel per la chimica**

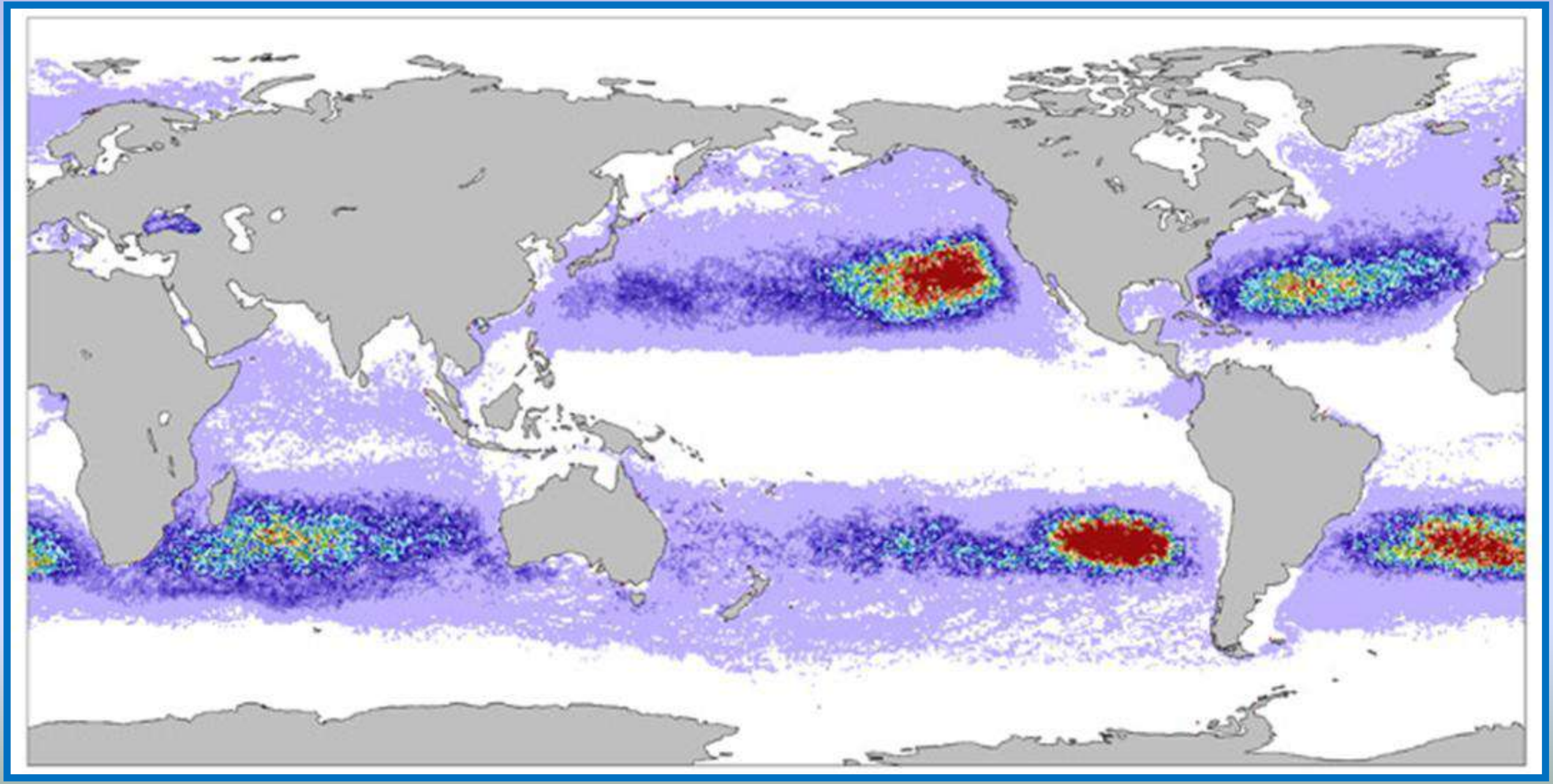
MOntecatini PolipropiLENe isotattico

University of Georgia. "Magnitude of plastic waste going into the ocean calculated: 8 million tons of plastic enter the oceans per year." ScienceDaily. ScienceDaily, 12 February 2015.

Correnti marine



Il Marine Litter può accumularsi nelle aree di convergenza delle correnti marine causando la formazione delle cosiddette "isole di rifiuti" (note anche con il termine inglese di "***Garbage Patch***" oppure di "***Trash Islands***"). In queste zone è possibile rilevare una concentrazione di rifiuti pari a 25.000 – 100.000 oggetti/Km^2



Aree oceaniche di maggior accumulo di rifiuti solidi galleggianti (www.MarineDebris.noaa.gov)

COMMISSION DECISION
of 1 September 2010
on criteria and methodological standards on Good Environmental Status of marine waters (2010/477/EU)

Marine Strategy Framework Directive
Descriptor 10

- 10.1. Characteristics of litter in the marine and coastal environment
  - — Trends in the amount of litter washed ashore and/or deposited on coastlines, including analysis of its composition, spatial distribution and, where possible, source (10.1.1)
  - — Trends in the amount of litter in the water column (including floating at the surface) and deposited on the sea- floor, including analysis of its composition, spatial distribution and, where possible, source (10.1.2)
  - **— Trends in the amount, distribution and, where possible, composition of micro-particles (in particular micro- plastics) (10.1.3)**
- 10.2. Impacts of litter on marine life
  — Trends in the amount and composition of litter ingested by marine animals (e.g. stomach analysis) (10.2.1).

COMMISSION DECISION (EU) 2017/848

of 17 May 2017

laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment, and repealing Decision 2010/477/EU

The amount of litter and micro-litter ingested by marine animals is at a level that does not adversely affect the health of the species concerned.

MSFD TG-ML: basic requirements for target species

"**Marine feeding habits**: stomach contents should only reflect the marine environment."

"**Regular plastic consumption**: Frequency of occurrence and amounts of plastic found in stomachs should be high enough to allow detection of trends over time and geographical patterns."

"**Sample availability**: Samples of a monitoring species should be available with adequate numbers of individuals over a wider span of time and space."

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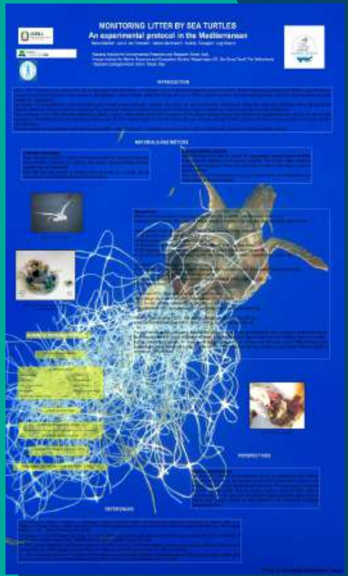


Marine Environmental Research 100 (2014) 25–32

Contents lists available at ScienceDirect

Marine Environmental Research

journal homepage: www.elsevier.com/locate/marenvrev

Interaction between loggerhead sea turtles (*Caretta caretta*) and marine litter in Sardinia (Western Mediterranean Sea)

Andrea Camedda[a,b,*], Stefano Marra[a,c], Marco Matiddi[d], Giorgio Massaro[e], Stefania Coppa[a], Angelo Perilli[a], Angelo Ruiu[f], Paolo Briguglio[g], G. Andrea de Lucia[a]


Environmental Pollution 230 (2017) 199–209

Contents lists available at ScienceDirect

Environmental Pollution

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Loggerhead sea turtles (*Caretta caretta*): A target species for monitoring litter ingested by marine organisms in the Mediterranean Sea[☆]

Marco Matiddi[a,*], Sandra Hochsheid[b], Andrea Camedda[c], Matteo Baini[d], Cristiano Cocumelli[e], Fabrizio Serena[f], Paolo Tomassetti[a], Andrea Travaglini[b], Stefano Marra[c], Tommaso Campani[d], Francesco Scholl[e], Cecilia Mancusi[f], Ezio Amato[a], Paolo Briguglio[g], Fulvio Maffucci[b], Maria Cristina Fossi[d], Flegra Bentivegna[c], Giuseppe Andrea de Lucia[c]

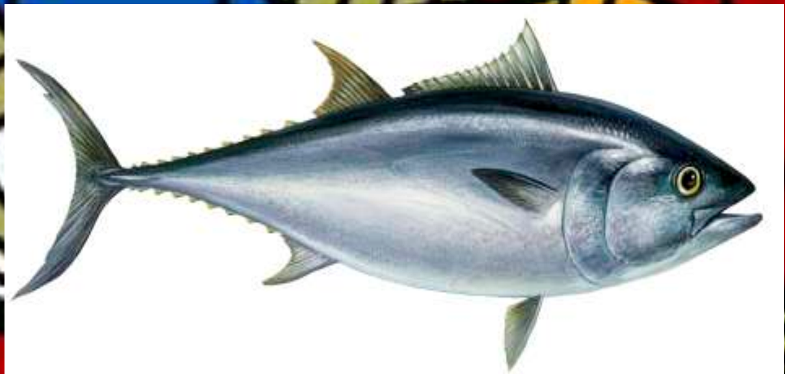
Microplastics are different

- Thomson et al., 2004: *Fragments of plastic around 20 µm in diameter*
- Arthur et al., 2009: *Plastic particles smaller than 5 mm*
- GESAMP 2016: plastic particles < 5 mm in diameter, which include particles in the nano-size range (1 nm)
- Galgani et al., 2019: *particles that pass through a 5 mm mesh screen but are retained by a lower one, according to the chosen size class*
- Matiddi et al., 2021: *All sorts of small particles of plastic, less than 5 mm in two of the three dimension or diameter that pass through a 5 mm mesh screen but are retained by a lower one, according to the chosen size class"*

Microplastics are different

Figure 4: Common shapes of microplastics. (1: fibers, 2-3: filaments, 4-7: films, 8-11: fragments, 12-14: foams, 15: pellet, 16-17: granule) (Photo: © Ülgen Aytan, Turkey).

Fish are different



Thunnus thynnus: 3 m 750 KG

Engraulis encrasicolus 18-20 cm 8/10 g

Environmental Pollution
Volume 247, April 2019, Pages 1071-1077

Determining suitable fish to monitor plastic ingestion trends in the Mediterranean Sea ☆

Laura Bray [a], Nikoletta Digka [a], Catherine Tsangaris [a], Andrea Camedda [b], Delphine Gambaiani [c], Giuseppe Andrea de Lucia [b], Marco Matiddi [d], Claude Miaud [c], Luca Palazzo [b, e], Ana Pérez-del-Olmo [f], Juan Antonio Raga [f], Cecilia Silvestri [d], Helen Kaberi [a]

Table 2
List of 49 fish species known to ingest plastics scored per index criteria. Asterisk (*) indicates where scale is defined by expert knowledge when published data was unavailable. Home range MDS = Migratory/deep sea, OC = Oceanodromous, RE = Resident, LR = Limited range. Figures rounded to nearest integer or 2 significant figures.

	Distribution		Gut length		Commercial value		Vagility		Plastic occurrence	
	% of Med.	Scale	cm	Scale	Euros/2015	Scale	Range	Scale	%	Scale
Argyrosomus regius (Asso, 1801)	69	4	–	2*	1.1E+6	4	OC	2	33	3
Boops boops (Linnaeus, 1758)	71	5	17	4	1.9E+6	4	OC	2	58	4
Caranx crysos (Mitchill, 1815)	63	4	25	3	3.3E+3	1	OC	2	100	5
Chelidonichthys lucerna (Linnaeus, 1758)	69	4	3	5	1.0E+4	2	RE	4	67	5
Citharus linguatula (Linnaeus, 1758)	68	4	4	5	1.0E+6	4	LR	3	2	1
Coryphaena hippurus (Linnaeus, 1758)	94	5	–	2*	2.8E+5	3	OC	2	7	1
Dentex gibbosus (Rafinesque, 1810)	56	3	18	4	9.1E+5	2	OC	2	14	2
Diaphus metopoclampus (Cocco, 1829)	63	4	–	5*	0	1	MD	1	1	1
Diplodus annularis (Linnaeus, 1758)	69	4	9	5	3.9E+5	3	LR	3	42	4
Electrona risso (Cocco, 1829)	94	5	–	5*	0	1	MD	1	6	1
Engraulis encrasicolus (Linnaeus, 1758)	68	4	8	5	1.3E+8	5	OC	2	57	4
Helicolenus dactylopterus (Delaroche, 1809)	68	4	–	3	2.2E+6	3	OC	2	1	1
Hygophum benoiti (Cocco, 1838)	100	5	–	5*	0	1	MD	1	7	1
Lithognathus mormyrus (Linnaeus, 1758)	69	4	–	3*	6.2E+6	4	RE	3	20	2
Chelon aurata (Risso, 1810)	69	4	111	1	4.2E+4	2	LR	3	36	3
Merluccius merluccius (Linnaeus, 1758)	9	1	7	5	3.8E+6	5	MD	1	58	4
Mora moro (Risso, 1810)	73	5	–	2*	1.1E+4	2	MD	1	9	1
Mullus barbatus barbatus (Linnaeus, 1758)	76	5	11	4	4.1E+5	4	RE	4	32	3
Mullus surmuletus (Linnaeus, 1758)	76	5	11	4	2.9E+7	3	RE	4	31	3
Myctophum punctatum (Rafinesque, 1810)	100	5	–	5*	0	1	MD	1	4	1
Naucrates ductor (Linnaeus, 1758)	20	2	–	2*	2.1E+5	3	LR	3	18	2
Nemipterus randalli (Russell, 1986)	–	1*	–	4*	0	1	LR	3	28	2
Nettastoma melanurum (Rafinesque, 1810)	76	5	28	3	0	1	MD	1	9	1
Pagellus acarne (Risso, 1827)	69	4	8	5	2.1E+5	3	OC	2	48	4
Pagellus bogaraveo (Brünnich, 1768)	55	3	8	5	2.7E+5	3	OC	2	2	1
Pagellus erythrinus (Linnaeus, 1758)	69	4	8	5	1.5E+6	4	LR	3	32	3
Pagrus pagrus (Linnaeus, 1758)	69	4	9	5	7.7E+4	2	OC	2	22	2
Pelates quadrilineatus (Bloch, 1790)	–	1*	11	4	0	1	RE	4	28	2
Polyprion americanus (Bloch & Schneider, 1801)	75	2	96	2	3.7E+5	3	OC	2	55	4
Pomadasys incisus (Bowdich, 1825)	31	3	17	4	3.2E+3	1	OC	2	31	3
Sardina pilchardus (Walbaum, 1792)	22	4*	10	4	8.9E+6	5	OC	2	32	3
Saurida undosquamis (Richardson, 1848)	–	1*	–	2	0	1	LR	3	36	3
Schedophilus ovalis (Cuvier, 1833)	89	5	–	2*	5.3E+4	2	MD	1	50	4
Sciaena umbra (Linnaeus, 1758)	55	3	8	5	5.0E+5	3	LR	3	100	5
Scomber japonicus (Houttuyn, 1782)	0	1	11	4	6.9E+6	4	OC	2	50	4
Seriola dumerili (Risso, 1810)	74	5	87	2	1.1E+7	4	OC	2	2	1
Serranus cabrilla (Linnaeus, 1758)	69	4	10	5	6.9E+4	2	RE	4	33	3
Siganus luridus (Rüppell, 1829)	–	1*	–	3*	5.2E+4	2	LR	3	60	4
Solea solea (Linnaeus, 1758)	76	5	59	2	3.7E+7	5	LR	3	3	1
Sparus aurata (Linnaeus, 1758)	68	4	396	1	1.5E+6	4	LR	3	27	2
Thunnus alalunga (Bonnaterre, 1788)	43	3	128	1	2.9E+6	4	OC	2	13	2
Thunnus thynnus (Linnaeus, 1758)	100	5	128	1	6.1E+6	5	OC	2	19	2
Trachinotus ovatus (Linnaeus, 1758)	99	5	28	3	2.3E+6	4	OC	2	24	2
Trachurus trachurus (Linnaeus, 1758)	100	5	7	5	6.6E+6	4	OC	2	24	2
Trachurus mediterraneus (Steindachner, 1868)	100	5	16	4	8.0E+5	4	OC	2	18	2
Trachyrincus scabrus (Rafinesque, 1810)	21	2	20	4	8.5E+3	1	LR	3	33	3
Upeneus moluccensis (Bleeker, 1855)	–	1*	–	4*	2.3E+5	3	RE	4	33	3
Upeneus pori (Ben-Tuvia & Golani, 1989)	–	1*	–	4*	2.3E+5	3	RE	4	29	2
Xiphias gladius (Linnaeus, 1758)	100	5	305	1	1.5E+11	5	OC	2	13	2

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Determining suitable fish to monitor plastic ingestion trends in the Mediterranean Sea ☆

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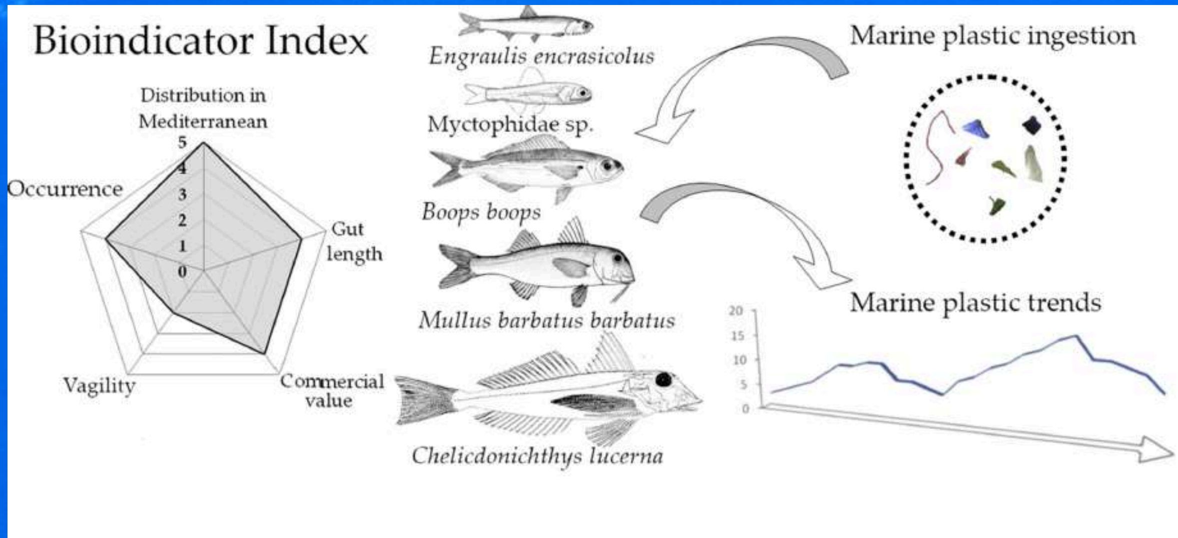

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Food preference determines the best suitable digestion protocol for analysing microplastic ingestion by fish

Jessica Bianchi[a,b,*], Tommaso Valente[b], Umberto Scacco[b], Roberta Cimmaruta[a], Alice Sbrana[b], Cecilia Silvestri[b], Marco Matiddi[b]

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Species-specific protocol

ABSTRACT

Microplastic presence in the marine environment has generated considerable concern. Many procedures for microplastics detection in fish gastrointestinal tract have been recently developed. In this study, we compared efficiencies of two common procedures applied for the digestion of organic matter (10% KOH; 15% H_2O_2) with a new proposal (mixture of 5% HNO_3 and 15% H_2O_2). We considered ecological diversity among species and differences in their diet compositions as factors that could affect the efficiency and feasibility of analytical approaches. Our aim was to understand whether either one of the three protocols might be suitable for all species or it might be more advisable to select a method according to the gut content determined by different food preferences. The results showed that the trophic level and feeding habits should be considered for protocol selection. Finally, we applied the best protocols on samples from the Tyrrhenian sea.

Table 1 Optimised protocols for digesting biota or biogenic material to isolate microplastics. Assumptions: 'overnight' given as 12 h; 'room temperature' given as 20 °C

Treatment	Exposure	Organism	Author
HNO_3 (22.5 M)	20 °C (12 h) + 100 °C (2 h)	Blue mussels	Claessens *et al.* (2013)[51]
HNO_3 (22.5 M)	20 °C (12 h) + 100 °C (2 h)	Blue mussels oysters	Van Cauwenberghe & Jansen (2014)[54]
HNO_3 (22.5 M)	20 °C (12 h) + 100 °C (2 h)	Blue mussels lugworms	Van Cauwenberghe *et al.* (2013)[23]
HNO_3 (100%)	20 °C (30 min)	Euphausids copepods	Desforges *et al.* (2015)[16]
HNO_3 (69–71%)	90 °C (4 h)	Manilla clams	Davidson & Dudas (2016)[61]
HNO_3 (70%)	2 h	Zebrafish	Lu *et al.* (2016)[105]
HNO_3 (22.5 M)	20 °C (12 h) + 100 °C (15 min)	Brown mussels	Santana *et al.* (2016)[63]
HNO_3 (65%) $HClO_4$ (68%) (4 : 1)	20 °C (12 h) + 100 °C (10 min)	Blue mussels	De Witte *et al.* (2014)[52]
HNO_3 (65%) $HClO_4$ (68%) (4 : 1)	20 °C (12 h) + 100 °C (10 min)	Brown shrimp	Devriese *et al.* (2015)[38]
CH_2O_2 (3%)	72 h	Corals	Hall *et al.* (2015)[32]
KOH (10%)	2–3 weeks	Fish	Foekema *et al.* (2013)[75]
KOH (10%)	60 °C (12 h)	Fish	Rochman *et al.* (2015)[58]
KOH (10%)	2–3 weeks	Fish	Lusher *et al.* (2016)[89]
H_2O_2 (30%)	60 °C	Blue mussels	Mathalon & Hill (2014)[53]
H_2O_2 (30%)	20 °C (7 d)	Biogenic matter	Nuelle *et al.* (2015)[137]
H_2O_2 (15%)	55 °C (3 d)	Fish	Avio *et al.* (2015)[81]
H_2O_2 (30%)	65 °C (24 h) + 20 °C (<48 h)	Bivalves	Li *et al.* (2015)[57]
NaClO (3%) $NaClO_3$ (10 : 1)	20 °C (12 h) 20 °C (5 min)	Fish	Collard *et al.* (2015)[82]

Lusher *et al.*, 2017


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Food preference determines the best suitable digestion protocol for analysing microplastic ingestion by fish

?

Different chemicals should be more or less incisive depending on the composition of the gut content.

To exemplify this, we chose three fish species according to samples availability, commercial and ecological importance, habitat use, and feeding habits

Merluccius merluccius, Linnaeus, 1758

Demersal species of high commercial importance worldwide

Scomber colias Gmelin, 1789

Pelagic species (Eastern Atlantic Ocean and Mediterranean Sea)

Trigla lyra Linnaeus, *1758*

Benthic species that lives on the continental shelf.


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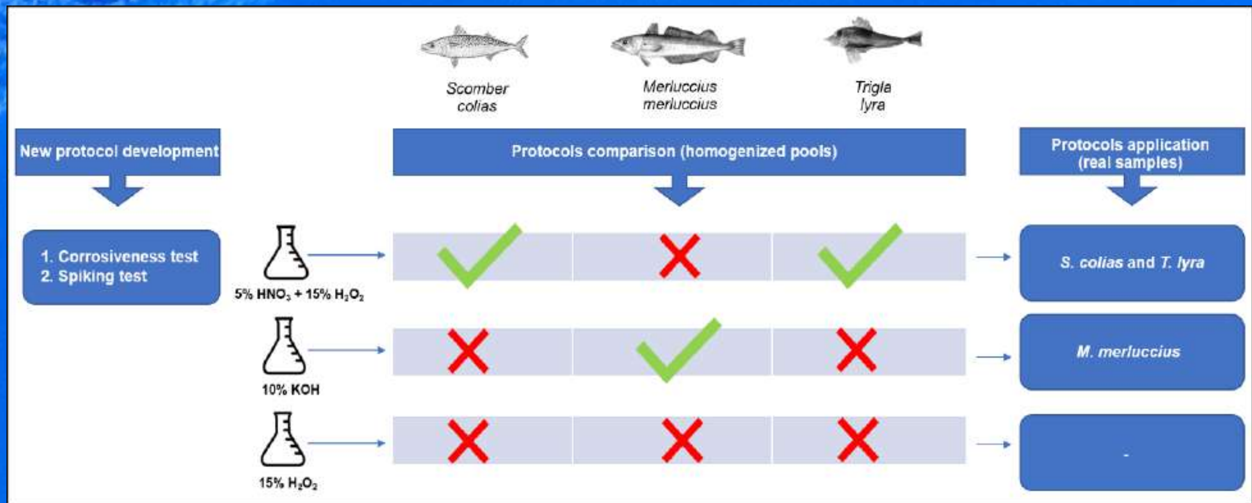
Food preference determines the best suitable digestion protocol for analysing microplastic ingestion by fish

Our study demonstrates that protocols efficiency changes according to the gut contents composition. Ecological diversity among species and differences in their diets are factors that affect the efficiency of different digestive solutions. Trophic levels and food preferences should be considered into protocol selection



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Spatial variability and influence of biological parameters on microplastic ingestion by *Boops boops* (L.) along the Italian coasts (Western Mediterranean Sea)☆

Alice Sbrana [a], Tommaso Valente [a], Umberto Scacco [a], Jessica Bianchi [a, b], Cecilia Silvestri [a], Luca Palazzo [b], Giuseppe Andrea de Lucia [c], Claudio Valerani [d], Giandomenico Ardizzone [e], Marco Matiddi [a, *]

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A B S T R A C T

Recently, many studies focus on the ingestion of microplastics by marine biota. Fish exploit almost every kind of marine environment, occupy many ecological niches and are an important food source for human populations worldwide. For these reasons, they seem to represent very appropriate biological indicators of microplastic ingestion. UNEP/MAP SPA/RAC (2018) identified the bogue, *Boops boops* (Linnaeus, 1758), as a possible target species for monitoring microplastic ingestion in fish populations. This study provides the first report of microplastic ingestion by *B. boops* from the Tyrrhenian and the Ligurian Seas (Western Mediterranean Sea). Generalized Linear Mixed Models were used to analyse the relationship among biological parameters and environmental factors. A total of 379 bogues were collected in three Italian regions, subject to different anthropogenic pressures (river input, human population, shipping lanes and distance from the coast). Microplastics were detected in the gastrointestinal tract of most individuals (56%) with a mean of 1.8 (±0.2) microplastics per individual. Our study further confirms that this species is able to highlight differences in the ingestion of microplastics according to local anthropization, resulting Latium region to be the most polluted. Fish with lower physical condition are more likely to ingest microplastics, suggesting a relationship with the level of local environmental contamination. Finally, the ingestion of microplastics might be influenced by behavioural differences between sexes. According to our results, males ingest significantly more microplastics than females ($p < 0.05$). Our research confirms that an extensive knowledge on the biology of a bioindicator species is a priority for developing a valid monitoring strategy, such as the Marine Strategy Framework Directive for European waters.

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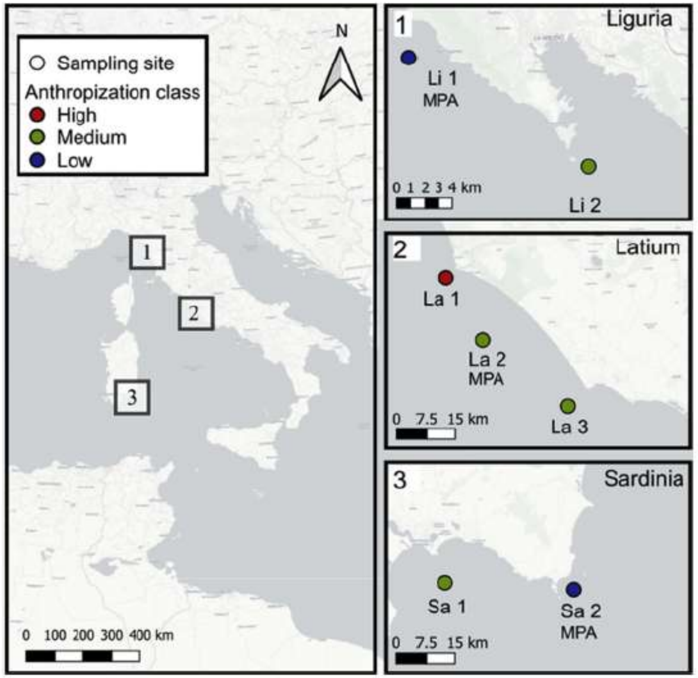

Fig. 1. Sampling sites of *B. boops* in three Italian regions (Liguria, Latium, and Sardinia) with relative anthropization class (High, Medium, Low), ranked according to different coastal pressures.

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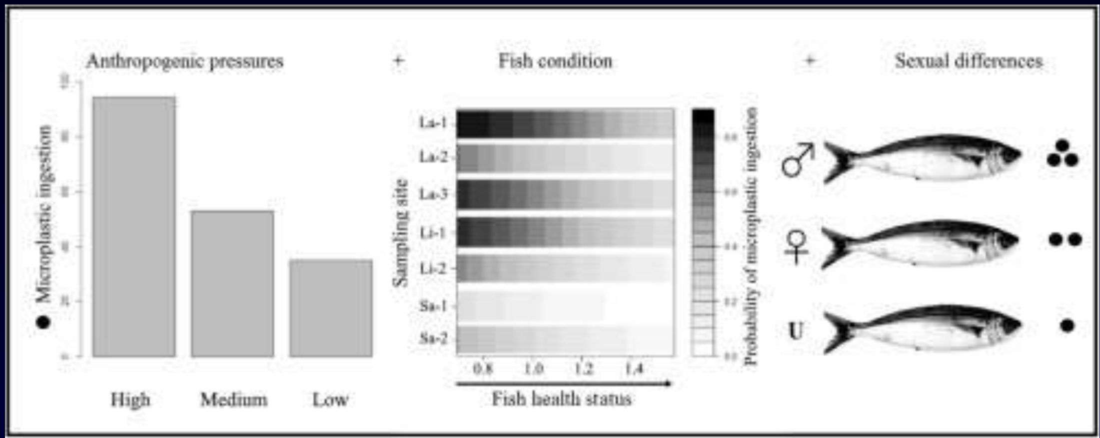
Spatial variability and influence of biological parameters on microplastic ingestion by *Boops boops* (L.) along the Italian coasts (Western Mediterranean Sea)☆

The results confirm *that B. boops* seems a suitable target species for the Mediterranean coastal zone.

- differences in the ingestion of microplastics according to local anthropogenic pressures
- individual ***condition factor*** is significantly related to the frequency of microplastic ingestion
- differences in microplastic ingestion between sexes are a new interesting topic for further research on both this and other fish species



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Marine Pollution Bulletin

journal homepage: www.elsevier.com/locate/marpolbul

Using *Boops boops* (osteichthyes) to assess microplastic ingestion in the Mediterranean Sea

Catherine Tsangaris[a,*], Nikoletta Digka[a], Tommaso Valente[b], Alex Aguilar[c], Asunción Borrell[c], Giuseppe Andrea de Lucia[d], Delphine Gambaiani[e], Odei Garcia-Garin[c], Helen Kaberi[a], Jessica Martin[e], Elena Mauriño[f], Claude Miaud[e], Luca Palazzo[d,g], Ana Pérez del Olmo[f], Juan Antonio Raga[f], Alice Sbrana[b], Cecilia Silvestri[b], Ester Skylaki[a], Morgana Vighi[c], Paprapach Wongdontree[e], Marco Matiddi[b]

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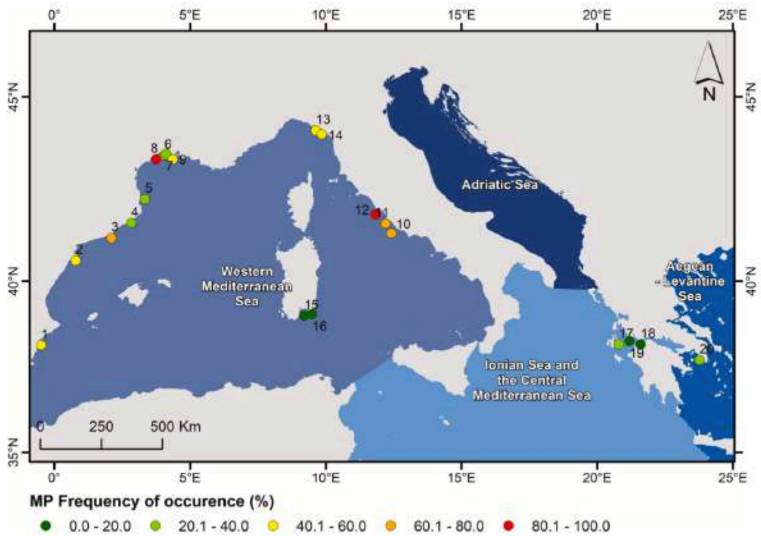
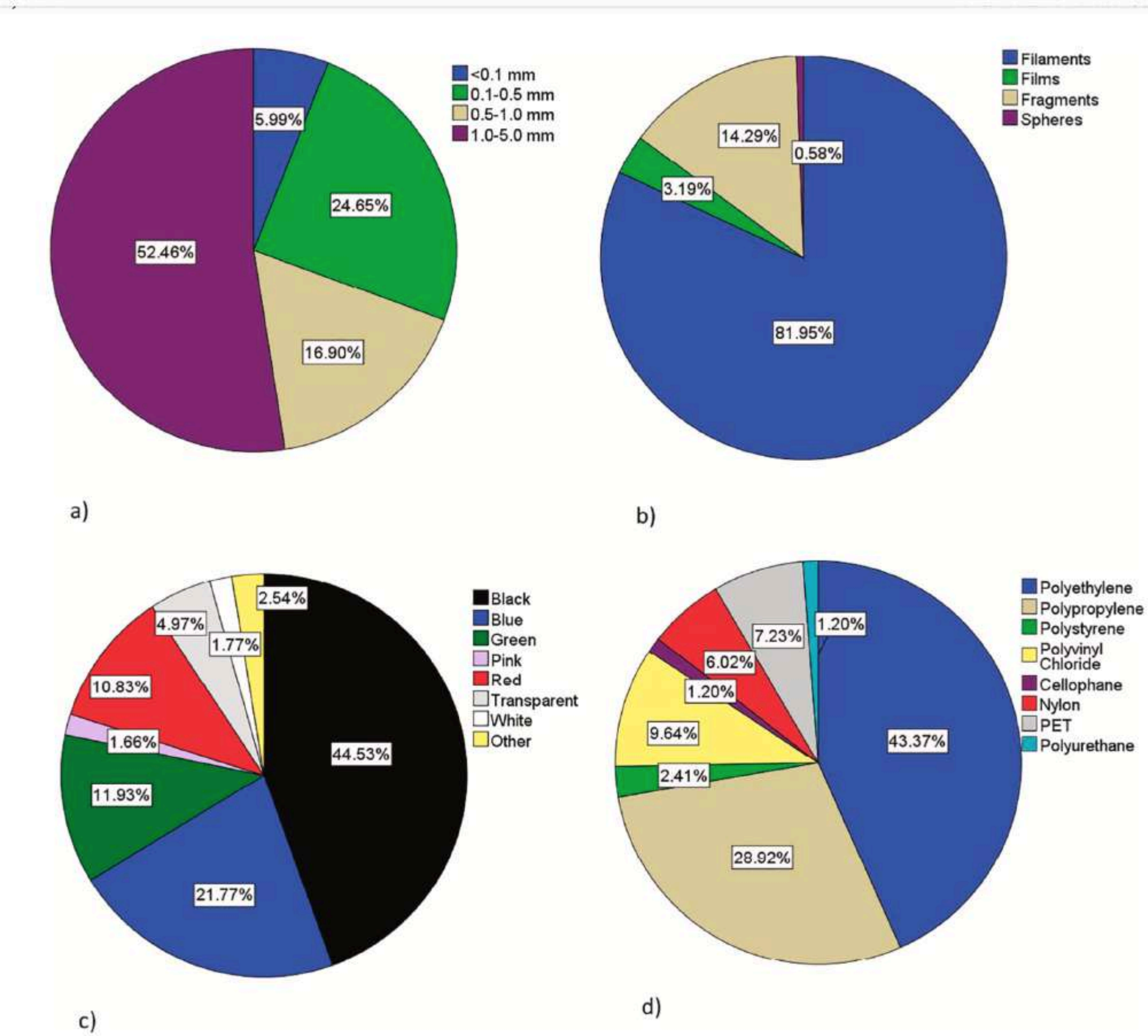
[g] Department of Ecology and Biology, University of Tuscia, 01100 Viterbo, Italy.

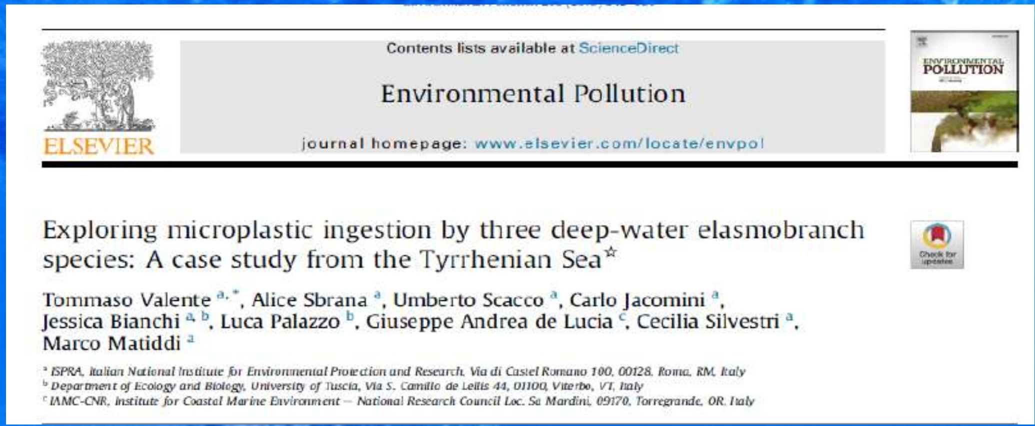
884 samples

FO= 46,8%





5.99%
24.65%
16.90%
52.46%
<0.1 mm
0.1-0.5 mm
0.5-1.0 mm
1.0-5.0 mm
a)
14.29%
0.58%
3.19%
81.95%
Filaments
Films
Fragments
Spheres
b)
2.54%
4.97%
1.77%
10.83%
1.66%
11.93%
21.77%
44.53%
Black
Blue
Green
Pink
Red
Transparent
White
Other
c)
7.23%
1.20%
6.02%
1.20%
9.64%
2.41%
28.92%
43.37%
Polyethylene
Polypropylene
Polystyrene
Polyvinyl Chloride
Cellophane
Nylon
PET
Polyurethane
d)



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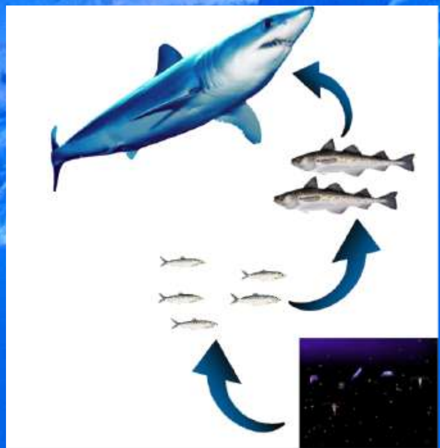
Exploring microplastic ingestion by three deep-water elasmobranch species: A case study from the Tyrrhenian Sea☆

Tommaso Valente [a,*], Alice Sbrana [a], Umberto Scacco [a], Carlo Jacomini [a], Jessica Bianchi [a,b], Luca Palazzo [b], Giuseppe Andrea de Lucia [c], Cecilia Silvestri [a], Marco Matiddi [a]

[a] ISPRA, Italian National Institute for Environmental Protection and Research, Via di Castel Romano 100, 00128, Roma, RM, Italy
[b] Department of Ecology and Biology, University of Tuscia, Via S. Camillo de Lellis 44, 01100, Viterbo, VT, Italy
[c] IAMC-CNR, Institute for Coastal Marine Environment – National Research Council Loc. Sa Mardini, 09170, Torregrande, OR, Italy



Elasmobranchs are **top predator** that play an important role in marine food webs

Few studies have investigated their interactions with marine litter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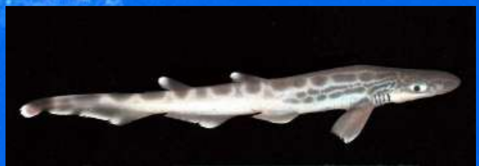
Mostly pelagic and feed on cephalopods and pelagic fish

Etmopterus spinax
(Linnaeus,1758)

Benthopelagic and feed on benthic crustaceans and small pelagic fish

Scyliorhinus canicula
(Linnaeus, 1758)



Mainly benthic feeders and feed on crusteans and epibenthic fish

Galeus melastomus
(Rafinesque, 1810))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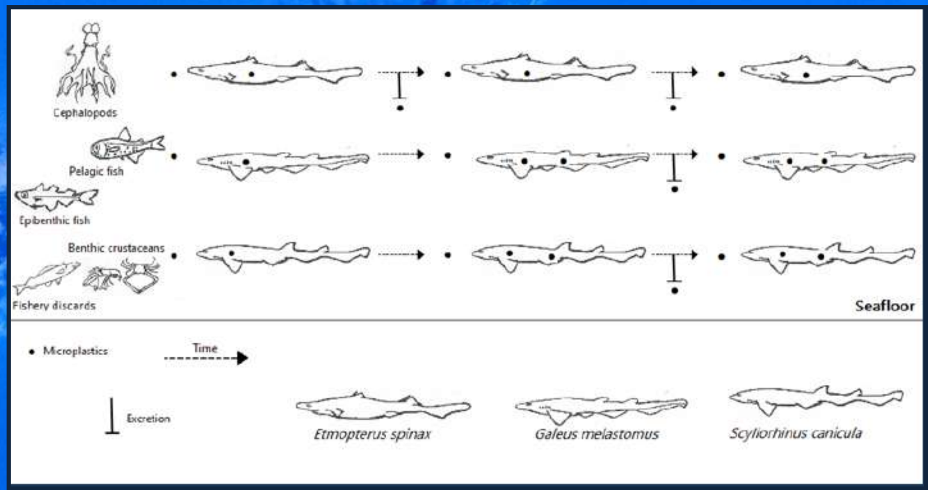


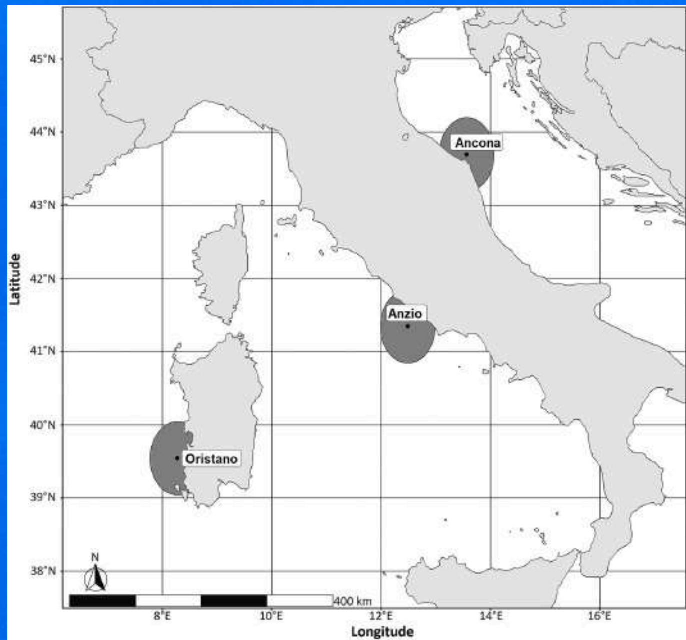
The results of the study suggest that the three species show a **similar probability to ingest plastic items**, but they have a **different ability in excreting ingested microplastics.**

The discrimination between stomach and intestinal contents highlights a possible origin for the differences recorded in the three species, giving information about the **retention time** of microplastics in the GI

Marine Pollution Bulletin
Volume 184, November 2022, 114133

One is not enough: Monitoring microplastic ingestion by fish needs a multispecies approach

Tommaso Valente [a] [b], Tania Pelamatti [b], Carlo Giacomo Avio [c], Andrea Camedda [d], Maria Letizia Costantini [a], Giuseppe Andrea de Lucia [d], Carlo Jacomini [b], Raffaella Piermarini [b], Francesco Regoli [c], Alice Sbrana [b] [e], Daniele Ventura [a], Cecilia Silvestri [b], Marco Matiddi [b]



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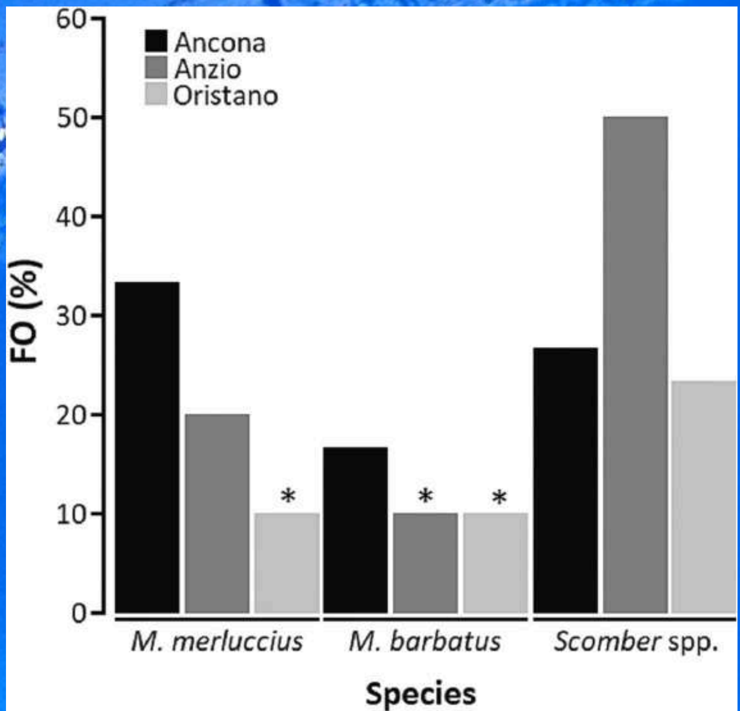

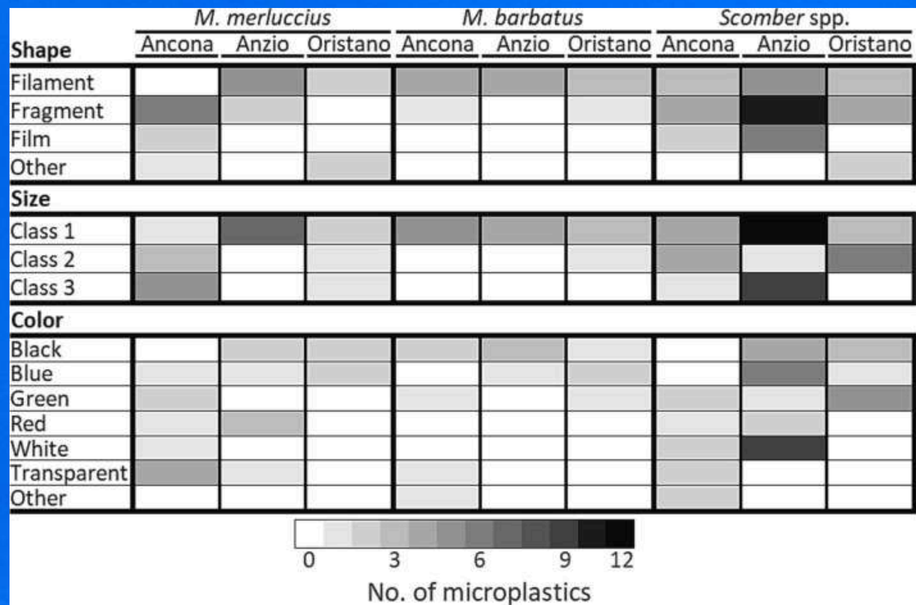

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Available online 5 May 2023, 163875
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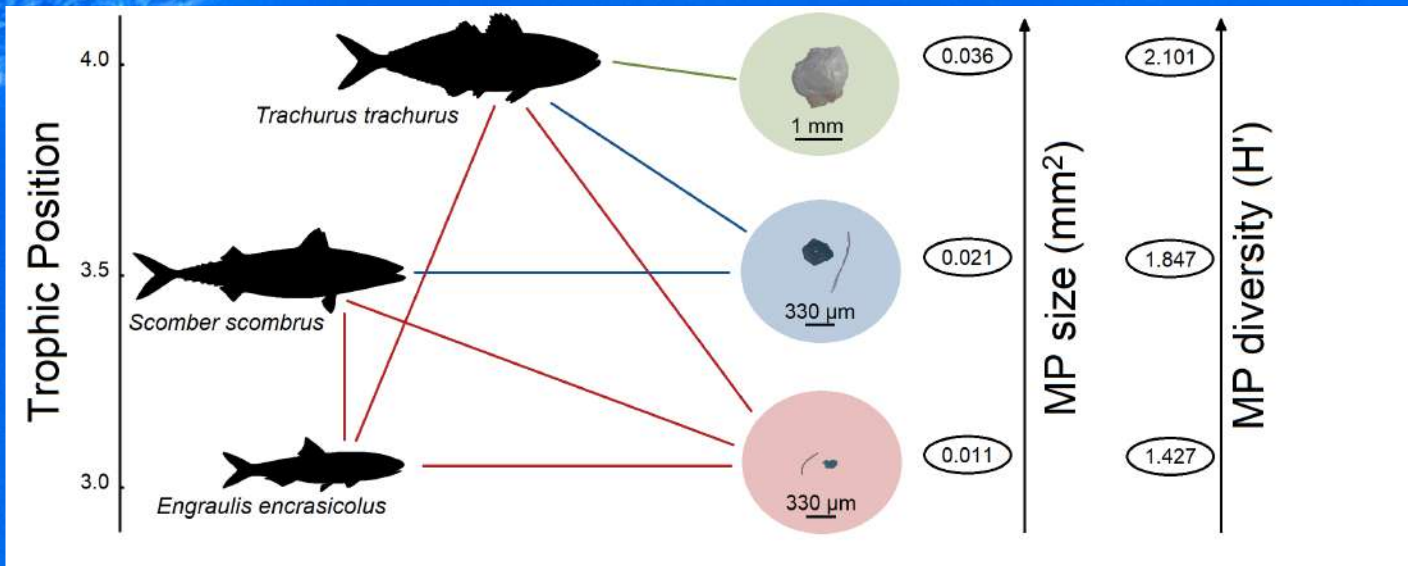
Short Communication

Tracing the route: Using stable isotope analysis to understand microplastic pathways through the pelagic-neritic food web of the Tyrrhenian Sea (Western Mediterranean)

Tommaso Valente [a b], Maria Letizia Costantini [a], Giulio Careddu [a], Daniela Berto [c], Raffaella Piermarini [b], Federico Rampazzo [c], Alice Sbrana [b d], Cecilia Silvestri [b], Daniele Ventura [a], Marco Matiddi [b]



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A guidance document within the Common Implementation Strategy for the Marine Strategy Framework Directive
MSFD Technical Subgroup on Marine Litter


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Draft Technical guidance document on integrated monitoring under the Ecosystem Approach


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GRAZIE

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