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Report of the IWC Workshop on Marine Debris: The Way Forward, 3-5 December 2019, La Garriga, Catalonia, Spain

IWC

INTERNATIONAL WHALING COMMISSION

Report of IWC Workshop on Marine Debris: The Way Forward

CHAIR'S SUMMARY

The IWC's third Workshop on Marine Debris met in La Garriga in Catalonia, Spain, 3-5 of December 2019 with experts from nine countries attending. The workshop aimed to progress the IWC's work on this threat by: (i) reviewing the latest evidence on interactions with cetaceans (both ingestion and entanglement) and considering evidence for associated toxicology; (ii) identifying best protocols for gross pathology, pathology for microdebris and the standardised classification of recovered plastics and other debris; and (iii) developing liaison with other relevant expert bodies.

The workshop considered published and unpublished information, including reviews of the latest literature and a comprehensive overview of marine debris-related activities by other international organisations. It also considered a number of regional reports, including from the Adriatic, the Spanish Canary Islands, German and Dutch waters and the Mediterranean. The workshop agreed that the scale of the actual and projected increase in plastics is alarming.

Cetaceans can die after marine debris ingestion, due to gastric impaction/occlusion, perforation, or the associated lesions. Besides direct lethal effects, presence of plastic debris could affect marine mammals' health if they persist in the gastrointestinal tract (GIT), for example by reducing the space for food and, subsequently, reducing their fitness and the nutritional condition. Presence of foreign bodies could also cause inflammatory changes to the GIT and/or induce stress and pain. An additional concern on the health effects of marine debris on cetaceans was related to the potential role of plastic debris as a carrier or vector of toxins and pathogens. The workshop also considered the relationship between marine debris and entanglement in fishing gear and received new information on Fisheries Aggregation Devices. Noting that approximately 640,000 tonnes of Abandoned, Lost and otherwise Discarded Fishing Gear (ALDFG) enters the oceans every year, the workshop also called for actions to address this threat, including for bowhead whales in the Bering Sea which may be at particular risk.

Based on its discussions, the workshop made a series of detailed recommendations, including emphasising the importance of long-term studies; the need for standardised approaches to post-mortem studies; the importance of strandings networks; the assessment of floating debris during aerial surveys and the integration of marine debris concerns into the IWC's Conservation Management Plans, where appropriate. The vulnerability of some species was highlighted and the potential of some to be used as indicator species. The workshop also called on the IUCN to consider marine debris in its next assessment of the sperm whale.

Other recommendations covered engagement with international bodies (the workshop encouraged the establishment of a roster of marine debris experts by the IWC who would help to represent it at key meetings) and the development of a marine debris database of information from post-mortem examinations. The joint ACCOBAMS/ASCOBANS document on 'Best practice on cetacean post-mortem investigation and tissue sampling' was strongly welcomed and commended to the Scientific Committee for its consideration. A link to that document is included in the report.

Communicating this issue was also discussed and it was agreed that this should: (i) take into account the audience; (ii) be accurate about the underpinning scientific information and its limitations; (iii) emphasize upstream solutions in addition to end of life measures; (iv) consider consulting communication professionals or social scientists; and (v) wherever possible, focus on positive, actionable messaging.

Please see the report below for the full recommendations.

1. INTRODUCTORY ITEMS

The workshop was held from 3-5 December, 2019 in La Garriga, Catalonia, Spain. The Chair, Mark Simmonds welcomed participants to the meeting and thanked the Netherlands for supporting the workshop. Anne Marie Svoboda and Sarah Smith added words of welcome on behalf of the Netherlands and the IWC.

The workshop aimed to progress IWC work on marine debris to date, including the recommendations of the previous IWC workshops by: (i) reviewing the latest evidence on interactions with cetaceans (both ingestion and entanglement) and considering evidence for associated toxicology; (ii) identifying best protocols for gross pathology, pathology for microdebris and the standardised classification of recovered plastics and other debris; and (iii) developing liaison with other relevant expert bodies.

The Chair noted that since the IWC started to look at this issue in 2011, there had been a tremendous increase in public concern and the threat to biodiversity posed by marine debris has come more sharply into focus for all, including policy makers. Marine debris was now recognised as a major global threat to biodiversity at a time when the accelerating loss of biodiversity needed to be ranked alongside the threat posed by climate change - to which it is of course linked. He concluded that we all needed to work expeditiously to address these existential threats.

The workshop Agenda is in Annex 1, the documents list is in Annex 2 and the list of participants is in Annex 3. Experts from nine countries were present at the workshop.

2. THE MARINE DEBRIS ISSUE

2.1 An introduction to the marine debris issue

2.1.1 Presentation

Eisfeld-Pierantonio gave an overview of the issue of marine debris and cetaceans. The United Nations Environment Programme (UNEP, 2009) defines marine debris as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine or coastal environment. In other words, it is human-created waste that has deliberately or accidentally been released in a sea or ocean.

Marine debris comprises various material types and can be classified into several distinct categories: Plastics, metal, glass, processed timber, paper and cardboard, rubber and clothing and textiles. Plastics Europe (2019) reports global plastics production in 2016 as 335 million tonnes, rising to 359 million tonnes in 2018. (Geyer *et al.*, 2017) estimated that in the last 60 years, 8.3 billion metric tonnes of plastic have been created, most of which is still on this planet. Only about 30% of this plastic is still in use, 79% of it is accumulating in landfill, 12% has been incinerated and only 9% have been recycled. Ritchie and Roser (2020) provide helpful data analyses and future predictions for marine debris.

It is estimated that every minute of every day, the equivalent of one truckload of plastic enters the sea, this equates to between 4.8 and 12.7 million metric tonnes of plastic trash every year (Jambeck *et al.*, 2015), which is estimated to be more than the weight of every blue whale left in the world today. Some estimates indicate that up to 333,000 items of debris can be found per square kilometre of ocean surface (National Research Council, 2009). Plastics, which account for 60-80% of marine debris (Gregory and Ryan, 1997), are ubiquitous and occur across all oceans, including in remote areas. Evidence suggests that plastics pose a serious threat to marine wildlife, with negative effects from plastic debris established for an increasing list of species.

Bigger items of plastic break down into smaller microplastics with sun, wind and wave action. A single 1L plastic bottle could break down into enough small fragments to put one on every mile of beach in the entire world (Roorda, 2020). Between 115,000 and 1,050,000 particles/km^2 are estimated to float in the Mediterranean Sea (Panti *et al.*, 2019) and refs therein). Studies have shown that plastic debris meeting other pollutants in the oceans absorbs some harmful chemicals from the sea water they float in, acting like pollution sponges. One study found that virgin plastic pellets 'suck up' these persistent organic pollutants (POPs) and other toxins with a concentration factor that is almost 1 million times greater compared to the overall concentration of the chemicals in seawater (Mato *et al.*, 2001). Filter-feeding marine megafauna are particularly prone to microplastic ingestion and contamination by plastic-associated toxins because of the large volumes of water they ingest during feeding, but microplastic particles have also been found in various odontocete species in the UK (Nelms *et al.*, 2019), China (Xiong *et al.*, 2018; Zhu *et al.*, 2019), Galicia (Hernandez-Gonzalez *et al.*, 2018) and also Canada (Moore *et al.*, 2019).

Over the last 50 years, as technology has advanced and human demand has risen, there has been a dramatic increase in fishing effort in the world's oceans. During this time non-biodegradable fishing gear' primarily made from plastics' has also been introduced. As a significant source of litter in the ocean, fishing-related debris- nets, line, rope, traps, pots, floats and packing bands are a key and distinct part of the global marine debris issue with disproportionately higher impacts to marine wildlife compared to other types of debris through its potential to entangle or trap or be ingested. The effects range from immediate mortality through drowning to progressive debilitation over a period of months or years. Some plastic fishing gear, for example monofilament line and monofilament gill nets, is almost invisible in water. It is also extremely strong and very resistant to biting and chewing by trapped animals. Richardson *et al.* (2019b) estimate that 5.7% of all fishing nets, 8.6% of all traps, and 29% of all lines are lost around the world each year.

Marine plastic litter pollution is already known to be affecting more than 800 marine species through ingestion, entanglement and habitat change (Secretariat of the Convention on Biological Diversity, 2016). Sixty-nine of the 89 cetacean species officially recognised by IUCN are reported to have been affected by marine debris pollution, 60 cetacean species have been impacted by entanglement, 48 species have ingested marine debris (Pierantonio *et al.*, 2018).

Eisfeld-Pierantonio noted that there is more awareness of marine plastic pollution but that this brings an evaluation problem: are there more plastic related deaths [of animals], because there is more plastic in the oceans or are people simply more aware and are looking for a plastic connection? Are funds available for plastic research, because there is more awareness? There is no reference point, since previous records (e.g. from the 1970s and 1980s) may not have specifically recorded 'plastic in the stomach', but a more general observation such as 'foreign bodies in the stomach'. When it comes to ingestion of marine debris, it remains a challenge to identify if the debris was the direct cause of death or a contributing factor.

She added that the scientific community appears split about the effects of microplastics - some say they cannot draw any firm conclusions on the potential biological significance of ingested microplastics and further research is required to better understand the potential chronic effects of microplastic exposure on animal health, whilst others believe that exposure to microplastics through direct ingestion and consumption of contaminated prey poses a major threat to the health of the animals.

Abandoned, lost or otherwise discarded fishing gear (ALDFG) represents a significant, yet ultimately unknown amount of global marine debris, with serious environmental and socioeconomic impacts. ALDFG is incredibly hard to track and to assess, as there is no global system or enforcement for reporting of lost gear. It is also hard to determine if the entangled animals were entangled by active gear or ghost gear.

2.1.2 Discussion
The workshop agreed that the scale of the actual and projected increase in plastics is alarming and noted the importance of communicating the treats posed by this impending 'tsunami' of plastic to the decision makers and the public in clear straightforward messages. Further discussion on communication is found in Section 7.

Participants discussed the relative merits of different marine debris definitions, noting that the EU (including for its Marine Strategy Framework Directive) describes marine litter as '*items that have been deliberately discarded, unintentionally lost, or transported by winds and rivers, into the sea and on beaches'*, whilst UNEP (2009) as noted above (in 2.1.1) provides a global definition of marine debris. Discussion on terminology noted the use of 'marine debris' (used by the IWC) versus 'marine litter' in different fora. Some participants felt that 'litter' implies a deliberate introduction by humans, whilst 'debris' has broader implications.

The workshop noted existing categorisation of plastics by size, including that developed by Germanov *et al.* (2018) and the categorisation developed by the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection - GESAMP (2019), and Fig 1.

Table 2.2 Size categories of plastic marine litter, assuming a near-spherical form, showing common definitions and alternative options that may be appropriate for operational reasons.

Field descriptor	Relative size	Common size divisions	Measurement units	References	Alternative options	Remarks
Mega	Very large	> 1 m	Metres	GESAMP		
Macro	Large	25 – 1000 mm	Metres Centimetres Millimetres	MSFD	25 – 50 mm	
Meso	Medium	5 – 25 mm	Centimetres Millimetres	MSFD	< 25 mm 1 – 25 mm	MARPOL Annex V (pre revision)
Micro	Small	< 5 mm	Millimetres Microns	NOWPAP MSFD	1 – 5 mm < 1 mm > 330 µm*	Eriksen *et al.* (2014)
Nano§	Extremely small	< 1 µm	Nanometres		< 100 nm	Not considered for monitoring

*operationally-defined, referring to the typical mesh size of 330 µm of towed plankton nets; §nano-sized particles can only be identified under carefully controlled laboratory conditions and may form a monolayer on one (plates) or two (fibres) dimensions

Fig 1. Size categories of plastic marine litter, assuming a near-spherical form, showing common definitions and alternative options that may be appropriate for operational reasons (GESAMP, 2019).

The workshop **endorsed** the categorisation of debris sizes set out in the report of the Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP, 2019).

2.2 Review of previous IWC workshops
Simmonds provided an overview of previous IWC work on this topic, noting that recommendations from previous IWC workshops had been helpfully summarised in a contribution from the IWC Secretariat to a report of the UN Secretary General on marine debris to the Open Ended Consultative Process on Oceans and Law of the Sea (provided to the workshop as an information document) (International Whaling Commission, 2016).

The IWC began to formally consider marine debris in 2011 following its endorsement of the UN Environment Programme Honolulu Commitment. The IWC finds marine debris to be conservation and welfare concern for cetaceans throughout the oceans. To date, the IWC has held two expert workshops on marine debris. The first was held at the Woods Hole Oceanographic Institution in May 2013 and focused on evaluation of the known effects on cetaceans - among other things it recommended that member nations of the IWC should report on marine debris interactions in their national progress reports and concluded that 'legacy and contemporary marine debris have the potential to be persistent, bioaccumalative and lethal to cetacean populations and represent a global management challenge' (IWC, 2014). The second workshop was held in August 2014 in Hawaii (IWC, 2016). Its primary focus was to explore how the IWC might best engage with existing international and regional mitigation efforts. The workshop agreed that the IWC's primary contribution should be to ensure that cetacean-related issues are adequately represented within existing initiatives, and that its strong scientific and other expertise is made available in collaborative efforts. Working effectively with other Multilateral Environmental Agreements (MEAs) has also been stressed as of high importance.

Entanglement
The IWC has held workshops on large whale entanglement in all fishing gear and has also established a global network for disentanglement of whales from gear, including a training and support programme. Entanglement in active fishing gear is well established as a significant problem in conservation and welfare terms. The IWC has signalled the need to determine the degree to which marine debris *per se* has population-level effects needs further study - and the key issue is separating out the effects of active gear from lost gear.

Ingestion
In addition to the discussions and conclusions of its two previous workshops on marine debris, the IWC Scientific |Committee has also received and reviewed various papers on debris ingestion by cetaceans, including, Simmonds (2012), Baulch and Perry (2014a);Baulch and Perry (2014b) and Pierantonio and Simmonds (2018). To date, ingestion of debris has been documented in 48 (56% of) of cetacean species, with rates of ingestion ranging from zero to as high as 31% in stranded animals from certain populations.

Plastics are dominant in ingested debris and parts of fishing gear also frequently ingested.

The IWC has previously expressed concern regarding the high rates of debris ingestion in ziphiids, sperm whales and certain populations of Franciscana dolphins. It has also noted a need for a significant improvement in data collection and collation to improve understanding of the ingestion threat and that this should include consideration of the physical and toxicological impacts.

3. REVIEW OF NEW INFORMATION SINCE PREVIOUS IWC WORKSHOPS

3.1 New information in the scientific literature

3.1.1 Presentation
Pierantonio summarised new information in the scientific literature on marine debris. In 2018, under the framework of the 2017-2019 Work Programme of The Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and contiguous Atlantic area (ACCOBAMS), a review of available information on the issue of interactions between marine litter and cetaceans was produced. The document was also made available to the IWC Scientific Committee Meeting in Bled, Slovenia, in May of the same year (Pierantonio and Simmonds, 2018). The document was based on a review of 182 sources, the great majority being scientific peer-reviewed articles, but also including reports, conference proceedings, and other grey literature published between 1962 and March 2018. A strong positive trend in the number of published accounts detailing the occurrence of interactions between marine litter and cetaceans was clear; the number of documents made available increased by a factor of 20 since 1962.

Evidence suggested an increase in the number of cases reported per species, with a concomitant increase in the number of cetacean species recorded to have ingested or have been entangled in debris. Overall, 69 of the 89 cetacean species officially recognised by the International Union for the Conservation of Nature (IUCN) were reported to be in some way affected by marine debris pollution either by ingestion or entanglement. A higher number of species seemed to be affected by entanglement rather than ingestion, with macrolitter representing the main issue for all Families. Microlitter showed the highest incidence in the *Balaenopteridae* Family, while the *Delphinidae* seemed to be particularly affected by meso and macrolitter. Only three Families of cetaceans, together accounting for four species, were not reported to be affected in any way by marine litter, these being the *Lipotidae*, *Monodontidae* and *Platanistidae*. The authors highlighted strong geographical patterns in the species and number of animals per species that have interacted with debris. Habitat preferences, diving and feeding behaviour, as well as the 'behaviour' and position of debris in the water column, cause these differences, by affecting the amount, type and rate of interaction between cetaceans and debris, with clear differences amongst species. The authors of the review concluded that cetaceans are affected by a wide range of types of debris and that effects range from negligible, through chronic to debris-related mortalities, although clear cases of ingested marine debris causing deaths remain few and scattered. The review further highlighted that, at the time, it was difficult to point at any specific debris type as presenting a particular threat to cetaceans.

Building on the 2018 review, and as a contribution to the La Garriga workshop, Pierantonio collated the most recent information concerning marine debris in terms of ingestion and entanglement: 17 new peer-reviewed journal articles, published between March 2018 and January 2020, were identified (see Annex 4). Of these, seven papers concerned abandoned, lost or otherwise discarded fishing gear (ALDFG) both globally and at Regional scales, five papers specifically concerned the presence of microplastic primarily in stranded small-sized cetaceans, and, finally, five papers described the occurrence of ingested macroplastic and macrodebris by cetaceans and its potential detrimental effects. The evidence provided in these new studies support the findings of the previous review but also provide further critical information to evaluate the extent and severity of the issue of interactions between cetaceans and marine debris. Strong evidence suggests that some species ingest debris more often than others due to their prey-capture strategy rather than the presence of higher amounts of debris in the water column or the species habitat preferences and diving behaviour. For small-sized cetaceans, the new studies suggest that the ingestion of significant amounts of microplastics could add long-term toxicological effects to the more immediate consequences of macroplastic ingestion.

Whilst it is still not clear which particular items of debris are the main cause of concern, the new information seems to support the fact that plastic items, in particular plastic bags and single use items, are the most prevalent macro debris found in stranded cetaceans. Finally, even though these papers presented new information on ingestion of micro- and macro debris, no new evidence was available for entanglement of cetaceans in marine debris, particularly in relation to ALDFGs, the extent and effects of which remain extremely difficult to assess.

A brief summary of the main findings and conclusions of these papers is presented below.

- Four papers presented information from two areas under-reported in the previous review: Latin America, specifically Brazil, and portions of the seas around China.
- From Chinese waters comes the first description of ingested microplastic in a stranded Indo-Pacific humpback dolphin (*Sousa chinensis;* Zhu *et al.* (2019) and the presence of microplastic in the intestinal tracts of East Asian finless porpoises (*Neophocaena asiaeorientalis sunameri;* Xiong *et al.* (2018) indicating that coastal delphinids might suffer from microplastic pollution, including young calves. The studies, despite a limited sample size, represent a starting point for assessing microplastics in the endangered coastal delphinid in the Chinese Seas and highlight the lack of robust information from the area and the necessity of further work to look for evidence of adverse effects of microplastics pollution on cetaceans in the studied areas.
- From Brazil the works by Brentano and Petry (2020) and Di Beneditto and Oliveira (2019) provided information on the presence of ingested debris in the pygmy sperm whale (*Kogia breviceps*), the Guiana dolphin (*Sotalia guianensis)* and the franciscana (*Pontoporia blainvillei*). Brentano and Petry (2020) show that, in southern Brazil, *K. breviceps* suffers intense impacts from both ingestion of anthropic material and fisheries, and so should be closely monitored. Di Beneditto and Oliveira (2019) show that the proportion of debris found in the stomach of stranded cetaceans varied among species with *P. blainvillei, a* pelagic demersal consumer, presenting a higher frequency of ingestion than *S. guianensis, a* pelagic consumer. The authors suggested that the feeding site in the water column does not predict the probability of debris ingestion, but, concerning these two species, this probability seems to be more associated with prey-capture strategies, regardless of debris availability in the environment.
- From the Mediterranean Sea, both at the basin and local scales, four papers presented new evidence on ingested macroplastics and the occurrence of fisheries related marine litter and specifically ALDFG. Alexiadou *et al.* (2019) analysed the stomach contents of 34 individuals from seven odontocete species stranded in Greece between 1993 and 2014. Macroplastic was found in the stomachs of nine individuals from four species (harbour porpoise *Phocoena phocoena*, Risso's dolphin *Grampus griseus*, Cuvier's beaked whale *Ziphius cavirostris* and sperm whale *Physeter macrocephalus*) with the highest frequency of occurrence in sperm whales. Gastric blockage following ingestion of plastic has been reported by the authors to be presumably lethal in three cases, with plastic bags being the most common finding. The authors highlighted that plastic ingestion is of particular conservation concern for endangered Mediterranean sperm whales and, therefore, a regular examination of stranded cetaceans with a standardised protocol is critical for allowing spatiotemporal comparisons within and across species. The works by Consoli *et al.* (2019), Moschino *et al.* (2019) and Sinopoli *et al.* (2020) present strong evidence that ALDFGs, particularly fish aggregating devices (FAD), greatly contribute to the Mediterranean litter-scape with an estimated 1.6 million FADs abandoned in the Mediterranean Sea between 1961 and 2017. The studies strongly highlight the potential harmful impacts of ALDFGs on the Mediterranean Sea biodiversity, including cetaceans, and recognise that preventive measures appear to be the most suitable strategies to mitigate the impact of ALDFGs on the environment.
- For the European North Atlantic waters Hernandez-Gonzalez *et al.* (2018), Nelms *et al.* (2019) and Puig-Lozano *et al.* (2018) provided information on the occurrence of microplastics in the stomach contents of common dolphin (*Delphinus delphis*) stranded on the Galician coasts of Spain, on the presence of microplastics in marine mammals stranded around the British coast and, finally on the pathology associated to the presence of foreign bodies in stranded cetaceans in the Canary Islands, respectively. These studies provide strong evidence that microplastic is ubiquitous not only amongst large filter feeding cetaceans but also in smaller odontocete species. Nonetheless, as previously stated, the presence of microplastic remains a cause of concern for these species and its effects cannot be assessed easily, with toxicological effects most likely to be detrimental in the long term. In this context, Nelms *et al.* (2019) indicate that animals that died due to infectious diseases had a slightly higher number of particles than those that died of trauma and other drivers of mortality, showing a possible relationship between the cause of death and the abundance of microplastics.
- Finally, Moore *et al.* (2019) described the occurrence of microplastics in beluga whales (*Delphinapterus leucas*) from the Eastern Beaufort Sea raising questions regarding the significance and long-term exposure of this pollutant in this ecologically and culturally valuable species.

3.1.2 Discussion

The workshop noted that some species seem to be able to discriminate plastics from food and others cannot or are unable to avoid ingesting it. Cuvier's beaked whale, for example, can distinguish between different species of cephalopods but still ingests plastic bags. This warrants further investigation.

The workshop stressed the value of retrospective studies (i.e. studies reviewing reports of previous post-mortem investigations) in studying marine debris but advised caution in interpreting these to compare different levels in different species, stressing that sample size needed to be taken into account. In addition, it is important for necropsy reports to record zero values for marine debris i.e. no plastics found. Previous reports might not have done this.

Participants noted that plastics are being identified in more and more species - circa 800, (Secretariat of the Convention on Biological Diversity, 2016). Methodologies used for other species (e.g. for modelling overlap between marine debris and different species) could provide insights for further work on marine debris impacts on cetaceans.

3.2 Review of evidence from strandings investigations

3.2.1 Latest results from the Adriatic

Mazzariol presented a review of information from stranded animals from the Adriatic. The establishment of an institutional stranding network in Italy involving the Coast Guard, Veterinary Public Laboratories and Universities, has ensured constant monitoring of the 8,000km long Italian coastline since 2015.

The percentage of cetaceans stranded in the period 2015-2018 submitted to necropsy was 45%. The cause of death was hypothesized in 65% of these cases: 40% of the necropsied cetaceans died due to spontaneous causes/natural diseases (Cetacean morbillivirus (CeMV) and bacteria mainly). 25% were deemed to have an interaction with human activities. For the remaining 35% the likely cause of death was not established.

Marine debris were found in the gastro-intestinal (GI) tract of 11 individuals (3% of examined animals), mainly sperm whales (4), beaked whales (1), and striped and bottlenose dolphins. Three sperm whales were found entangled in passive nets out of 360 animals necropsied in 4 years (3.8%). While entanglement was deemed to be fatal in all the cases, no cetaceans displaying evidence of marine litter ingestion had plastic debris in the GI tract established as cause of death. These data are lower if compared with results from Canary Islands but confirm that deep divers are the species mainly affected.

Preliminary data for 2019 confirm an additional six animals, mainly sperm whales (4) with marine debris in their stomach contents, including an exceptional finding of 29kg of plastic bags and sheets in a pregnant female found stranded in Sardinia in March 2019. Additionally, a sperm whale calf was found floating entangled with the mother in the same period. Most of them were in poor nutritional condition status.

All sperm whales belonged to an outbreak of strandings which occurred between November 2018 and June 2019, with 14 mortalities. All the examined animals (7/14) in good preservation condition for postmortem analyses were positive to CeMV. This outbreak and the recent findings from Italy, confirm that the sperm whale, can be considered a target species for marine debris ingestion and entanglement in the Mediterranean Sea as in other parts of the world. The concurrent presence of a spontaneous disease should be considered as the principal cause of death and it is not clear from necropsies if marine debris presented a predisposing factor, a consequence or an incidental finding. Finding marine debris in the stomach does not directly indicate it is the cause of death: a through and detailed necropsy should be performed according to standard veterinary procedures. Interpretation of evidence should be undertaken using a forensic approach identifying the mechanism of death and excluding all the other possible causes.

In order to compare these data across the Mediterranean and worldwide, Mazzaroil opined that necropsies should be run routinely from fully-functioning and well-established stranding networks including, if possible, trained professionals, including veterinary pathologists. Common language, procedures and data collection are needed to create baseline data, assess the trends of ingestions in specific areas for each species and understand the real impact of marine debris and entanglement on marine mammals. The minimum data set should include location where carcass was found, species, age and gender, nutritional condition code, presence/absence of litter in the stomach or around the body of the animal, associated Gastro-Intestinal-Tract (GIT) pathology, and likely cause of death.

Mazzariol further reported that ACCOBAMS, with the support of MEDPOL (a marine pollution assessment programme of the European Environment Agency), are undertaking pilot studies on marine litter and entanglement monitoring in Adriatic Sea. In this basin, an Interreg[1] project - Network for the Conservation of Cetaceans and Sea Turtles in the Adriatic (NETCET) has already established transboundary cooperation with sharing of common procedures. During the inaugural workshop for the new project, a common necropsy protocol was proposed and a common data collection method has been in place for one year. In addition to information from single countries, the workshop also reviewed an assessment of marine litter from the seabed produced by the Italian National Institute for Environmental Protection and Research (ISPRA) as a result of another Interreg Project (ML REPAIR): the amount of recovered litter from fishermen is huge and, even if a certain variety based on different countries was reported, marine litter was generally related to disposable plastic materials coming from agriculture, industry and fishing activities.

Mazzariol concluded that, reflecting on the most affected species in the Mediterranean (sperm whales) and the litter on the sea bottom, concerted actions on monitoring not just surface litter, but also litter underwater should be conducted.

[1]Policy learning programme for EU authorities: *https://www.interregeurope.eu/*.

3.2.2 Retrospective study of foreign body-associated pathology in stranded cetaceans, Canary Islands.
Puig-Lozano reported on long-term studies on stranded cetaceans in the Canary Islands (Arbelo *et al.*, 2013; Díaz-Delgado *et al.*, 2018). Marine debris is a growing global concern and an important threat to marine biodiversity, including cetacean species. The Canary Islands represent a hotspot for cetacean biodiversity in Europe. Its proximity to the Canary Current, which brings marine debris from the Atlantic Ocean, also makes this geographical area an interesting place for the study of interactions between cetaceans and marine debris.

After more than 20 years of systematic research on cetacean health, scientists of the Atlantic Center for Cetacean Research (University of Las Palmas de Gran Canaria) are able to present novel results of pathological findings in stranded cetaceans with foreign body (FB) ingestion. In this area, almost 8% of studied cetaceans showed FB ingestion, mostly plastics (80.55%). FB was directly associated with the death of approximately 3% of animals, due to impactions, gastrointestinal perforations, and ulcerative gastritis. In addition, to the author's knowledge, this study was the first which employ statistical analysis to identify protective (age) and risk (poor body condition and deep diver) factors for foreign body presence.

In conclusion, Puig-Lozano strongly recommended that long-term pathological studies on stranded cetaceans should continue monitoring the health of cetacean populations, including the evaluation of marine debris as a possible threat to the conservation of these populations and in particular in the Canary Islands.

3.2.3 Continuing strandings investigations in Germany
Unger presented a review of information from necropsies on harbour porpoises and seals in Germany (Unger *et al.*, 2017). Necropsies have been conducted since 1990 by the Institute of Terrestrial and Aquatic Wildlife Research (University of Veterinary Medicine, Foundation) on marine mammals regularly occurring in German waters (harbour porpoise, harbour seals and grey seals). Animals impacted by marine debris from 1990 to 2014 were examined to learn more about the health impacts associated with both entanglement and ingestion. In Germany, two federal states are located at the coastline collecting stranded carcasses for further necropsy: Schleswig-Holstein (SH) covers parts of the North- and parts of the Baltic Sea, Mecklenburg-Western Pomerania (MWP) covers the German Baltic Sea. They differ in their data collection: while SH has an established stranding network, stranded carcasses in MWP are mostly reported by tourists to the authorities. In total, 1,622 individuals were necropsied including the GIT. Out of this large sample size, 31 (9 harbour porpoises, 16 harbour seals, 6 grey seals) animals were found entangled in (n=14) or having ingested (n=17) marine debris. 25 were found at the coastline of SH, 6 at the coastline of MWP. Comparing the species, in relation to the number of stranded and dissected individuals, grey seals seemed the most impacted. The share of fishing related debris was 64.9%, it was predominantly plastic items which were detected (73%). The major outcome of this study is the identified associated health impacts on the individuals. For entanglements, wounds and cuts, suppurative inflammation of the skin and fatal septicaemia could be diagnosed, while for ingestions, perforations and ruptures of the GIT as well as peritonitis and fatal septicaemia were identified.

The study demonstrated the value of necropsies to learn more about marine debris occurrence and effects and, thus, underlines the importance of stranding networks. It would be useful to extend this to very mobile species such as the harbour porpoises, harbour seals and grey seals in order to be able to judge the extent of debris.

Unger suggested that other countries bordering the North and Baltic Seas should also consider seals and that a standardized method needs to be established to ensure their comparability. Unger further noted that countries with existing well-functioning strandings networks could help others establish their own.

Responding to a question, Unger confirmed that bycatch cases were excluded from the results if these were reported as bycaught animals. Animals suspected to be bycaught were excluded as well, since those cases could not clearly be associated to either ALDFG or active fishing gear.

3.2.4 Information from Kenya
Michael Mwangombe provided information on the marine debris situation in Kenya. There is emerging evidence of marine debris impacts in Kenya, with most work done relating to macrodebris (although there is some experience of finding smaller plastic particles in turtles). Plastics are also a problem for terrestrial species. In addition to plastic pollution, there are problems from poorly secured drift nets becoming ghost gear and posing hazards for boating and divers in addition to endangering marine life. Mwangombe suggested that there is scope for a review of previous necropsy results to further evaluate impacts of plastics on marine mammals.

There are some positive responses to the plastic problem including removal and community recycling projects (e.g. the manufacture of flip flops from plastic waste) and potential for such projects to be scaled up in other parts of Africa. The policy response also includes a ban on plastic bags.

Mwangobe concluded that there is a need for increased research, collaboration and capacity building in Kenya and elsewhere in Africa to improve the understanding and evaluation of marine debris impacts on cetaceans.

3.3 Discussion of evidence from strandings investigations

The workshop thanked all the presenters for the information provided in Section 3.2. It agreed the value of long-term data sets from strandings investigations and necropsy (such as those from Canaries and Germany) in establishing impacts from marine debris and encouraged that such studies should continue.

Participants discussed the importance of strandings networks, the need for capacity development to help establish these in parts of the world where there is no coordinated strandings response and need for strengthening in several places (for example, in Germany a gap in strandings data was attributed to a lack of strandings network coverage for the Baltic Sea, and a general lack of monitoring of pinniped strandings). They agreed on the need for better protocols for strandings investigation and necropsy, including for close observations of the gastrointestinal tract to identify any impacts arising from marine debris ingestion (including presence of microscopic or macroscopic lesions) and establishment of cause of death. (Further discussion on protocols for necropsy is found in Sections 3.2 and Sections 4 and 5).

Though evidence of welfare impacts has been established, it was noted that further multidisciplinary efforts were needed to further investigate the potential for population level impacts of marine debris on cetaceans, following on from improvements in establishing causes of death for individuals.

Participants further discussed vulnerability of different cetacean species and behaviours associated with debris ingestion. There is an association between feeding behaviour (e.g. bottom feeding) and macrodebris ingestion and differences in prey organisms have been shown to cause different levels of microdebris ingestion (Burkhardt-Holm and N'Guyen, 2019). There may be additional factors causing the extent of ingestion seen in some animals, for example plastics becoming coated in organisms causing an associative taste, or prey becoming wrapped in plastic. Noting that entanglement investigations try to establish whether an animal was already compromised when it became entangled, it was posed than an animal struggling to feed might become more likely to ingest plastic.

Noting the apparent vulnerability of deep diving animals to marine debris ingestion and that many marine litter surveys are surface surveys the workshop agreed on the need for more information on marine debris on the seafloor, including through the deployment of Remotely Operated Vehicles (ROVs).

During discussions on the vulnerability of Sperm Whales to marine debris ingestion, it was observed that IUCN last reviewed this species in 2008, ranking it as vulnerable. However, no detail was included on marine debris and this should be explored in any future IUCN review.

Despite its focus on cetaceans, the workshop noted the apparent vulnerability of pinnipeds to marine debris ingestion and impacts and suggested that surveillance of seal strandings should be extended.

Noting the value of long-term datasets for investigating the role of marine debris in cetacean mortality and strandings, the workshop **recommended** maintaining the long-term studies in the Canaries.

The workshop also acknowledged the importance of the marine debris-associated lesions shown in results of strandings investigations and necropsies in Germany and **recommended** that this research should be continued.

The workshop **recommended** that, with respect to marine debris, standardised approaches for post-mortems should be used, taking into account e.g. microscopic and macroscopic lesions, which can place marine debris in the context of the cause of death. The workshop further **recommended** that zero values for marine debris ingestion or entanglement should be recorded in necropsy reports.

The workshop stressed the importance of stranding networks for obtaining information on the impacts of marine debris on cetaceans and **drew attention** in particular to the: (i) need for continued support for existing strandings networks; (ii) capacity building and support for new networks where there are gaps; (iii) importance of government support and coordination of strandings networks; and (iv) need for networks to include appropriately trained pathologists.

The workshop highlighted the role of the IWC strandings initiative in supporting countries to increase their capacity to respond to and investigate strandings and **recommended** its continued funding.

Considering the incidence of marine debris in deep diving cetaceans, the workshop r**ecommended** that further work is needed to obtain information on marine debris on the seafloor, including through the deployment of Remotely Operated Vehicles (ROVs) in the deep sea.

The workshop noted that the last global assessment of sperm whales was made by IUCN in 2008 and is now overdue and **encouraged** IUCN to take marine debris into account in its next assessment of this species.

3.4 Concerning whale entanglement in active and lost gear

Latest information concerning the entanglement of whales in active and lost gear is found in sections above and in Section 4.5.

3.5 Review of latest evidence on microdebris

3.5.1 Overview of latest studies on microdebris

Panti presented an overview of the latest studies on microdebris. The study of microplastic ingestion by marine mammals is a challenging task. Few studies have directly identified microplastics in the digestive tracts of stranded individuals (e.g. (Besseling *et al.*, 2015; Lusher *et al.*, 2018). Evaluating the frequency and severity of impacts of marine debris on cetaceans is complicated by low sample sizes linked to the low rate of detection and the compounding effects of a low necropsy and publication rate. New techniques have been developed to detect plastic additives using non-lethal methods (e.g. skin biopsies) (Fossi *et al.*, 2016; Panti *et al.*, 2019).

Sub-lethal impacts of plastic ingestion are more difficult to assess. Such impacts may include injury within the gastro-intestinal tracts (GITs), compromised feeding, malnutrition, disease and, reduced reproduction, growth and/or longevity; these issues may be reported with the evaluation of specific molecular markers.

Field studies and monitoring indicate that interactions between marine litter and a mixture of chemical compounds are of significance. Laboratory studies could shed light over possible interactions (synergy or antagonism) learning from the field mixture toxicity.

Panti suggested that given the multiple potential physical and ecotoxicological effects of marine debris interactions, the impact of litter on marine mammals should be assessed using a new threefold approach which can add to the data on the rate of ingestion in cetaceans and data on the multiple sub-lethal stresses that marine debris ingestion can cause in the short and long term. Each of the three levels of investigation tools that make up the threefold approach can be applied independently or simultaneously and whether the animals concerned are stranded or free ranging. The threefold approach comprises the following elements.

(a) Analysis of gastro-intestinal content: Detection of the occurrence and rate of marine litter ingestion and any associated pathology through analysis of the gastro-intestinal content (with a particular focus on plastics and microplastics) in stranded cetaceans.

(b) Analysis of the levels of plastic additives, as a proxy for ingestion of additives: The indirect quantification of plastic additives can be applied both to free ranging as well as to stranded organisms. The levels of plastic additives (such as phthalates or PBDEs) and associated Persistent Bioaccumulative and Toxic (PBT) compounds allow evaluation of exposure to additives and PBT, which might have been taken up from the water, via the prey organisms, or with plastic items.

(c) Analysis of biomarker responses: Biological responses can be used to detect the potential toxicological effect related to PBT and plastic additives in free ranging individuals or in stranded organisms up to a few hours after death.

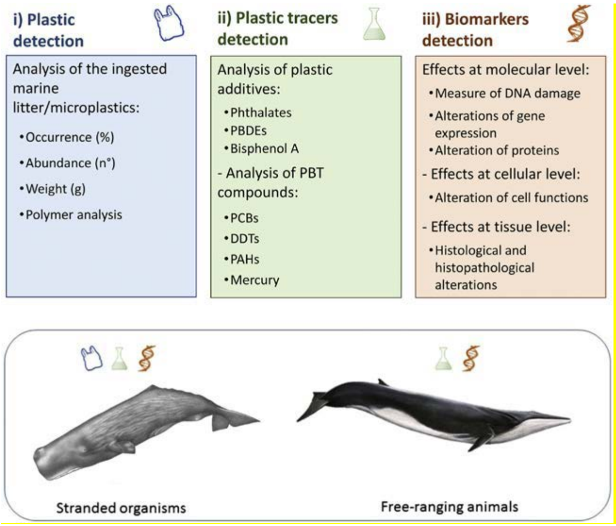

Fig. 2. The threefold monitoring approach to detect marine litter presence and impact in cetacean species (stranded and free-ranging organisms). Taken from: Fossi *et al.* (2018).

Plastic marine debris is well known to be associated with chemical contaminants. Therefore, the ingestion of plastic litter could cause severe toxicological effects due to the exposure to both chemicals absorbed by plastics and plastic components. The most common compounds used as plastic additives are brominated flame retardants (BFR), stabilizers, phthalate esters (PAEs), bisphenol A (BPA), and nonylphenols (NPs). Once in the environment, these compounds may leach out from plastic litter (both macro and microplastics) or be accumulated on the surface of plastic items. Tracers of plastic additives present in animal tissues can be used as an indirect method for detecting exposure to additives, in particular phthalate esters (PAEs). For example, eight different phthalates (MBZP, MBP, MEHP, DNHP, BBzP, DEHP, DIOIP, DNDP)[2] were detected in neustonic/planktonic samples and also in four cetacean species (blubber from skin biopsies) sampled in the Pelagos Sanctuary (North-Western Mediterranean Sea) (Baini *et al.*, 2017). The results showed different fingerprints and levels across the neustonic/planktonic samples, indicating a heterogeneous pattern of phthalates in the environment, which may be associated with microplastics. In addition, seven out of eight PAEs were also detected in the blubber of *Balaenoptera physalus*, *Tursiops truncatus*, *Grampus griseus* and *Stenella coeruleoalba* sampled in the same area, which might therefore indicate plastic ingestion, but could also result from uptake of these compounds via water or food.

Uptake and accumulation of plastic-associated chemical contaminants may produce undesirable biological effects. For example, when fin whale and sperm whale organotypic skin cell cultures were treated with increasing doses of PAEs, it showed an upregulation of the mRNA levels of the peroxisome proliferator-activated receptor gamma (PPAR'γ) gene (Fossi *et al.*, 2018); these results suggest that PAEs play an important role in the alteration of the PPAR'γ, which regulates physiological processes of lipids homeostasis, inflammation, adipogenesis, reproduction, etc.

Panti noted that another approach is an *ex-vivo* assay using organotypic skin cell cultures from the bottlenose dolphin, cultured and treated with different perfluorooctanoic acid (PFOA) and BPA concentrations (Lunardi *et al.*, 2016). The transcriptomic techniques could represent an additional application to analyse global gene expression for assessing the exposure to a certain class (or a mixture) of compounds. The skin transcriptome could reveal information about contaminant exposure. Such assays may allow researchers to assess long-term effects on health, as the genes affected are involved in immunity modulation, response to stress, lipid homeostasis, and development. The transcriptomic signature of dolphin skin could be therefore relevant as classifier for a specific contaminant such as plastic-associated contaminants. Further research on biomarkers targeting the exposure of plastic ingestion and their additives is required.

However, studies on the effects of microplastics (both toxicological and as vector of pathogens) on marine mammals (in particular) are lacking. Some evidence may be drawn from the existing literature on laboratory studies on model species (e.g. zebrafish or seabass), but very little is available about mammals and it is difficult to compare effects between species.

3.5.2 Risk of microplastic uptake in baleen whales

Holm summarized Burkhardt-Holm and N'Guyen (2019) which investigated the occurrence of microplastics in the food web of cetaceans to assess the risk of microplastic uptake in baleen whales. The common minke whale was chosen as an example because most data are available for it, and it has similar feeding behaviour to many other baleen whales. The study firstly evaluated the common minke whale diet in different regions and, secondly, reviewed available evidence of microplastic ingestion by these prey species. It was found that common minke whales forage opportunistically on fish from various families: *Ammodytidae, Clupeidae, Gadidae, Engraulidae* and *Osmeridae*. Minke whales feeding in different geographic areas are exposed to different risks of ingesting microplastics. Specifically, the highest levels of microplastic contamination were reported for *Scombridae* and *Gadidae*. Sei whales mostly feed on copepods, *Engraulidae, Clupeidae* and *Scombridae*. High levels of MP contamination are reported for *Scombridae* in the Atlantic and *Engraulidae* in the northwest Pacific Ocean. Copepods exhibit low levels of MP ingestion in the northeast Pacific Ocean.

3.5.3 Cetaceans as a potential indicators of micro- and macroplastic impact in the marine environment

Fossi reported scientific evidence and identified emerging gaps in the interactions between the charismatic megafauna (filter feeder baleen whales and deep diving cetaceans) and micro- and macroplastics. She proposed these species as candidate indicators for micro- and macro-plastic pollution, respectively, at global scale.

Regarding the interactions between whales and microplastics, the first warning was reported for Mediterranean fin whales (*Balaenoptera physalus*) in 2012, and confirmed later (high concentrations of plastic additives and specific biomarker responses, detected in skin biopsies) in the same species and for other filter feeders (basking and whale sharks) (Fossi *et al.*, 2014; Fossi *et al.*, 2012). Filter-feeding megafauna are susceptible to high levels of microplastics ingestion and exposure to associated toxic compounds due to their feeding strategies and because of habitat overlap with microplastic hot spots. For these reasons, the fin whale has been proposed as a candidate indicator of microplastics pollution in semi-enclosed basins.

On the other hand, deep divers such as the sperm whale and the Cuvier's beaked whale, are exposed to the ingestion of marine litter (ML), including large plastic fragments, due to their feeding in marine canyons. High occurrence of ML (75%) has been reported in stranded Mediterranean sperm whales. This species was recently proposed as a candidate indicator for the presence of ML in the Mediterranean (MSFD, Descriptor 10 and candidate IMAP indicator 24) (Claro *et al.*, 2019; Panti *et al.*, 2019). As these megafauna species are charismatic and iconic indicators that serve as flagship species for marine conservation, this research field recently started to 'trend'. However, several gaps must be resolved, such as the investigations into the feasibility and reliability of using plastic additives as tracers and the identification (through omics techniques) of the toxicological effects caused to plastic debris ingestion in these species.

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[2]MBZP, Mono-Benzyl phthalate (MBZP), Mono-Butyl phthalate (MBP), Mono (2-ethylhexyl) phthalate (MEHP), Di- n-Esilphthalate (DNHP), Benzyl butyl phthalate (BBzP), Bis (2-ethylhexyl) phthalate (DEHP), Diisooctyl isophthalate (DIOI), Di-n-decyl phthalate (DNDP).

3.5.4 Categorisation of microdebris by size

Holm noted a new study by Triebskorn *et al.* (2019) which compiled all studies so far conducted on the type, and the size of micro-and nanoplastic particles as well as the applied experimental design under which a tissue translocation of these particles was reported. The study covered a range of species of aquatic taxa. A summary table from this study is in Fig. 3.

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Table 2

Overview of the available studies on the tissue translocation of NP and MP; [a]translocation reported by the authors. Detailed citations are provided in supplementary material (T2/1-31).

Species	Polymer type (size/size range; µm)				Trans-location[a]	Reference
	PMMA	PS	PET	PE		
Caenorhabditis elegans		0.1			+	T2/1:Zhao et al.Env. Sci. Nano.(2017).
Amphibalanus amphitrite	<0.2				+	T2/2:Bhargava et al.Chem. Eng. (2018).
Carcinus maenas		500			+	T2/3:Farrell and NelsonEnviron. Pollut. 177 (2013) 1–3.
		10			–	T2/4:Watts et al.Environ. Sci. Technol. 48 (2014) 8823–8830.
		8			–	T2/5:Watts et al.Environ. Sci. Technol. 50 (2016) 5364–5369.
Uca rapax		180–250			–	T2/6:Brennecke et al.Mar. Pollut. Bull. 96 (2015) 491–495.
Daphnia galeata		0.052			+	T2/7:Cui et al.Sci. Rep. UK 7 (2017).
Daphnia magna		0.025			+	T2/8:Brun et al.Nanotoxicol. 11 (2017) 1059–1069.
		0.06039; 0.05745; 0.05729			+	T2/9:Chae et al.Sci. Rep. UK 8 (2018) 284.
			60–1400		–	T2/10:Jemec et al.Environ. Pollut. 219 (2016) 201–209.
		0.02; 1			+	T2/11:Rosenkranz et al.Toxicol. Chem. 28 (2009) 2142–2149.
Scrobicularia plana		20			+	T2/12:Ribeiro et al.Mar. Pollut. Bull. (2017).
Dreissena polymorpha		1; 10			+	T2/13:Magni et al.Sci. Total Environ. 631–632 (2018) 778–788.
Mytilus edulis		0.0096; 3			+	T2/14:Browne et al.Environ. Sci. Technol. 42 (2008) 5026–5031.
				<80	+	T2/15:von Moos et al.Environ. Sci. Technol. 46 (2012) 11327–11335.
					–	T2/16:Kolandhasamy et al.Sci. Tot. Environ. 610/611 (2018) 635-640.
Mytilus galloprovincialis				1–50	–	T2/17:Détrée and Gallardo-EscárateMollus. Stud. 83 (2017) 220–225.
Paracentrotus lividus		0.04; 0.05			–	T2/18:Della Torre et al.Environ. Sci. Technol. 48 (2014) 12302–12311.
Carassius carassius		0.040; 0.050; 0.052; 0.053; 0.057; 0.120; 0.180; 0.33			+	T2/19:Mattsson et al.Sci. Rep. UK 7 (2017).
Carassius auratus			50–500	>63	–	T2/20:Grigorakis et al.Chemosphere 169 (2017) 233–238.
Danio rerio		0.025			–	T2/21:Brun et al.Environ. Sci. Nano. (2018).
		0.05			+	T2/22:Chen et al.Sci. Total Environ. 609 (2017) 1312–1321.
		0.07; 5; 20			+	T2/23:Lu et al.Environ. Sci. Technol. 50 (2016) 4054–4060.
		0.042			+	T2/24:Pitt et al.Aquat. Toxicol. (2017).
						T2/25: Pitt et al.Sci. Total Environ. 643 (2018) 324–334.
		0.02			+	T2/26:Skjolding et al.Nanotoxicol. 11 (2017) 351–359.
		0.025–0.05; 0.25; 0.7			+	T2/27:van Pomeren et al.Aquat. Toxicol. 190 (2017) 40–45.
					–	
Engraulis encrasicolus				124–438	+	T2/28:Collard et al.Environ. Pollut. 229 (2017) 1000-1005.
Mugil cephalus		10–5000		10–5000	+	T2/29:Avio et al.Mar. Environ. Res. 111 (2015) 18–26.
Oreochromis niloticus		0.1			+	T2/30:Ding et al.Environ. Pollut. 238 (2018) 1-9.
Oryzias latipes		0.0394; 0.474; 0.932; 18.6; 42.0			+	T2/31:KashiwadaEnviron. Health Perspect. (2006).
Oryzias sinensis		0.06039; 0.05745; 0.05729			+	T2/9:Chae et al.Sci. Rep. UK 8 (2018) 284.

[a] Particles > 100 µm tested, particle type unknown.

3.6 Discussion of evidence on microdebris

The workshop welcomed the studies reported, noting that the understanding of potential impacts of microplastics on cetaceans is still in its infancy.

Participants noted the value of emerging results on other species, whilst also noting the limitations in extrapolating these results for cetaceans, bearing in mind differences in uptake across species groups e.g. fish take up many chemicals through skin and gills, that are not taken up via the skin by cetaceans. In addition, having the same experimental approach for cetaceans as have been obtained for fish and other laboratory animals will not be possible. However, recent studies on potential human health impacts might have useful insights for cetaceans (see also Section 5).

It was debated whether the detection of phthalates in whales is sufficient to describe these substances as ‘plastic tracers’. It was pointed out that phthalates are produced in quantities of several million tonnes per year and that much of this is released into the environment. Although these substances are frequently used as plasticizers in plastics, they can also be found in other products such as cosmetics and are also dissolved in water. This means that phthalates can also be taken up by whales from water or through the food chain, and not necessarily and exclusively by being released into animals from ingested plastic debris. It is important to strictly distinguish between correlations (e.g. phthalates found in animals and phthalates found in water or other prey organisms) and causal relationships (phthalates in cetaceans released by ingested plastic waste). However, a correlation between the level of PAEs (Phthalic acid esters) and the number and type of microplastics in neustonic samples collected by manta trawl in the Pelagos Sanctuary has been found as well as detection of PAEs and euphasiid species (prey of baleen whales) in the Mediterranean sea (Baini *et al.*, 2017).

The workshop recognized the importance of both the scientific evidence and the emerging gaps concerning the interaction between megafauna (e.g. filter feeder baleen whales and deep diving whales) and micro- and macroplastics and recommend studying the impact of plastic debris and their related potential toxicological and noxious effects. The workshop also agreed the following species as candidate indicators for microplastics (fin whale, *Balaenoptera physalus*) and macro-litter pollution (sperm whale, *Physeter macrocephalus*) at global scale, respectively. Filter-feeding megafauna (e.g. whale sharks and baleen whales) are prone to high levels of microplastics ingestion and exposure to associated toxic compounds due to their feeding strategies and for habitat overlap with microplastic hot spots (such as the Mediterranean Sea).

While the skim feeders, like right and bowhead whales, should be monitored for their possible greater susceptibility, the workshop recognized that species with a wider distribution, may be better candidates as global indicators. For these reasons the workshop suggests that the humpback and fin whales would be the best candidates for this type of monitoring. Humpback whales are generally faithful to discrete feeding grounds in several Oceans, while fin whales are believed to be more far roaming in their foraging, except for some unique, segregated populations (e.g. Mediterranean and Gulf of California). For these reasons, these whale species could be proposed as candidate indicators of microplastics pollution in both wide ocean basins and confined seas. On the other hand, deep divers such as the sperm whale and the Cuvier's beaked whale, are exposed to the ingestion of marine debris, including large plastic fragments, due to their feeding in marine canyons. Marine debris has been reported in 75% of examined stranded Mediterranean sperm whales. This species was recently proposed as a candidate indicator for the presence of marine debris in the Mediterranean (MSFD, Descriptor 10 and IMAP Ecological Objective 10, candidate indicator 24).

The workshop also supported research and investigations into new plastic tracers in the tissues of the organisms and the identification (also through omics techniques) of the potential ecotoxicological effects caused by plastic debris ingestion in these species.

Finally, it was noted that the gray whale feeds almost exclusively on the bottom and could therefore make a good candidate for monitoring microplastic impact from the benthos at appropriate depths.

It was noted that previous IWC recommendations had advocated the integration of marine debris concerns into Conservation Management Plans (CMPs), and that both the Mediterranean Fin Whale and Sperm Whale were candidates for CMP, with drafting of the Mediterranean Fin Whale CMP currently ongoing.

With regard to cetaceans as potential indicators of interaction with marine debris, the workshop **recommended** that the following species were good candidates for various reasons related to prey type, distribution and existing knowledge: fin, sperm, gray, humpback whales and beaked whales.

The workshop **urged** that consideration of macro- and microplastics be included in the Conservation Management Plan (CMP) currently under development for the Mediterranean fin whale.

3.7 Review of recent work undertaken by other MEAs

3.7.1 Presentation

Smith presented document IWC/DEC19/MD/02, a review of marine debris work by other IGOs and international organisations. She noted that marine debris has been recognised as an issue of global concern, resulting in a range of initiatives to address this problem at global, regional and national scales. Previous IWC workshops had concluded that a significant role of the IWC should be to input cetacean-specific expertise into other fora undertaking work on this issue, and made specific recommendations for engagement with a range of organisations. IWC had made some significant progress on engagement including with the Food and Agriculture Organization of the United Nations (FAO) (e.g. regarding gear marking), and the UN.

Several global targets now set a framework for global work on marine debris including Sustainable Development Goal 14 and Target 14.1, and the Strategic Plan for Biodiversity 2011-2020 and Aichi Target 8 (*https://www.cbd.int/sp/*). There may be opportunities to strengthen this in development of the new post-2020 biodiversity framework.

Smith briefly summarised work in other organisations including:

3.7.1.1 THE UNITED NATIONS

Several United Nations General Assembly (UNGA) Resolutions relate to marine debris and ADLFG. In 2016, the Informal Consultative Process for Oceans and Law of the Sea under the (United Nations Convention on the Law of the Sea (UNCLOS) looked at this issue in depth and the IWC contributed a summary of its work and recommendations as input to the UN Secretary General’s report to this meeting.

The United Nations Environment Assembly (UNEA) has adopted several resolutions on marine debris. It recently extended the mandate of the ad hoc open-ended expert group on marine litter and microplastics (AHOEEG) until UNEA-5 in 2021 to increase coherence, coordination and synergies between existing mechanisms to better address the challenges posed by marine litter and microplastics.

The United Environment Programme (UNEP) convenes the Global Partnership on Marine Litter (GPML), supporting development of action plans (from international to local) and projects on clean up and removal, coordination and monitoring, education and awareness and post-disaster response.

3.7.1.2 IMO AND MARPOL

The International Convention for the Prevention of Pollution (MARPOL) Annex V specifically prohibits the discharge of plastics from ships. In addition, it recognises that some sea areas require higher degrees of protection and can be designated as Special Areas under MARPOL. Dumping wastes at sea is also regulated by London Convention and its protocol.

The Marine Environment Protection Committee (MEPC) of the International Maritime Organization (IMO) has adopted the Action Plan to Address Marine Plastic Litter from Ships, which outlines a range of actions to be completed by 2025 on fishing gear, passively fished waste, port reception facilities, cost recovery systems and on-board waste management. The IWC has regularly attended IMO MEPC and keeps a watching brief on this issue.

The GESAMP working group on marine litter published its global assessment in 2015 and its new work programme covers a series of objectives including related to developing guidelines on terminology and methodologies for the sampling and analysis of marine plastics and microplastics; assessing the occurrence and effects of nano-sized particles on marine organisations and assessing the significance of plastics and microplastics as a vector for indigenous and non-indigenous organisations. The IWC may have the opportunity to field expert observers at future GESAMP meetings.

3.7.1.3 CHEMICALS CONVENTIONS

Work under the Basel Convention includes Decision 13/17 to consider relevant options to further address marine plastic pollution. The Stockholm Convention on Persistent Organic Pollutants has a potential role related to greening the lifecycle of a range of plastic polymers. The most recent IWC Scientific Committee meeting made recommendations for IWC engagement with these Conventions with respect to chemical pollution and this could be extended to marine debris if useful.

3.7.1.4 FISHERIES ORGANISATIONS AND GEAR

At its Committee on Fisheries meeting in 2018, FAO adopted voluntary guidelines for marking of fishing gear which have potential to help address both ALDFG and live whale entanglements. Several Regional Fisheries Management Organisations (RFMOs) have also adopted resolutions on ALDFG and Fish Aggregating Devices (FADs). The General Fisheries Commission for the Mediterranean (GFCM) has developed specific recommendations based on the FAO gear marking guidelines. But a proposal from the EU on marine litter, including marking of fishing gear put to the 94th meeting of the Inter-American Tropical Tuna Commission (IATTC) (July 2019) was not endorsed, suggesting that further advocacy might be needed within the RFMOs on this issue.

The Global Ghost Gear Initiative (GGGI) is a cross stakeholder alliance of fishing industry, private sector, NGOs, academia and governments focused on solving the problem of lost and abandoned fishing gear worldwide. In 2018, the GGGI launched the Best Practice Framework for the Management of Fishing Gear, a tool to assist actors throughout the seafood supply chain to embed measures to prevent, mitigate and cure the challenge of ALDFG in their operations. There are also outstanding IWC recommendations for closer cooperation with GGGI.

3.7.1.5 THE BIODIVERSITY RELATED CONVENTIONS

There are a range of relevant work programmes under the biodiversity-related Conventions. The Convention on the Conservation of Migratory Species of Wild Animals (CMS) has a resolution 12.20 on marine debris and work to take this forward has included outreach and communications to raise awareness of this issue, including through making plastic pollution the theme for the World Migratory Bird Day 2019, and engagement with other international bodies in order to address the issue at source. At the time of this workshop the Draft Decision for CMS COP13 *inter alia* directs the Secretariat to further cooperate with other organisations working on this issue, including UNEP and the IWC, and requests the CMS Scientific Council to undertake further work on the impact of plastics on CMS-listed species that inhabit terrestrial and freshwater ecosystems. Cooperation with other organisations is currently strategically focused on engagement with UNEP and the process under UNEA, including encouraging CMS members to engage with the UNEA process and with the recently circulated UNEP questionnaire on marine debris.

Work under the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas (ASCOBANS) and the Agreement for the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area (ACCOBAMS) has included joint work on best practice guidance for cetacean necropsy and tissue sampling (see section 4.4).

The Convention on Biological Diversity (CBD) has undertaken several activities on marine debris including development of voluntary practical guidance on means to prevent and mitigate impacts of marine debris on the oceans.

3.7.2 Discussion on IWC engagement with other organisations

The group thanked Smith for this presentation, noting that IWC engages with a range of other organisations and conventions directly and through membership of the Liaison Group of the Biodiversity related Conventions so there are many opportunities for collaborative work.

The workshop noted efforts in other international organisations to address the issue of marine debris and stressed the importance of FAO and other relevant UN bodies continuing to develop and prioritise marine debris related actions. Recalling previous recommendations on this topic, the workshop re-emphasised the importance of IWC cooperation with other organisations on marine debris to promote synergies and avoid duplication of efforts. It encouraged the input of IWC expertise to appropriate fora including from research and data collection associated with its entanglement and strandings initiatives. In this context, the workshop discussed capacity of the Secretariat to engage with other IGOs on marine debris, noting resource and time constraints and the need for prioritisation of engagement towards where IWC input would be most feasible and useful. It suggested a roster of experts, drawn from the IWC community, might identify people willing to help represent the IWC at other meetings and in technical discussions and add value to Secretariat efforts.

Despite the growth in work in international bodies, the workshop noted there remained a major gap in national implementation of recommendations. Noting the projected acceleration in production of plastics, it stressed the need for enhanced efforts to address this at source. Participants thus encouraged IWC engagement with the UNEA process and its efforts to strengthen the global framework for dealing with marine debris, including at source. The workshop also discussed engagement with funding bodies (e.g. EU LIFE and similar programmes) including the potential for the IWC to offer support to marine debris projects put forward for funding by such bodies, as well as the opportunity to pursue fundraising for IWC collaborative efforts.

Participants raised the need for the IWC to lead by example and reduce its own use of plastic in its operations, including at meetings.

The workshop noted several upcoming opportunities to progress IWC recommendations on marine debris in other international processes including development of the post-2020 biodiversity framework, and the United Nations Environment Assembly (UNEA) in 2021. The workshop **encouraged** the Secretariat to engage with the work of the ad-hoc technical expert group established by UNEA to promote synergies between existing mechanisms.

The workshop **recommended** that a roster of marine debris experts be established from which the IWC Secretariat can request experts to represent the IWC at relevant technical meetings, and offer further advice as required to progress marine debris related recommendations.

The workshop **recommended** that the IWC should set an example and, as part of wider efforts to reduce its environmental footprint, have single use plastic-free meetings.

The workshop **recommended** that the IWC explores the potential to support or otherwise engage with projects funded under the EU LIFE programme and similar funding programmes that could support research into the effects of marine debris on cetaceans and the associated development and application of tangible actions.

4. METHODOLOGIES

4.1 How to best collect and collate scattered information from cetaceans

4.1.1 Mapping the Mediterranean Litterscape
Pierantonio reported on efforts to map the Mediterranean Litterscape (Lambert *et al.*, 2020). Data on floating marine debris collected during aerial surveys across a large portion of the Mediterranean Sea, and in the framework of the ACCOBAMS Survey Initiative, were used to obtain density and abundance estimates of particles greater than 2 and 30cm in size, respectively. Preliminary results suggest that highest densities of debris occur in central basin, while numbers decrease in eastern portion of the Mediterranean. When only considering items larger than 30cm the total number of floating mega-debris was estimated at 2.9 million items, taking into account imperfect detection. Nonetheless, items larger than 30 cm represent only one fourth of the complete load of anthropogenic debris (Suaria and Aliani, 2014). Therefore, when considering all floating items larger than 2cm, the overall abundance scales up to 11.5 million floating debris. These results will set the scene for identifying high vulnerability areas to plastic debris for marinefauna, and permitting the implementation of adequate strategies to thwart plastic pollution in the Mediterranean Sea and its impact of marine ecosystems.

Pierantonio also informed the workshop participants that the entire ASI raw dataset, including data on floating macro-litter, is fully available upon request from the ACCOBAMS Secretariat and could be, therefore, used by the research and scientific communities for further analysis and modelling exercises to investigates the sources and accumulation patterns of marine floating debris in the Region.

4.1.2 Information from aerial surveys in Germany
Aerial surveys have been conducted by the Institute of Terrestrial and Aquatic Wildlife Research (Veterinary University of Hannover, Foundation) since 2002 to estimate harbour porpoise distribution and abundance in German Waters (North- and Baltic Seas). Data on floating marine debris were collected opportunistically during those flights and analysed for the very first time. This study showed that marine debris is ubiquitous with higher encounter rates in offshore waters. It furthermore showed how valuable aerial survey data are for gaining information on the distribution of floating debris, identifying overlaps with protected areas and looking at seasonal changes. Furthermore, a distinction can be done between industrial and household debris versus fishing related debris.

4.1.3 Discussion on aerial surveys and marine debris mapping
The workshop expressed thanks to ACCOBAMS for supporting this important survey work in the Mediterranean, noting that this data set was now available for further work or analysis. Discussion also confirmed that the Mediterranean data set is comparable with a similar study for all of the French territorial waters, and that data sharing was also planned with ongoing work to identify hotspot areas for marine debris (e.g. the Pelagos Sanctuary).

Participants stressed that abundance and density data relate only to the specific time of the survey and estimates must be looked at critically. Marine debris distribution can change dramatically over time, depending on currents and circulation and hotspots of marine debris are not permanent- it is possible to come back to the same area a few days later and find it completely empty of debris. Thus, when using survey information for risk assessment, including assessment against feeding grounds of cetacean species, this is a really important point to note. Pierantonio confirmed the next steps for the Mediterranean study would include the use of drift models to explore how debris move across the Mediterranean Sea in different seasons under different conditions of wind, currents etc.

The workshop welcomed the approach applied in Germany, and recommended the wider collection of data on floating marine debris during already existing aerial survey monitoring programmes. This will allow information to be gained on the distribution and abundance of floating marine debris in a cost-effective way over large-scales. Alongside existing programmes, the possibility of conducting dedicated aerial surveys to specifically monitor floating litter should be further explored.

Further consideration could also be given to combining aerial survey data on floating litter with other data sources, e.g. digital surveys, vessel-based fishery surveys, and particularly in areas where there are limited coverage and research effort. In particular, the workshop also discussed beach litter mappings, and the potential for comparisons of their results compared with those from floating debris research. It was also noted that beach clean-up activities have added value in raising awareness, supporting interaction between public and policy. The workshop took note of and especially welcomed work under the Barcelona Convention which had launched an ‘adopt the beach’ project proving effective in terms of public engagement.

Recalling the previous day’s discussions on microdebris, participants discussed using species as indicators of macrodebris e.g. deep divers such as sperm whales and gray whales as bottom feeders as indicators of macrodebris on the seabed. Given migratory patterns, data from resident populations might be more useful. It was noted that some true skin feeders e.g. right whales may also be more susceptible to marine debris so should be monitored, though might not necessarily suitable as indicators e.g. right whales.

The workshop also discussed whether/how the density of macroplastics might be used to estimate microplastics. There are some areas where it appears macrodebris can be a good predictor.

The workshop **recommended** the collection of data on floating debris during aerial and boat-based surveys.

The workshop **emphasised** that beach clean ups are important initiatives for data collection and public awareness, whilst not directly addressing the problem at source, and welcomed the progress made on this *inter alia* under the Barcelona Convention.

4.2 Global surveillance on marine debris

A wider discussion focused on data challenges and means to build up a global picture or repository of data on marine debris from strandings investigations. A potential role for the IWC in supporting global surveillance on marine debris was discussed, including through: (i) developing capacity of countries to respond to and investigate strandings through the IWC strandings initiative; (ii) improving information from IWC Scientific Committee progress reports; and (iii) some form of global database on marine debris. With regards to a global surveillance initiative, or database, participants suggested starting with necropsy data relevant to marine debris (rather than e.g. much wider records of marine debris observations or observed cetacean/marine debris interactions).

The workshop noted that the IWC, in partnership with NOAA, the University of Padua, IFAW, Seawatch and other organisations would be holding a workshop on strandings response harmonisation at the World Marine Mammal Conference (WMMC) on Saturday 7 December. It asked Mazzariol to communicate its discussions to this event and encourage further thought on means of increasing global surveillance of marine debris.

The workshop **recommended** that the IWC Scientific Committee consider development of a database of marine debris information from post-mortem examinations, taking into account the model provided by the IWC ship strikes database. This would contribute to global surveillance on marine debris and capture information as set out in Table 1 of the *Evidence-based diagnostic assessment framework for cetacean necropsies on marine debris ingestion and common data collection* developed by the workshop (Annex 5)

Building on IWC Resolution 2018-3, the workshop **strongly encouraged** countries to submit data on marine debris ingestion and entanglement in their national progress reports. In the case of a post-mortem investigation, this should specify the number of animals exhibiting marine debris interactions as a percentage of the total number of examined animals.

The workshop **encouraged** participants attending the upcoming workshop on Strandings Response Harmonisation, at WMMC on Saturday 7 December 2019, to explore the potential to increase global surveillance of marine debris.

4.3 'Plastic Busters' - a methodology and approach for consolidating Mediterranean efforts against marine litter

Fossi provided information on 'Plastic Busters MPAs'' an EU Interreg Med[3] funded project aiming to maintain biodiversity and preserve natural ecosystems in coastal and marine protected areas by consolidating Mediterranean efforts against marine litter. The project entails actions addressing the whole management cycle of marine litter, from monitoring and assessment, to prevention and mitigation. The project deploys the multidisciplinary strategy and common framework of action developed within the Plastic Busters initiative, led by the University of Siena and the Sustainable Development Solutions Network. This initiative frames the priority actions needed to tackle marine litter in the Mediterranean and was identified by the Union for the Mediterranean in 2016, gathering the political support of 43 Euro Mediterranean countries. Plastic Busters MPAs bring together 15 implementing partners and 17 associate partners from 7 Mediterranean countries, namely Albania, Croatia, France, Italy, Greece, Slovenia and Spain. Plastic Busters MPAs consolidate Mediterranean efforts against marine litter by (i) Assessing the impacts of marine litter on biodiversity in MPAs and identifying marine litter 'hotspot' areas; (ii) Defining and testing tailor-made marine litter surveillance, prevention and mitigation measures in MPAs; (iii) Developing a common framework of marine litter actions for Interreg Mediterranean regions towards the conservation of biodiversity in Med MPAs.

One of the aims of this project is to realize a harmonized monitoring methodology to detect the impact of marine litter on Mediterranean ecosystems and particularly on marine biodiversity, including endangered species inhabiting pelagic and coastal MPAs (cetaceans, sea turtles, birds, endangered sharks, etc.). The final aim of the application of this approach will be to support MPA managers in their efforts to achieve the conservation goals set in their MPAs. Furthermore, these results will facilitate effective policymaking at local, national and regional levels with regards to the prevention, reduction and removal of marine litter in Mediterranean MPAs, within the framework of the EU MSFD and the Barcelona Convention Regional Plan for Marine Litter Management in the Mediterranean.

4.4 Post-mortem investigations

4.4.1 Overview of post-mortem investigations in the Netherlands

4.4.1.1 MARINE MAMMALS AND MARINE DEBRIS: AN OVERVIEW OF THE DUTCH SITUATION

IJsseldijk presented an overview of cetacean post-mortem investigations in the Netherlands. Since 2006, post-mortem examinations on a subsample of all stranded harbour porpoises have been conducted at the Faculty of Veterinary Medicine, Utrecht University (UU), by experienced veterinarians and biologists. The main aim of the research is to determine causes of death, especially the discrimination between natural and anthropogenic causes. The research is funded by the Dutch Government, due to the involvement of this species in several regional, international convention (e.g. ASCOBANS, MSFD and Habitat Directives). In addition, samples for tissue banking and other research uses are collected.

One of the additional projects that the UU is involved in focusses on the presence of marine debris in stranded cetaceans. This is a collaboration with Bureau Waardenburg and Wageningen Marine Research. Collectively, it published the results of the examination of 654 harbour porpoise stomachs for the presence of marine debris in *AMBIO* in January 2018 (van Franeker *et al.*, 2018). This showed that the frequency of occurrence of plastic litter was 7% using only the overflow method, but this percentage increased to 15% using a 1mm sieve in addition to the overflow method[4]. They concluded that standardization of methods is necessary, as proven by the study, but that in general harbour porpoises presented a low frequency of ingestion of minor numbers and masses of litter items. Post-mortem investigations did not reveal any cases of direct fatal plastic ingestion, but at least one case of fatal entanglement in fishing gear (non-bycatch; laryngeal entanglement by a line with a fishing hook) was noted (unpublished). Indirect effects of debris ingestion (e.g. links with nutritional condition, inflammation, infectious disease etc.) have not yet been determined and require further investigation, which could be done retrospectively.

From ten other species, comprising 33 individuals (both baleen- as well as toothed whales), gastrointestinal tracts were analysed. Plastic items were found in two sperm whales (Unger *et al.*, 2016), one beaked whale (Bravo Rebolledo *et al.*, 2018), one humpback whale and one white-beaked dolphin, but not in any other species (Table 1). No cases of direct fatal ingestion were determined. Standardized protocols are required in order to compare results between animals, species, regions and countries, with considerations among sample procedure started at the stranding event. This includes a best practise per species (e.g. which parts to sample from which species, depending on their size), logistics, environmental pollution (e.g. from items flying in during beach necropsies), as well as processing the samples in the lab.

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[3] *https://www.interreg-med.eu/.*

[4] Stomachs and intestinal contents of large whales were washed using a series of 1x1m sieves, with 1.0mm and 0.5mm mesh size. Obtained sieve fractions were machine-washed, following Bravo Rebolledo *et al.* (2013) to collect marine debris and hard prey remains. For dolphins an overflow method, following van Franeker *et al.* (2018) was used to collect hard prey remains and marine debris.

Table 1

Overview of investigated cetaceans in the Netherlands for the presence or absence of marine debris item in stomach and/or intestine. (Unpublished data).

Species	N=	Stomach	Intestine	Plastic in Stomach	Plastic in Intestine
Bottlenose dolphin	1	1	1	0	0
Common dolphin	6	5	4	0	0
Fin whale	7	2	1	0	0
Humpback whale	1	1	1	0	1
Long-finned pilot whale	4	4	4	0	0
Minke whale	4	4	4	0	0
Sowerby's beaked whale	5	4	4	0	1
Sperm whale	10	8	8	2	0
Striped dolphin	3	2	2	0	0
White-beaked dolphin	9	2	1	1	0

The only information on marine debris in harbour seals in the Netherlands is collected by analysis of faecal samples (Bravo Rebolledo *et al.*, 2013), as a dedicated post-mortem program for seals is lacking.

A recent plastic disaster occurred in January 2019, when the cargo ship MSC Zoe lost 342 containers north of the Netherlands which resulted in the spillage of tons of debris in the Natura2000 Wadden Sea site, where there is a great abundance of seals. As of the date of this workshop 800,000kg of this debris were 'missing'. Monitoring of top predator species, including pinnipeds and porpoises, in addition to monitoring of seabirds and beach litter surveys are recommended in the long term in order to increase understanding on where plastic in the oceans accumulate and persists and what its effects are on the marine life.

The recommendation for further improvements in investigating marine debris impacts on cetaceans in the Netherlands are to: (1) increase the sample size of marine debris determination, including its absence, in all species that are stranded on the beaches, but especially the deep divers; (2) link with (histo)pathology, retrospectively this can be done for the cases in which marine debris ingestion has been observed; (3) expand the research to pinnipeds; (4) standardize protocols, taking into account the species involved and the logistics; and (5) develop an international database in order to work towards defining hotspot areas which could be in a similar design as the IWC ship-strike portal.

STUDIES ON FULMAR IN THE NETHERLANDS

Bravo Rebolledo presented data from fulmar studies in the Netherlands. Plastic ingestion in Northern Fulmars has been monitored in the Netherlands since the early '80s. Fulmars are purely offshore foragers that ingest all sorts of litter from the sea surface and normally do not regurgitate poorly degradable diet components like plastics. The monitoring uses fulmars that are found dead on the beach or accidentally killed e.g. fisheries bycatch. North Sea governments aim at a long-term OSPAR Ecological Quality Objective (EcoQO) in which for at least 5 constructive years, the proportion of fulmars with more than 0.1 gram of plastic in the stomach remains under 10%. Over the 5-year period 2014-2018, EcoQO performance among 115 fulmars beached in the Netherlands was 43% (Van Franeker and Kühn, 2019). In this period Van Franeker and Kühn (2019) found ingested plastics in 93% of the fulmars, with an average over all birds of 24 particles per stomach, weighing 0.26g. Standard procedures for dissection and stomach analyses have been documented (in reports, scientific literature and formal OSPAR guidelines) and are used internationally.

4.4.2 Discussion on Netherlands studies

The workshop welcomed the Dutch studies and the efforts made to standardise approaches to necropsy and GIT investigations. It stressed the need for wider standardisation of approaches and discussed the specialisms involved in necropsy for marine debris. Initial observation of presence/absence of plastic (including as for the fulmar study) and the apparent presence/absence of lesions can be done first but determining health status of animal and cause of death (including, e.g. interpreting macroscopic lesions) is a task for an experienced veterinarian/pathologist. Samples needed to be taken in an appropriate way to include the apparently healthy part and the part with the pathology/legion. This had been discussed in detail during the development of the ACCOBAMS/ASCOBANS Best practice for cetacean post-mortem investigation and tissue sampling, and is further discussed below.

Bravo-Rebolledo confirmed that plastic ingested by fulmars of the Dutch coast has been decreasing slowly (Van Franeker and Kühn, 2019). This indicates that the marine litter situation of fulmars found on the Dutch coast is gradually improving. The same indication is not, however, evident in beach studies and further research would be required to fully establish a decline, identify which plastics are reducing and the measures that were introduced to achieve this and when. Furthermore, fulmars only feed at sea and are surface feeders, so these results are only an indication of floating debris, not of debris in the water column. Nonetheless, the workshop participants welcomed this good news story and hoped that further work could bring insights on what mitigation measures might have been a success. The workshop encouraged further dissemination of success stories.

The workshop noted anecdotal information on the MSC Zoe incident-including the huge loss of containers and the resultant follow up work to trace debris. It stressed the importance of monitoring such incidents and using them to learn more about marine debris, its distribution and impacts.

To follow up on the development, implementation and, in particular, on the effect of measures to reduce the risk of interaction of cetaceans with marine debris, the workshop **recommended** that the Environmental Concerns subcommittee of the IWC Scientific Committee compiles a catalogue of successful mitigation measures, which the SC could then evaluate for best practice recommendations.

4.4.3 Joint ACCOBAMS/ASCOBANS Best practice on cetacean post-mortem investigation and tissue sampling

Mazzariol presented the Joint ACCOBAMS/ASCOBANS Best practice on cetacean post-mortem investigation and tissue sampling, which can be downloaded from the following web page: *10.31219/osf.io/zh4ra*.

During the VIII ASCOBANS Meeting of the Parties (MoP) in 2016, the Advisory Committee (AC) and Secretariat were requested to engage actively in the work on best practice guidelines for response to stranding events and in the establishment of an updated post-mortem protocol within the frameworks of the International Whaling Commission (IWC), ACCOBAMS and the European Cetacean Society (ECS) under Resolution 8.10. In the same year, ACCOBAMS endorsed the document on common best practices for a basic post-mortem examination of stranded cetacean (Resolution no. 6.22; VI MoP). ACCOBAMS also asked ASCOBANS, ECS and the IWC Scientific Committee (SC) to review the common definitions, common data collections and common post-mortem protocols during the triennium. In 2018, during the 24th ASCOBANS Advisory Committee and 12th ACCOBAMS Scientific Committee, a joint workshop was proposed to harmonize the existing initiatives. This meeting was held in Padua (Italy) in June 2019 and involved 24 experts from ASCOBANS and ACCOBAMS and from also from Macaronesia, representing the MARCET project.

The aim of the Best Practice document was to update the protocol with the currently available techniques and methodologies agreed between all member countries of ACCOBAMS and ASCOBANS. It is hoped that this updated protocol can serve three overall aims: (i) To provide a reference document for veterinarians and biologists currently engaged in cetacean post-mortem investigations, summarising a recognised approach to stranding investigation across European networks; (ii) To highlight areas where harmonisation of data from existing networks could allow for analysis and inference to be made between networks, of particular relevance for the transboundary, mobile species; and (iii) To provide a start-up guide for researchers attempting to instigate new stranding monitoring programmes, particularly in regions of the world with limited resources for extensive, top-down surveillance programmes.

This document was not designed to replace existing protocols, particularly those of longstanding and well-established laboratories and stranding networks, but offers a post-mortem framework aiming for consistency across Europe when conducting examinations on dead cetaceans. By outlining current European best practices, it was assumed that there is sufficient time and resources to carry out a full post-mortem examination, although it is recognised this may not always be the case.

The quality of the information gathered is influenced by logistical capacity, e.g. carcass accessibility, available equipment/supplies and finances, and the skills, experience and capacity of the human resources. Nonetheless, it should be emphasized that following a precise and well-defined data collection procedure ensures the information collected during post-mortem investigations is of high quality. To be able to assess the cause of death and health status, a full post-mortem investigation with additional examinations as proposed below is deemed necessary. If a full investigation cannot be carried out for any reason, one should always attempt to collect the following data: species, sex, stranding location, stranding date and (approximate) body length to assess age class.

Common terms and definitions frequently used throughout the document, and general terminology used in stranding events and forensic human and veterinary medicine were harmonized and collected at the beginning (see Annex 6).

The document is structured using a tiered approach to carcass triage which allows investigations to be conducted at a number of levels, depending on the resources, facilities or experience of the stranding network. Whilst the ‘gold standard’ centres around a thorough and detailed post-mortem investigation conducted by well-resourced and experienced veterinary pathologists, it is recognised that this capacity is often the exception rather than the rule. The tiered approach offers a framework for data collection and interpretation appropriate to the resources available. In describing the tiers, information regarding who can do and what should be assessed are reported.

Tier One - External examination and stranding data collection.

Tier Two - Post-mortem investigations and tissue sampling.

Tier Three - Post-mortem examination with diagnostic aims.

The document describes the best practices for cetacean post-mortem investigations, and outlines basic best practice up to and including tier two. Guidance in cetacean post-mortem examinations or causes of death at tier three is outside the scope of the basic protocol.. For this level, it is recommended that a veterinarian with specific training in pathology is involved in the examination, and principles and protocols according to professional bodies such as the European College of Veterinary Pathology (ECVP) are followed.

Furthermore, the decomposition code was revised to be adapted to post-mortem investigations only and a nutritional condition code was defined. The document includes tables summarizing the possible investigations according to the decomposition code, tissues that should be collected and how to preserve them with special instructions.

4.4.4 Discussion on Joint ACCOBAMS/ASCOBANS best practice guidance

The workshop welcomed this important contribution from ASCOBANS, ACCOBAMS and others and encouraged its use. It recognised that some countries will already have their own protocols but observed that they might find value in reviewing these for alignment with the ASCOBANS/ACCOBAMS document and integrating any additional guidance that is useful. The workshop noted the value of the tiered approach for different capacities and stressed that Tier 1 gives a useful starter for countries operating in low capacity and low technology environments. It encouraged that this best practice guidance should be presented to the IWC Scientific Committee for discussion and endorsement.

The discussion highlighted that though specific protocols for marine debris and bycatch investigations are useful, these should be components of protocols for establishing cause of death which remains the main aim of necropsy and is the main aim of the ASCOBANS/ACCOBAMS protocol.

The workshop furthermore stressed necropsy guidance as one important part of improving strandings response and surveillance for marine debris. Improvements are also needed in the organisation of strandings networks and strandings event management. There are important roles for a range of stakeholders, including governments and legislators in addition to technical specialists.

The workshop, noting the need for harmonisation to allow data to be compared globally, **strongly welcomed** the European Best practice on cetacean post-mortem investigation and tissue sampling and encouraged its wider use. The workshop **commended** this protocol to the IWC scientific committee for its consideration and potential endorsement.

The workshop discussions brought forward much anecdotal information on marine debris types commonly seen in particular countries for example, synthetic raffia (used in agricultural construction) in the Canary Islands, plastic sheeting in the Adriatic and found in sperm whales (thought to be from discarded material from hothouses), and plastic bags in Greece. A preliminary review of literature considered during the workshop suggested the most commonly observed items were plastic bags, plastic bottles and food packages in general with some specific cases (such as those above) where particular items occur more frequently than others. The workshop noted other efforts to identify frequently occurring marine debris types, for example the ‘top marine beach litter items’ identified in Europe (Addamo *et al.*, 2017).

The workshop agreed that more efforts to identify commonly occurring debris types (including specific types more prevalent in particular locations) in addition to improved information on what is ingested by marine mammals, could help to identify particularly problematic marine debris types and thus priorities for improvement of waste disposal and recycling facilities and for addressing marine litter at source.

The workshop noted the emergence of some forms of debris as particularly prevalent globally, and that others can be identified as potentially problematic in some specific locations and **recommended** these debris types should be addressed at source as a priority.

4.5 Consideration of extent of cetacean entanglement in debris versus entanglement in active gear

4.5.1 Presentation

Mattila provided a brief overview and update on the difficulty of determining the origin of materials removed from entangled large whales, especially differentiating between actively fished gear and ALDFG. The importance of making this determination has been stressed at previous IWC marine debris and entanglement workshops, as incorrect assumptions about the source and origin of entanglements could funnel time, resources and political will in the wrong directions. Because many large whales destroy the gear that they become entangled in, and can drag the remnants for many weeks or months over thousands of kilometers, much of what is removed can look like debris, and is often classified as ‘undetermined rope or net’. However, when identifying marks remain and the gear can be traced back to the owner, it has virtually always been actively fished gear. Currently, when there are no identifying marks, an attempt to differentiate between ALDFG and actively fished gear usually relies on unusual types or amount of fouling organisms, or on multiple gear types. However, even these can be misleading as a whale can drag gear through unusual habitats where it may pick up ‘exotic’ fouling organisms, and an entanglement in actively fished gear, if dragged long enough, could pick up multiple gear types as well as actual debris. So far, the only entanglement response network that has identified multiple entanglements in ALDFG is the network in Hawaii. It’s determination of ALDFG as the origin of entanglement has varied annually between 5-16%. While many networks report ‘unidentified rope or net’, their affirmative determinations of ALDFG are extremely rare (Richardson *et al.*, 2019a).

The IWC currently coordinates a Global Whale Entanglement Response Network, which is made up of approximately 3,000 trained members in representing about 25 country networks. The coordinators of these networks were recently polled about the extent to which they encounter entanglements in ALDFG (rarely, see above) and for ideas about how to differentiate. The need to identify better diagnostic fouling was reiterated, along with monitoring the rates of large whales becoming entangled in fishing areas that are closed to fishing, for some natural or management reason, during the whale's presence in that area. The latter idea assumes that any gear that a whale would encounter and become entangled in, during such a closure would have to be ALDFG. An example of a 'natural closure', is the case of bowhead entanglement in Bering Sea crab gear, as telemetry tracking indicates that the whales stay in the sea ice during the winter, where they could only encounter ALDFG lost in the ice (Citta *et al.*, 2013). Two examples of management closures shown were the seasonal lobster fishery closure in the Bay of Fundy and SW Nova Scotia, and the NARW closure of the snow crab fishery in the Gulf of St. Lawrence. However, in these examples it was noted that whales can easily roam in and out of the closure areas and could therefore be exposed to entanglement in active gear outside of the closed areas.

4.5.2 Discussion
In discussion, the group recognised that entanglement in fishing gear, both active and lost, is a threat to a range of marine species. The origin and impact vary according to species, population and habitat. For example, in most areas where data are available, large whales are primarily entangled in active gear, while lost gear may have a relatively larger impact on small cetaceans. But regardless of this variance, the benefits of both sound fisheries management, that prevents entanglement in active gear, and facilitates the prevention, mitigation and clean-up of lost gear should be pursued in national, regional and international policy.

It was also recognized that differentiating between the origins of entanglements is important for focusing resources and management actions, and therefore it is helpful for ongoing research to provide tools that can assist in making these determinations for particular situations. But further research should not stall mitigation measures.

The workshop noted with interest the information from both the Bering Sea and North American crab fishery closures and the potential value of further research in 'closed areas' (to active fishing) in establishing impacts of ALDFG, whilst agreeing that movement of animals in and out of these areas might impact results.

The workshop agreed that further inquiry about diagnostic fouling may be valuable. It is recommended that inquiries be made with groups that are developing tools to track biotic fouling on marine debris (e.g. Plastisphere), in order to determine the utility of their methodology for determining if materials removed from entangled animals are from actively fished gear, or ALDFG.

The workshop **requested** the Secretariat to establish contact with organisations developing tools to track biotic fouling on marine debris (e.g. Plastisphere) and report back to the IWC Scientific Committee on the utility of such methods to investigate materials removed from entangled animals.

Given current knowledge, bowhead whales in the Bering Sea appear to be the species of large whale at the greatest risk to entanglement in ALDFG (Citta *et al.*, 2013). Therefore, the workshop **encouraged** the range states of the Bering Sea to engage stakeholders (e.g. Fisheries, subsistence whalers and others interested in the health of the Arctic) to investigate: (1) the removal and appropriate disposal of fishing gear that is lost in the ice, perhaps through a pilot project off Alaska; and (2) the use of gear that is less likely to entangle and less likely to be lost (e.g. remote release buoy lines). Furthermore, the group noted that, if these actions were successful and then expanded to an appropriate geographic area, this should benefit several populations of critically endangered large whales (e.g. North Pacific right whales, Western gray whales).

The workshop **welcomed** the plans of the Government of Canada to invest significant resources to remove ALDFG from NA right whale habitat in the Gulf of St. Lawrence. **The workshop therefore recommended** that the IWC Secretariat invite Canada to provide an overview of this effort (e.g. underpinning data, methodology, anticipated outcomes), and other related mitigation measures, to the next meeting of the IWC Scientific Committee.

5. HEALTH CONSEQUENCES OF MARINE DEBRIS FOR CETACEANS

5.1 Health consequences from ingestion

5.1.1 Review of latest evidence
Mazzariol gave a review of latest evidence of health consequences of ingestion of marine debris for cetaceans. Cetaceans can die after marine debris ingestion, due to gastric impaction/occlusion, perforation, or the associated lesions. Besides direct lethal effects, presence of plastic debris could affect marine mammals' health if they persist in the GIT, e.g. by reducing the space for food and, subsequently, reducing their fitness and the nutritional condition. In addition, this may induce malnutrition, which is presented by a range of pathological changes (i.e. muscular and pancreatic atrophy, hepatic lipidosis, haemorrhages, etc.). Presence of foreign bodies could also cause inflammatory changes to the GIT and/or induce stress and pain. However, other indirect effects remain unclear, despite, the concerns that have been raised by different studies on other taxa.

An investigation conducted on sheep and goats living in the Sahara Desert by Centelleghe *et al*. from the University of Padova (Mazzariol, personal communication) showed a direct relation between plastic ingestion and diseases. Here, ovi'caprine eat plastic litter, which filled their forestomach. During a morbilliviral outbreak (Pest de Petite Ruminant Virus - PPRV) (in Algeria in 2010), a direct relation was found between rumen repletion from the ingested plastic and sick animals with clear pathological findings associated to the viral outbreak.

An additional concern on the health effects of marine debris on cetaceans was related to the potential role of plastic debris as a carrier or vector of toxins and pathogens. This could respectively impair the immune function and change the (intestinal) microbiota. Recent studies conducted confirmed that polystyrene microfibers induced intestinal microbiome dysbiosis, hepatic metabolism disorders and induce changes in the gut barrier function.

5.1.2 Discussion

The workshop noted overall that more information is needed on the effects of macro and microdebris on cetaceans in order to determine the role of marine debris ingestion in causing mortality and to determine any risk of population level impacts. However, there are a growing number of reports showing ingestion of debris, in some cases relatively large quantities, and increasing documented evidence of associated pathology (Baulch and Perry, 2014a; IWC, 2014), Section 3.2.1 above). The complicated gut structure of cetaceans is such that it could facilitate impaction, and there have been some confirmed cases where marine debris has been established as cause of death (Baulch and Perry, 2014a; IWC, 2014). In addition, sublethal (chronic) impacts from marine debris ingestion have the potential to affect the overall health and welfare of the animal.

It was reiterated that the IWC has an interest in the threat from marine debris not only from a conservation but also a welfare perspective.

5.2 An evidence-based diagnostic assessment framework for cetacean necropsies on marine debris ingestion and common data collection

Following the discussion above, the group worked to develop an evidence based diagnostic framework for data collection on marine debris during necropsies. In presenting this, Mazzariol noted that interpreting post-mortem findings and evidence collected during a thorough necropsy, not limited to gross examination, needs specific skills and expertise. These data should be elaborated by skilled professionals to properly hypothesize the possible cause, mechanism and manner of death. A necropsy is a specialized medical procedure comprising of a thorough examination of a carcass by dissection with the aim to determine the likely cause of death. Sampling and testing should be complete and not be driven by any previous hypothesis or speculation; interpretation of evidences should be based on the best existing literature and protocols already published and/or used, ruling out any possible causes of death without bias. Even if it depends on the specific country's legal framework, post-mortem investigations with diagnostic aims should be conducted with the involvement of a veterinarian trained in animal pathology with an experience in marine mammal diseases.

In Annex 5, best practices and criteria associated with diagnoses of marine debris ingestion are summarized. These set of findings constitute an evidence-based diagnostic assessment framework and could support the interpretation of data and observations collected during a thorough and complete necropsy by a veterinary pathologist and/or a veterinarian.

The workshop **recommended** the adoption of the *Evidence-based diagnostic assessment framework for cetacean necropsies on marine debris ingestion and common data collection* in Annex 5 by veterinary/biologists working in stranding networks during post-mortem examination of cetaceans in order to study the impact of marine debris ingestion on marine mammals.

Considering the concern about the effects of ingested marine debris and the existing knowledge gaps on the effects that marine debris ingestion could have on the health of cetaceans, the workshop **encouraged** collaborative and comparative studies on this, also noting potential links to human health studies.

In particular, noting the potential role of marine debris in carrying pathogens and toxins, the workshop **strongly welcomed** further studies on the effect of marine litter on the animals' microbiota and associated metabolic disorders, and the development of diagnostic approaches aimed at evaluating these effects.

In this regard, the workshop recognised the activities of other IGOs and research institutions to improve understanding of the impact of microplastic ingestion in humans (e.g. World Health Organisation) and fish (e.g. Food and Agricultural Organisation of the United Nations) and **encouraged** the sharing of information via the IWC Scientific Committee, e.g. through a presentation from WHO, FAO and other leading experts on the status of current knowledge in this field at the next possible meeting.

6. CONSIDERATION OF SPECIFIC MITIGATION APPROACHES FOR CETACEANS

6.1 Addressing ghost nets

6.1.1 Overview of ALDFG issue

Dixon provided an overview of the issue of Abandoned, Lost and otherwise Discarded Fishing Gear (ALDFG). To the best available knowledge, approximately 640,000 tonnes of ALDFG gear enters the oceans every year, though this is considered to be an underestimate. By weight 70% of macroplastics are thought to be fisheries related and studies such as that from Lebreton *et al.* (2018) in the Pacific, point to over 50% concentration of marine debris originating from fisheries. A lot of fishing gear is underwater and therefore difficult to quantify in surveys or on the beach. Dixon also highlighted the research from CSIRO and Ocean Conservancy which indicates fishing gear is also the deadliest form of marine debris as it is designed to catch and kill, which does not stop once control of the gear has been lost. This is a significant risk for wildlife entanglement.

The main drivers of gear loss are from direct (adverse weather, spatial pressures, gear conflict with other vessels and animals) and indirect (predominantly issues related to lack of disposal facilities), noting also that Illegal, Unreported and Unregulated Fishing (IUU) is considered to be a key driver of fishing gear dumping and loss but that this is an area requiring further research. Dixon suggested that understanding IUU hotspots where gear is frequently dumped due to enforcement issues or lost as a result of gear conflict may be useful as a focus for protecting cetaceans from entanglement.

Dixon described the progress made with the development and adoption of the FAO Voluntary Guidelines for the Marking of Fishing Gear, which were formally endorsed by the FAO Committee on Fisheries in July 2018. The intended benefits of implementation of the guidelines are wide ranging, from enabling better capacity control in fisheries to aiding in the detection of IUU fishing and ALDFG. The guidelines at present are voluntary, though FAO are conducting a series of capacity-building workshops in collaboration with Global Ghost Gear Initiative and others in order to encourage countries and other fisheries stakeholders to implement the guidelines. In 2020 FAO are also partnering with IMO under the GloLitter project to continue scaling these efforts.

The workshop heard about the GGGI Best Practice Framework for the Management of Fishing Gear (BPF) which was formally launched in 2017 after an extensive stakeholder consultation. The BPF is another useful tool to support effective fisheries management and the reduction of ALDFG, providing a potential opportunity to benefit cetaceans. Dixon described the risk assessment approach to understanding which gear types pose the greatest risk as ALDFG and what their likelihood of loss is, noting that gillnets, then pots and traps and then FADs had been identified as the most high-risk gear types in the context of ALDFG.

The workshop also heard about the concepts of 'prevention, mitigation and cure', with the focus being on prevention of gear loss through measures such as gear marking, effective spatial management and improved port reception facilities as the preferred route. Dixon noted that several prevention and mitigation measures such as gear marking could be useful in identifying gear types and origins on entangled cetaceans, therefore encouraging the workshop to endorse gear marking.

Dixon described some of the recent policy developments in the European Union under the Single Use Plastics Directive, in particular the focus on scaling and replicating projects to facilitate the collection and recycling of fishing gear, therefore bringing it into the circular economy. Notably the EU is introducing an Extended Producer Responsibility (EPR) mechanism in 2024 which will enable improved gear design, management and disposal throughout the gear lifecycle. Dixon encouraged the workshop to take note of the EPR system as a potential policy approach to endorse to increase accountability with regards to the use and distribution of fishing gear.

In closing, Dixon introduced some potential areas for discussion as recommendations to IWC, notably referencing the possibility for IWC to support the call for a new legally-binding global governance framework to address plastic pollution; to further research links between IUU, ALDFG and cetacean entanglement in identified hotspot areas; to support policy approaches such as EPR and improved portside measures which aim to tackle producer responsibility and the circular economy of fishing gear; and to support pilot projects in collaboration with FAO to implement the gear marking guidelines in areas of cetacean entanglement; and to highlight the potential usefulness of the GGGI Best Practice Framework.

6.1.2 Discussion

The workshop discussed the different degrees of risk (of becoming Ghost Gear) with different gear types e.g. trap and pot gear will keep on fishing in perpetuity, whereas trawl/seine nets tend to ball up on the bottom and would not then pose the same risk. It was noted that means of identifying gear type when investigating entanglements are improving but that (as already discussed) there remain significant challenges in distinguishing between active gear and ALDFG.

Participants discussed provisions for shoreside disposal/recycling of unwanted gear, noting that there had been positive developments (including e.g. the EU Port Reception Facilities Directive) but that there was progress still to be made. It discussed legislative factors needing to be addressed for ghost gear mitigation- for example in some parts of the world (including some states in the USA), legally speaking, gear belongs to individuals even after it is lost and another party cannot have it on their boat without permission. It further noted the potential for ALDFG considerations (alongside active fishing, which is likely to remain the even bigger threat in most locations) to be integrated into fisheries certification schemes.

Finally, the workshop noted further potential for collaboration between the GGGI and IWC including in implementation of the GGGI Best Practice Framework.

The workshop **recommended** that further research into links between ghost gear and cetacean entanglement be conducted - e.g. in hotspot gear loss areas, also exploring links with key drivers for gear loss (e.g. IUU). The workshop further noted the need to collaborate with the IWC Bycatch Mitigation Initiative (BMI) and the Entanglement Initiative.

Recognising previous recommendations on engagement with the GGGI, the workshop **encouraged** the IWC to consider the GGGI Best Practice Framework and recommended potentially undertaking pilot projects with GGGI on mitigation approaches to reduce impacts of ALDFG on cetaceans.

The workshop **encouraged** countries to implement policy approaches aimed at preventing and mitigating ALDFG, e.g. Extended Producer Responsibility and end-of-life gear management (e.g. circular economy, port reception facilities).

The workshop **encouraged** countries to support a global governance mechanism which would bring coordination and management for the full life cycle of plastics, including ALDFG, under one umbrella.

The workshop **welcomed** the introduction of the Port Reception Facilities Directive in the EU and efforts underway as part of the IMO Action Plan to Address Marine Plastic Litter from Ships to improve access and adequacy of port reception facilitates for end-of-life fishing gear and waste generated from ships. The workshop **encouraged** IWC members to implement or increase the capacity of existing convenient, cost-effective shoreside disposal/recycling infrastructure and logistics systems in order to enable responsible disposal of gear and other waste.

The workshop r**ecommended** that fisheries certification schemes should take into account impacts from bycatch and ALDFG.

6.2 **Addressing Fish Aggregation Devices (FADS)**

6.2.1 Overview of the FAD issue

Mattila gave an overview of the Fish Aggregating Devices (FADs) issue. FADs are manmade structures that are placed (vertically) in the water column in order to encourage fish to gather and hide amongst the hanging materials, therefore aggregating harvestable fish, often in an otherwise low-density habitat (e.g. tropical or pelagic). Originally, FADs were made with floats made of bamboo or some other floating wood, with a vine or woven rope hanging below, to which items like palm fronds were attached. Today, they are often made of synthetic rope with debris or old netting attached loosely to the rope, topped by a float of some type, and a weight or anchor at the bottom. FADs can either be anchored in a permanent location, or can be set to drift in the open Ocean (dFADs).

The IWC Global Whale Entanglement Response Network has considered the entanglement risk that FADs pose to large whales since 2014, when a sperm whale female and calf (dead) were found entangled together in an artisanal FAD off the Island of Guadeloupe (Rinaldi and Rinaldi, 2014). The 2018 meeting of the GWERN (IWC/67/WKMWI/Rep/01) received further information about the increasing numbers and geographic scope of commercial FADs, along with reports of more large whale entanglements. Estimating the numbers of FADs, both commercial and artisanal, is difficult but a Pew report (PEW, 2015) estimated over 120,000 (commercial) FADs in international waters in 2013, with a rapidly increasing trend. Maufroy *et al.* (2018) estimated a loss rate of 8.8%, for commercial drifting FADs.

For a number of reasons, there is growing concern about both the use of and loss of FADs. The International Seafood Sustainability Foundation (ISSF) has recently published a document (August, 2019) with guidance for the construction and use of ‘Non-Entangling and Biodegradable’ FADs. At its next Congress (June, 2020) the International Union for Conservation of Nature (IUCN) will consider a motion in support of non-entangling and biodegradable FADs, along with other management measures (e.g. limits per boat, etc).

It was also noted that FADs are not the only fishing gear used on the high seas that may pose a risk to cetaceans, whether tended or ALDFG. In particular, with regard to fishing effort on the high seas, long lines are estimated to be the most prevalent. Actively fished long lines are known to entangle large whales, and so abandoned, lost or discarded long lines would pose some risk as well.

6.2.2 FADs in the Mediterranean

Pierantonio summarised Sinopoli *et al.* (2020) which assessed the FAD situation in the Mediterranean Sea. In the Mediterranean Sea, this activity is widespread in southern Italy, Tunisia, Malta and Majorca (Spain). Sinopoli and colleagues estimated that every year, for at least 30 years, about 60,000 FADs have been placed at sea and in most cases are not recovered. In their study, they estimate that approximately 1.6 million FADs were abandoned in the Mediterranean Sea between 1961 and 2017. The largest fishing areas are off Malta (34,465km^2) and Tunisia (23,033km^2). The greatest numbers of abandoned plastic sheets (452,742) and concrete blocks (905,483) were estimated to be around Tunisia, while the greatest amount, in terms of length, of polyethylene cable (399,423km) was estimated to be around Sicily. The authors of the study discuss how the legislation on the use of Mediterranean FADs is still poor and does not address environmental issues and emphasise that, overall, reducing the number of FADs and introducing new types of FADs equipped with specific technological systems appear to be the most suitable strategies to mitigate the impact of FADs on the environment and resources.

6.2.3 Discussion of draft IUCN motion on FADS

Following on from these presentations, the workshop discussed a draft IUCN motion on FADS being proposed to the IUCN Congress in 11-19 June 2020. It welcomed IUCN engagement with this issue, expressed its hope that this motion would be supported and suggested that the motion could be strengthened by the additional of language on recent whale entanglements in FADS. It noted that there should be opportunities for online debate of this motion in the coming month.

The workshop **welcomed** the draft of IUCN motion #28 for the IUCN World Conservation Congress to be held in June 2020, which seeks to promote more sustainable management of Fish Aggregating Devices (FADs). The workshop **encouraged** IUCN members to engage with the IUCN process to: (1) add wording that expresses concern about recent whale entanglements in FADs; and (2) support this motion when it comes to a vote.

6.3 Identification of species/populations under particular threat of marine debris (i.e. hot-spots)

6.3.1 Overview from the literature

Nunny had reviewed the literature for the workshop and described the most relevant papers that show areas which could be considered hotspots where cetaceans are more likely to come into contact with marine debris. Identifying hotspots does not just mean noting areas where there are lots of plastics but also needs to consider the feeding habits and behaviour of the animals in that area.

Avila *et al.* (2018) reviewed publications highlighting threats to marine mammals and created risk maps. Almost all marine mammal species faced at least one threat. Although they did not create risk maps specifically for marine debris, this is included in the pollution map and the incidental catch and fishing gear interaction map which includes lost gear. Pollution hotspots were areas located along the coasts of industrialized nations with a few hotspots also being identified around northwest Africa and the Philippines whilst interactions with fishing gear were ubiquitous particularly in temperate waters though they are concentrated in coastal areas, enclosed seas and some areas of the Tropical Eastern Pacific and North Atlantic.

Modelling of hotspots for sea turtles by Schuyler *et al.* (2016) combined global marine plastic distributions based on ocean drifter data with sea turtle habitat maps to predict exposure levels to plastic pollution. The regions of highest risk to global sea turtle populations are off the east coasts of the USA, Australia and South Africa, the east Indian Ocean and South-east Asia.

Video transects were used to record the litter density in an area of 3,735,900m^2 of the seafloor in the Barents and Norwegian Seas (Buhl-Mortensen and Buhl-Mortensen, 2017). The mean density of items was 202 items/km^2 in the Barents Sea and 279 items/km^2 in the Norwegian Sea. The highest density recorded was >6,000 items/km^2 in a trough offshore alongside a fishing bank called Sveinsgrunnen. Fishery debris dominated the debris recorded. Litter density was higher than or similar to that recorded in other European waters.

Nøttestad *et al.* (2015) provide some distribution maps for cetaceans in the Norwegian Sea from 3 summer seasons which can be compared with the debris density maps from Buhl-Mortensen and Buhl-Mortensen (2017).

IMMAs (Important Marine Mammal Areas) which are being identified by the Marine Mammal Protected Areas Task Force (MMPATF) are available as maps (*https://www.marinemammalhabitat.org/imma-eatlas/*) which could be overlaid with the presence of marine debris to create hotspot maps where cetaceans could be particularly affected by debris.

The workshop thanked Nunny for providing this latest information.

6.3.2 Cetaceans and microplastics hotspots in the Mediterranean

Fossi gave a summary of work on marine debris hotspots in the Mediterranean. Monitoring of the impact of marine litter on cetacean species should include an understanding of likely exposure to marine litter in the area concerned. The Mediterranean Sea is one of most affected areas by debris in the world: 115,000-1,050,000 particles/km^2 are estimated to float in the Mediterranean Sea (Fossi *et al.*, 2012; UNEP-MAP, 2015). Plastics and other polymer materials are the most common types of marine debris, representing some 80% of debris found on sea surface (Fossi *et al.*, 2017). As larger pieces of plastic debris fragment into smaller pieces, the abundance of microplastics in marine habitats increases. Despite the recent advances made within the framework of the Barcelona Convention Regional Plan for Marine Litter Management in the Mediterranean and the EU Marine Strategy Framework Directive (Descriptor 10), there is still a long way to go to tackle debris in the Mediterranean and reduce the risks posed to Mediterranean marine wildlife.

Recent studies suggest that debris, including microplastics and chemical additives (e.g., phthalates), tend to accumulate in pelagic areas in the Mediterranean (Panti *et al.*, 2015; Pedrotti *et al.*, 2016), indicating a potential overlap between debris accumulation areas and endangered species' feeding grounds (Fossi *et al.*, 2016; Fossi *et al.*, 2017). This fact highlights the potential risks posed to endangered, threatened and endemic species of Mediterranean biodiversity. In one of the most biodiverse areas of the Mediterranean Sea, the Pelagos Sanctuary, cetaceans coexist with high human pressure and are subject to a considerable amount of plastic debris, including microplastics (Collignon *et al.*, 2014; Fossi *et al.*, 2012).

Fossi and collaborators (Fossi *et al.*, 2017) investigated the possible overlap between microdebris, mesodebris (from 5 to 25mm) and macrodebris (>25mm) accumulation areas and the fin whale feeding grounds in the pelagic Specially

Protected Area of Mediterranean Importance, the Pelagos Sanctuary. Models of ocean circulation and potential fin whale habitat were merged to compare debris accumulation with the presence of whales. Field data on the abundance of micro-, meso-, and macrodebris, and on the presence of cetaceans were collected simultaneously. The resulting data were compared, as a multi-layer, with the simulated distribution of plastic concentration and the whale habitat model.

Field and model observations on marine debris distribution and accumulation areas overlapped the fin whale feeding habitat, paving the way for a risk assessment of fin whale exposure to microplastics at global level (Germanov *et al.*, 2018). The approaches used in this paper, and by Darmon *et al.* (2017) for sea turtles, predict where species will be the most affected by plastic debris, enabling the identification of sensitive areas for species specific ingestion to be defined, and providing a basis for the mapping of areas to be protected. Based on data or outputs from models on both macro- or microplastics, and species distribution, from plankton to large vertebrates, the same approach could be largely used to predict areas where the risk of ingestion occurs and the possible consequences on biodiversity.

6.3.3 Discussion on marine debris hotspots
The workshop noted the potential threats posed by marine debris hotspots to cetacean species, particularly in convergent zones.

Mattila provided information on IWC collaboration with WWF and the IMMAs process, following on from a joint IWC-IUCN-ACCOBAMS workshop in 2019 to evaluate how the data and process used to identify IMMAs could be used to assist the IWC to identify areas of high risk for ship strikes. WWF is leading work to map the overlap between IMMAs and shipping and bycatch, which could potentially be extended to other threats.

IJsseldijk provided information on spatial risk analyses of marine debris exposure using predicted debris distributions and ranges for sea turtles (Schuyler *et al.*, 2016) and sea birds (Wilcox *et al.*, 2015). Participants expressed support for similar analyses for cetaceans.

Several participants described studies modelling the overlap between cetacean distributions and marine debris. Though noting such studies as useful, participants stressed that it is important to 'ground truth' modelling data with field studies wherever possible and the importance of taking into account sample sizes (where observations are small in number). Transience needed to be taken into account, with models accounting, if possible, for movements of hotspots with currents etc.

Participants also discussed potential risks of marine debris to critically endangered species. In the case of the vaquita, for example, it had been observed that abandoned and lost fishing gear is adding to the threat already posted by active gear. Further work could potentially explore overlap between ranges of critically endangered species and marine debris hotspots, including those for ghost gear.

Dixon reported that the GGGI have undertaken some comprehensive efforts to build up a ghost gear database and collect and standardise all data globally - this is currently accessible through the GGGI.

Where suitable data exist, the workshop **recommended** investigating co-occurrence of cetacean distribution with marine debris, for example through modelling exercises similar to those that have been done for seabirds and turtles. The workshop stressed the value of verifying modelling exercises using field data.

The workshop **recommended** that the IWC Secretariat adds marine debris mapping to its engagement with the IMMA process in order to identify potential high risk areas.

Noting the potential threat of ghost gear to critically endangered species for which bycatch in active gear is the primary threat, the workshop identified in particular the vaquita (*Phocoena sinus)* as a species in a high risk that incidental mortality (bycatch) in gillnets will lead to its extinction. It therefore **strongly recommended** the continuation of the removal of ghost nets in its distribution area.

7. COMMUNICATIONS

7.1 Small group presentation
A small group presented on the issue of communications related to plastics pollution, focusing predominantly on consumer plastics rather than fisheries-related materials, which were covered elsewhere in the workshop. They highlighted the recent shift in public awareness on plastics pollution, giving examples of the 'Attenborough/Blue Planet Effect' and the viral images and videos of charismatic species interacting with marine debris as examples of tipping points in public awareness.

The presenters explained that as certain items have triggered awareness amongst the public, there has been a subsequent wave of product bans and community campaigns, e.g to ban straws locally. The group talked about how the activism and awareness has translated to a shift from companies and local municipalities to ban single use plastic items. They highlighted that campaigning can raise awareness, which can translate into industry and/or policy action, but questioned whether the most harmful/appropriate items are targeted through these actions. Often the 'easy wins' are the focus, rather than those causing the most harm in the marine environment. Also, misinformation, such as the lack of definitive degradation rates of various types of marine debris, was raised as an issue of concern in some campaign messaging.

The group talked about the statistics sometimes used in public awareness campaigning, e.g ‘more plastic than fish in the ocean by 2050’ and the usefulness of these types of statistics. For campaigners, concrete numbers, when grounded in science, are helpful for communication, though some participants remained sceptical about sharing statistics derived from highly variable and time-dependent models. Discussion about the need for clear, impactful communications to make the topic relevant and accessible cautioned the need to be clear about these statements.

The presenters talked about the zero-waste movement and plastic bans as promoted approaches for targeting consumers. Zero-waste living is not accessible for everyone, so there is a need to be clear that plastics do have useful applications, and audiences in various geographies will require specified, considerate messaging, but single use plastics are not acceptable for those who have easily accessible alternatives. Stopping plastic production completely is not likely to be a message that resonates, but targeting measures upstream in the supply chain (e.g through Extended Producer Responsibility) and restricting production could aid in addressing the challenges posed by this problem.

The group talked through tips for messaging and communication around behavioural change including:

- share the ‘do’ not the ‘don’t’;
- focus on one action/location/initiative;
- show images of the desired behaviour;
- show positive progress, give hope;
- represent your audience; and
- caution against doom and gloom, facts first.

The presenters summarised that with regards to public-facing campaigning, there has been a big shift in progressive policy that is grounded in both the awareness and the presence of solid data on which to base policy decisions. The European Single Use Plastics Directive is a good example of this. Science, education and activism must come together to inform policy.

The presentation also touched on the importance of engaging industry in effective solutions to the plastic pollution crisis. The presenters talked about the role of ‘brand auditing’ in identifying the major polluters and highlighted the predicted increase in plastic production over the coming decades.

The group talked about industry targets and sustainability commitments, which have recently gained attention - e.g. commitments to increase recovery and recycling. It is notable that often these commitments are not focused on a restriction or reduction in production. In terms of assessing the role of industry in advocating around plastic policy, the presenters noted the presence of industry lobbying in key fora where scientists and NGOs are also engaging. Typically, a reluctance to commit to legally binding targets, taxes or other producer responsibility schemes and a focus on voluntary measures forms the basis of advocacy; however, it is critical for plastics industry representatives to be a voice in marine debris efforts, as solutions cannot be reached without their input.

The group discussed the importance of collaborating with a range of stakeholders to inform local, national, regional and global policy and identify clear communications approaches, in addition to engaging with behavioural and social scientists to promote long-term, effective system change.

7.2 Discussion

The workshop noted that, in part due to the successful awareness campaigns of a number of organisations, there has been a significant increase in awareness of the marine debris issue, but still a huge amount is needed to translate these campaigns into action, particularly for addressing the issue at source. Participants stressed the value of promoting positive solutions - what can be changed, or realistically achieved (and for the public, what actions individuals can take) rather than focusing on what should not be done.

It was noted that the wider public will act on things directly in their control e.g. use of drinking straws and shopping bags, switch to multi use rather than single use items. On other things e.g. awareness and influence of actions needed by the fishing industry and wider issues to address plastics at source, there is much lower awareness.

Participants noted some challenges in advocacy, particularly for larger, more bureaucratic organisations and where there are complexities in the science. Lessons could perhaps be learnt from recent effective environmental campaigns - including those of organisations such as Extinction Rebellion. Whilst their actions were not necessarily condoned by all workshop participants, they have been successful in side-stepping bureaucracy and engaging directly with public, particularly a youth audience impatient, for action.

They further noted that marine debris and other environmental issues should be presented within the context of ‘one health’. Challenges posed by marine debris affect the health of animals, ecosystems and people and should be represented in this context.

It is noted that the IWC should consider its own specific role in communicating on marine debris- with regards to other IGOs and the public, as well as internally in communicating between its scientific and conservation committees and advocating its recommendations to member countries and other stakeholders (for which the new IWC database of recommendations will be useful). Messages and approaches will be different for different stakeholders. However, the discussions under this item highlighted some useful lessons for all organisations in communicating on this issue.

The workshop **recommended** that when communicating on the issue of marine debris, stakeholders should: (i) take into account the audience; (ii) be accurate about the underpinning scientific information and its limitations; (iii) emphasize upstream solutions in addition to end of life measures; (iv) consider consulting communication professionals or social scientists; and (v) wherever possible, focus on positive, actionable messaging.

8. CONCLUSIONS AND RECOMMENDATIONS

The workshop covered a wide range of issues related to: (i) the latest evidence on marine debris; (ii) methodologies for determining the extent of marine debris and its implications for cetacean conservation and welfare-including some detailed considerations for cetacean necropsy; and (iii) mitigation approaches for cetaceans. The conclusions and recommendations can be found highlighted in blue boxes under each agenda item.

9. ADOPTION OF THE REPORT

The Chair thanked all the participants for their hard work, high quality presentations and lively discussions during the workshop. The recommendations were reviewed and agreed during the workshop and the full report was adopted by correspondence on Friday 24th April 2020. The Chair in adopting the full report notes his thanks to Sarah Smith for acting as rapporteur and to Heidrun Frisch-Nwakanma for her assistance. He also thanks all the participants for taking part in what were stimulating and helpful discussions which should help not only the IWC take work forward on this topic but also help to address this global problem more robustly in the coming years.

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Annex 1

Agenda

1. Background

1.1 Review of contributions and recommendations from previous IWC workshops[1] and also recent work undertaken via CMS/ACCOBAMS/ASCOBANS, OSPAR and UNEP[2];

1.2 Review of new key information since last workshop[3] - to include information about whale entanglement in active and lost gear;

1.2 New information about the 'microdebris' threat; and

1.3 Consideration of lessons from other species (e.g. turtles and seabirds)

2. Methodologies

2.1 Discussion of how to best collect and collate scattered information from cetaceans (identified as a key issue and opportunity for the IWC workstream

2.2 Identification of 'best practice' in terms of protocols[4] for data collection, to include

a. Post-mortem investigations, including 'easy-to-collect' information from strandings and toxicology from plastic additives

b. Categorization of debris, including plastic types, microdebris and ghost gear

c. Consideration of extent of cetacean entanglement in debris versus entanglement in active gear

3. Consideration of specific mitigation approaches for cetaceans

a. Addressing 'ghost nets'

b. Addressing Fishing Aggregation Devices (FADs)

c. The role of litter streaming, clean-ups, recycling and biodegradables

d. Identification of species/populations under particular threat of marine debris (i.e. hot-spots)

e. Deep sea concerns

4. Research recommendations and identification of priorities.

a. Addressed to the IWC

b. Addressed to other bodies/more generally

c. Networking opportunities

5. Policy recommendations

a. Addressed to the IWC

b. Addressed to other bodies/more generally

c. Potential comment to World Marine Mammal Conference

d. Other outreach

e. Networking opportunities

Annex 2

Documents list

IWC/DEC19/MD/

01. George, J.C., Sheffield, G. and Suydam, R. Working paper on E Bering Sea bowhead entanglement (not for further distribution).

02. Smith, S. and Dixon, C. Review of recent Marine Debris work undertaken in other International Organisations.

03. Mazzariol, S., Povinelli, M., Corazzola, G., Marcer, F., Casalone, C., Grattarola, C., Mignone, W., Mancusi, C., Garibaldi, F., Baini, M., Panti, C. and Fossi, C. A novel meshes system prototype to examine the gastro-intestinal tract (GIT).

04. Mazzariol, S., Grattarola, C. and Casalone, C. An update on human induced mortality in the Italian waters (2015-2018): a focus on marine litter and ghost nets.

05. Mazzariol S., IJsseldijk L.L., Puig Lozano R., De La Fuente J. Evidence-based diagnostic assessment frameworks for cetacean necropsies on marine debris ingestion and common data collection.

Annex 3

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Annex 4

New Literature Concerning Marine Debris and Cetaceans

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Annex 5

Evidence-Based Diagnostic Assessment Frameworks for Cetacean Necropsies on Marine Debris Ingestion and Common Data Collection

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Interpreting post-mortem findings and evidences collected during a thorough necropsy, not limited to gross examination, needs specific skills and expertise. More in detail, these data should be elaborated by skilled professionals to properly hypothesize the possible cause, mechanism and manner of death.

A necropsy is a specialized medical procedure comprising of a thorough examination of a carcass by dissection with the aim to determine the likely cause of death. Sampling and testing should be complete and not be driven by any previous hypothesis or speculation; interpretation of evidences should be based on the best existing literature and protocols already published and/or used, ruling out any possible causes of death without bias. Even if it depends on the specific country's legal framework, post-mortem investigations with diagnostic aims should be conducted with the involvement of a veterinarian trained in animal pathology with an experience in marine mammal diseases.

In the present document, best practices and criteria associated with diagnoses of marine debris ingestion. These set of findings constitute an evidence-based diagnostic assessment framework and could support the interpretation of data and observations collected during a thorough and complete necropsy by a veterinary pathologist and/or a governmental veterinarian.

All the most relevant findings and diagnostic criteria reported in the most relevant literature will be summarized. The listed evidences should be interpreted with the results of the complete necropsy and all the other possible causes of death should be ruled out.

The ingestion of marine litter can occur in many cetacean species and the number of reports of foreign bodies found in the stomachs of stranded marine mammals is increasing. Despite these numbers, it should be noted that findings of plastic debris are not often deemed to be the main cause of stranding and are poorly reported in pathology literature. Recent papers published in the Canary Islands (Díaz-Delgado *et al.*, 2018; Puig-Lozano *et al.*, 2018) underline that only a few species seem to be lethally affected by plastic ingestion, with deep divers such as sperm whales and beaked whales more affected than others; young age and poor nutritional condition seems to be another relevant factor. With regards to the nutritional condition, it is not yet clear if it is a predisposing factor for the ingestion of marine litter, or a consequence thereof.

While, during necropsy, it is easy to state the possible ingestion of marine debris, it is more difficult to assess the impact it has on the animal's health.

While entanglement could be hypothesized in tier 1 by reporting external evidences and poor body condition, marine debris ingestion could be assessed since tier 2: data and information collected could be useful to evaluate marine debris ingestion in the area from different species. In this case the following common information should be collected and evaluated (see next page):

Table 1

Data collection for tier 2 postmortem examination.

Data requested	**To be filled by personnel**
Species	name of the species
Gender	F/M
Age estimation	newborn/calf/juvenile/adult
DCC	1-5
Marine debris ingestión	Y/N
Type of object	Use INDICIT/MFSD
Size	surface, volume
Weight	g
Colours	describe different colors
Pictures	Y/N
Samples	according to Best practice document
Necropsy tier 3	Y/N
GIT associated pathology	from necropsy report
Cause of death	from necropsy report

In tiers 3, the pathological findings summarized in Table 2 below could be observed, alone or associated with evidences of marine debris ingestion and they can support the interpretation of the pathologist in the assessment of the cause of death during the complete necropsy.

Table 2

Postmortem findings associated to marine debris ingestion during necropsy (tier 3).

<table>
<tr><td colspan="3">Moderate-severe presence of marine debris in the GIT could be consistent with:</td></tr>
<tr><td>Postmortem interpretation</td><td>Postmortem findings</td><td>Notes</td></tr>
<tr><td>Incidental finding</td><td>Limited / moderate amount of marine debris without lesion associated with the foreign body</td><td>The volume and location of the debris should be evaluated</td></tr>
<tr><td>Possible contribution to the cause of death and/or deterioration of health condition*</td><td>Partial repletion or obstruction with moderate-severe presence of lesion associated with the foreign body (e.g.: ulcerations, hyperkeratosis of the forestomach, gastritis and/or enteritis, haemorrages, etc.)</td><td rowspan="2">It is necessary to interpret in the general context of the postmortem study (necropsy and histopathology, as well as complementary analyzes if needed), and exclude other possible causes of death</td></tr>
<tr><td>Probable cause of death</td><td>Traumatic perforation, severe impaction or complete obstruction of GIT with severe presence of lesion associated (e.g.: ischemia, necrosis, perforation, peritonitis, etc.)</td></tr>
<tr><td colspan="3">* Long-term pathological processes can cause or increase the possibility of presenting of other secondary processes like infectious diseases, parasitic infestation and / or signs of malnutrition or starvation (poor - very poor body condition, serous atrophy of fatty deposits, muscular atrophy, pancreatic acinar atrophy, etc.)</td></tr>
</table>

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Annex 6

Key terms used in post-mortems

DISSECTION/PROSECTION: Medical and/or biological procedure to dismember the body of a deceased animal according to specific protocols in order to study its anatomical structure and/or to evaluate and sample specific organs and tissues.

NECROPSY/AUTOPSY/POST-MORTEM/POST-MORTEM EXAMINATION: Synonyms for a specialised medical procedure comprising of a thorough examination of a carcass by dissection to determine the cause, the mechanism and manner of death through the collection of evidence. In the case of wild animals this requires the involvement of a veterinary pathologist or a veterinarian with specific training in animal pathology, diseases and assessment of health.

POST-MORTEM INVESTIGATIONS: All studies and investigations carried out on an animal's carcass and/or samples taken after death, including those aimed to determine the cause of death.

HEALTH STATUS: Subjective assessment of diseases, conditions, or injuries that not only contributed to the proximal cause of death but which characterize the ante-mortem health status of the individual and the possible health status of cohort animals.

CAUSE OF DEATH/STRANDING: The disease, injury or abnormality that alone or in combination with other factors (environmental, other concurrent diseases, age, etc.) is responsible for initiating the sequence of functional disturbances that resulted in live stranding and death. In the case of an aquatic animal stranded on shore, the post-mortem investigation is aimed to determine the cause of stranding.

MECHANISM OF DEATH: The immediate physiologic derangement resulting in death. A particular mechanism of death can be produced by a variety of different causes of death.