Agenda Item 4.5 — Review of New Information on Threats to Small Cetaceans

Pollution

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An update on research into marine debris and cetaceans

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Sarah Baulch & Mark P. Simmonds

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An update on research into marine debris and cetaceans

Sarah Baulch[1] and Mark P. Simmonds[2]

1. Environmental Investigation Agency (EIA), 62-63 Upper Street, London N1 0NY, UK. Contact: sarahbaulch@eia-international.org.
2. Humane Society International, c/o 5 Underwood Street, London N1 7LY,UK and School of Veterinary Sciences, University of Bristol, Langford House, Langford, North Somerset BS40 5DU. Contact: mark.simmonds@sciengyre.co.uk

Abstract

Further to recent reviews of marine debris as it may affect cetaceans, we provide an update of more recent information. This includes further evidence of accumulation of marine debris in the oceans and biota, and the first direct observation of ingestion of microplastics by a mysticete and an odontocete species. Future research priorities are proposed, including identification of hotspots of interaction between cetaceans and debris, better collation of data on rates and impacts of debris ingestion or entanglement in stranded and bycaught cetaceans, and development of methods to determine when whether fishing gear was active or not when entanglement occurred.

Introduction

With marine debris now widely recognised as a major threat to marine biodiversity (e.g. CBD, 2012), marine debris research represents a rapidly evolving field, although action to prevent marine debris appears to be developing less expeditiously. Studies have documented at least 690 species that have ingested or been entangled in marine debris, with at least 17% of species affected listed as threatened or near threatened (Gall & Thompson, 2015). Plastic available to enter the ocean from land is predicted to increase by an order of magnitude by 2025 (Jambeck *et al*., 2015) and, although population level impacts remain difficult to determine (Simmonds, 2012; Baulch & Perry, 2014; Browne *et al*., 2015), particularly where marine debris combines with other anthropogenic stressors it may affect populations, trophic interactions and assemblages (Gall & Thompson, 2015).

The two recent IWC workshops on marine debris highlighted a number of recommendations for further research, including: improved data collection on the rates and impacts of debris interactions in stranded animals, further non-lethal research on the impacts of microplastics, development of methods to distinguish gear that was operational versus gear that was abandoned at the time of entanglement, mitigation approaches and identification of high risk areas and populations using ecological risk assessment methods in order to identify priorities for mitigating and managing the impacts of marine debris on cetaceans (IWC, 2013, 2014). This paper highlights some new relevant research, new case studies of debris ingestion by cetaceans and developments in understanding of the uptake and impacts of microplastics on cetaceans and other marine fauna.

Distribution and quantities of debris

There remain many gaps in knowledge regarding the global quantity and distribution of marine debris, as well as the relative contribution of different point sources. However, there have been significant advances in knowledge during the last few years, with better quantification and mapping of the occurrence of plastic debris on coastlines, in Arctic Sea ice, at the sea surface and on the sea floor (Cózar *et al*., 2014; Obbard *et al*., 2014; Woodall *et al*., 2014).

Global plastic resin production has increased 620% since 1975, with the largest market sector being packaging – single-use materials designed for immediate disposal (Jambeck *et al*., 2015). New estimates of plastic waste inputs from land indicate that 275 million metric tons (MT) of plastic waste was generated in 192 coastal countries in 2010, with 4.8 – 12.7 million MT entering the ocean (Jambeck *et al*., 2015). Without improvements in waste management, the cumulative quantity of plastic available to enter the ocean from land is predicted to increase by an order of magnitude by 2025. There remain no current global estimates for other sources, such as losses from fisheries, shipping and other commercial vessels.

Based on regional surveys, estimates of the global load of plastic on the open ocean surface have now been generated and are in the order of tens of thousands of tons, 100-fold lower than expected based on conservative estimates of plastic released into the ocean from terrestrial sources (Cózar *et al*., 2014). Evidence indicates size-selective sinks, particularly removing millimetre-sized fragments from the ocean surface on a large scale, potentially through nano-fragmentation, transference into food webs or processes not yet discovered. Floating debris was found to be largely accumulating in the convergence zones of the five subtropical gyres, with comparable density (Cózar *et al*., 2014). Deep-sea sediments have since been identified as a likely sink for microplastics, with samples from the Atlantic Ocean, Mediterranean Sea and Indian Ocean containing abundances of microplastics (particularly in the form of fibres) up to four orders of magnitude greater than in surface waters (Woodall *et al*., 2014)

New research in 2014 found that Arctic Sea ice also contains concentrations of microplastic several orders of magnitude greater than those reported in debris hotspots such as the Pacific Gyre (Obbard *et al*., 2014). Historically representing a major sink of man-made particulates, polar sea ice now represents a significant source of microplastics that may be released back into the ocean as the extent of sea ice melting increases with climate change. With regards to the relative abundance of microplastics, studies in the Austrian Danube river found the abundance and mass of plastics to be higher than that of larval fish, with industrial raw material accounting for 79% of the estimated input of 4.2 tonnes per day in to the Black Sea (Lechner *et al*., 2014).

Regional surveys of sea-floor debris show differences in the type and density of debris in different areas and at different depths. Surveys of the Gorringe Bank, which lies between the Atlantic and Mediterranean and is characterised by intense maritime traffic and fishing, show a high frequency of lost or discarded fishing gear at 60-3015m depths (Vieira *et al*., 2014). A survey of European seas found litter in remote deep-sea areas, with the highest density in submarine canyons, and the lowest on continental shelves and ocean ridges (Pham *et al*., 2014). Plastic was the most prevalent component, with litter from fishing activities particularly common on seamounts, banks, mounds and ocean ridges.

Although there are no global estimates of fishing gear loss or discarding, increasingly there are regional estimates, for example in South Korea it is estimated 11,436 tonnes of traps and 38,535 tonnes of gill-nets are abandoned annually (Kim & Moon, 2014), whilst in the Florida Keys National Marine Sanctuary it is estimated that 85,548±23,387 (mean±SD) ghost traps and 1,056,127±124,919 non-fishing traps or remnants of traps were present in the study area (Uhrin *et al*., 2013). This was attributed to the large numbers of traps in the fishery and the lack of effective measures for managing and controlling the loss of gear (Uhrin *et al*., 2013). Researchers conclude that certain areas of the seafloor may form focal points for litter due to topography, currents, fishing grounds or shipping lanes (Wei *et al*., 2012).

Impacts of debris

The recently published reviews of the impacts of marine debris on cetaceans (Simmonds, 2012; Baulch & Perry, 2014) found that ingestion of debris has been documented in 48 (56% of) cetacean species, with rates of ingestion as high as 31% in some populations. Strandings indicated potential debris-induced mortality rates of 0–22% in some populations, though sample sizes were small, limiting the accuracy of such estimates. There are few publications documenting cases of entanglement in debris and this may, in part, relate to the difficulties involved in distinguishing whether gear was operational or discarded/lost at the time of entanglement. There has been an increase in the number of cases of ingestion and entanglement reported per decade (see Figure 1) ; however, data on changes in necropsy and reporting effort over this period are needed to determine the degree to which this represents an increase in interaction rates (Baulch & Perry, 2014). Generally, it remains true that data on rates of debris ingestion or entanglement and debris-induced pathology and mortality in stranded animals remain very limited, preventing better understanding of the relative impact of marine debris on cetacean populations.

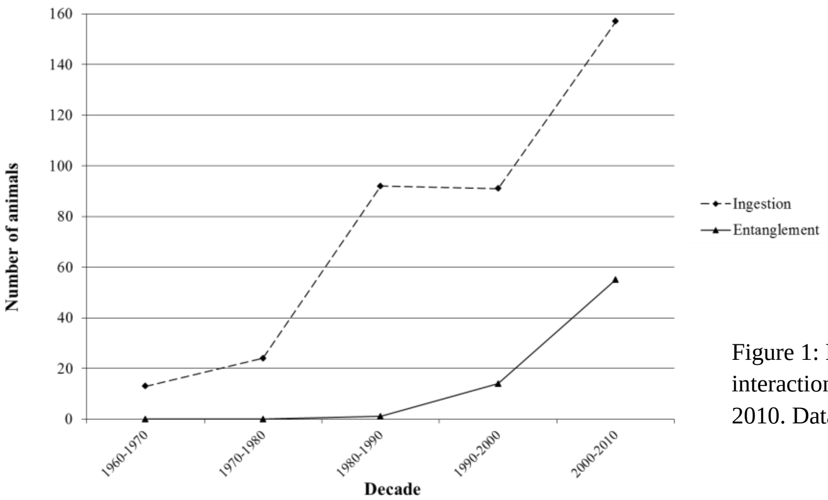

Figure 1: Number of documented debris interactions involving cetaceans from 1960 to 2010. Data from Baulch & Perry (2014).

In 2014 and 2015, new cases of ingestion have been published and the uptake and impacts of microplastics have been investigated in a range of marine fauna, including cetaceans. Recently published cases of debris ingestion by cetaceans include a Longman's beaked whale (*Indopacetus pacificus*) which stranded on the Saurashtra coast, India which was presumed to have been killed by the ingestion of four plastic bags, which blocked the passage of food to the intestine (Kaladharan *et al*., 2014). In a rare stranding of True's beaked whales (*Mesopledon mirus*) in Ireland, macroplastic items were identified in the stomachs of both the adults, though not in quantities likely to cause satiation and with no signs of malnutrition (Lusher *et al*., 2015). A comparison of debris ingestion in two coastal species in Brazil, Franciscana (*Pontoporia blainvillei*) and Guiana dolphin (*Sotalia guianensis*) found that prevalence of debris ingestion was higher in Franciscana (15.7% compared to 1.3% in *Sotalia guianensis*), a trend attributed to the feeding activity of Franciscana, which mainly feeds near the sea bed, the main zone of accumulation of debris in the study area (Di Beneditto *et al*., 2014a, b).

Difficulties remain in linking the effects of debris at a physiological or individual level to population level impacts (Browne *et al*., 2015). Relatively few studies demonstrate that death was due to the material ingested and there is rarely any information about how representative cases are of populations, and therefore no indication of any population level impact or its magnitude (Browne *et al*., 2015). While individual strandings cases provide important insights into the physiological impacts of debris, there is a clear need to better understand the actual and potential consequences for populations. Browne *et al*. (2015) show that microplastics reduce the 'health', feeding, growth and survival of 'ecosystem engineers' and that larger debris alters assemblages. The study also explores methods to assess the likelihood of impacts where there is an absence of data, through synthesizing studies and the use of population models to examine ecological impacts and linkages.

Until recently, the work of Fossi *et al*. (2014) on the Mediterranean fin whale (*Balenoptera physalus*) was the only indication of microplastic ingestion by cetaceans. In the last two years microplastic ingestion has been identified in two further species. Firstly, microplastics were recorded in the stomach of a single stranded True's beaked whale that was examined for their presence (Lusher *et al*., 2015). This was the first study to directly identify microplastics in a cetacean species, applying a new technique for the detection and identification of microplastics in the digestive tract (Lusher *et al*., 2015. It was not possible to ascertain the source of microplastics, with possible routes being ingestion from the water column while feeding, inhalation at the air-water interface or via trophic transfer from prey items – the latter being identified as the more likely route of exposure for this species. Microplastics were found throughout the intestine suggesting egestion might be occurring, as has been observed in seals. Given the paucity of data on the frequency and impacts of microplastic ingestion by cetaceans, this study represents an important step forward in developing methods to identify microplastic ingestion in stranded animals.

A similar study of a stranded humpback whale (*Megaptera novaeangliae*) also recorded the presence of microplastic in the intestines. This is the first time this has been confirmed in a baleen whale. Fragments included sheets, fragments and threads with a size of 1mm to 17cm, and from analysis of a section of the gastrointestinal tract, it was estimated that the gut would contain up to 160 small particles or a volume of up to 137 mm^3 (Besseling *et al*., 2015). Besseling *et al*. (2015) suggested that microplastic ingestion may be lower in humpbacks than other baleen whales due to their lunge feeding behaviour compared to baleen species that skim water or sediment when feeding.

Studies of microplastic exposure have also continued in Mediterranean fin whales. Using phthalates (a common plastic additive which leaches from plastic debris) as a tracer of microplastic uptake, Fossi *et al*. (2014) found that concentrations of the phthalate metabolite and organochlorines were markedly higher in the fin whale compared to the basking shark. They attributed this to a difference in the total plankton consumed daily and excretory activity, in particular the potential excretion of such contaminants through the gills in fish versus bioaccumulation in adipose tissue in cetaceans. The mean abundance of microplastics in the Pelagos Sanctuary in the Mediterranean was found to be of the same order of magnitude as that in the North Pacific Gyre, with particularly high levels in the Ligurian Sea and it is hypothesized that fin whales could consume 3,653 microplastic particles per day, along with associated persistent, bioaccumulative and toxic (PBT) chemicals (Fossi *et al*., 2014).

Although the impact of microplastic ingestion by cetaceans is not yet well understood, there is increasing evidence of their uptake and impacts in a range of other species. As well as direct uptake of microplastics from the water column, cetaceans may also ingest microplastics and associated PBT chemicals via prey species. Uptake of microplastics has been recently demonstrated in zooplankton (Frias *et al*., 2014; Setälä *et al*., 2014), shellfish (Van Cauwenberghe & Janssen, 2014), benthic organisms (Browne *et al*., 2013; Besseling *et al*., 2013), planktivorous fish (Boerger *et al*., 2010) and pelagic and demersal fish (Lusher *et al*., 2012) and may be retained in the gut, translocate into tissues or excreted (Browne *et al*., 2008; Wright *et al*., 2013). Once ingested, microplastics may cause physical harm or increase contaminant loads, either through the leaching of chemical additives or the release of PBT chemicals which concentrate on plastics in sea water and are then transported into the food chain where they may bioaccumulate. Impacts recorded thus far in a range of marine fauna include effects on feeding activity, survival, growth, metabolism, behaviour and reproduction (Besseling *et al*., 2014; Mattsson *et al*., 2015; Rochman *et al*., 2014; Wright *et al*., 2013). Ingestion of microplastics by individual organisms at lower trophic levels could have consequences for organisms at high trophic levels if contaminants that are transferred have the potential for biomagnification (Teuten *et al*., 2009).

Conclusions and recommendations

The latest information provided here builds on the concerns expressed in the earlier reviews that marine debris poses a growing threat to cetaceans and other species. This is supported by both information concerning growing quantities in the marine environment and further evidence of exposure of cetaceans to macro- and micro-debris.

There are now numerous recorded incidents where ingested debris has caused pathology. However, overall the relevant data are generally scattered and often remain unpublished (Simmonds, 2012). The importance of full necropsies of stranded and bycaught cetaceans in order to investigate this issue is apparent and likewise, as highlighted by the IWC workshops on marine debris, the desirability of developing approaches to determine if fishing gear was active or discarded when entanglement occurred. There remains a need to compile individual records that may previously have been deemed unsuitable for publication and to assess rates of debris impacts in stranded and bycaught cetaceans in order to give an indication of population level impacts (Simmonds, 2012; Baulch & Perry, 2014). We also reiterate the recommendation that further consideration should be given to where vulnerable cetaceans and marine debris may be converging—for example, the deep water canyons used as core habitat by beaked whales, and to the further investigation of the impacts of microplastics.

In summary, based mainly on the recommendations of the two recent IWC workshops on marine debris, research priorities could include:

- Dissemination of standard necropsy protocols to support collection of data on marine debris ingestion/entanglement (see for example those developed by the first IWC debris workshop);
- Collation of rates of debris ingestion and entanglements in stranded/bycaught cetaceans via national progress reports (and/or other mechanisms) and addition to a suitable database (this might be combined with the large whale entanglement database – see also the report of the Provincetown Entanglement workshop held in 2015[1]);
- Further development and application of methods to determine whether fishing gear was active or discarded when entanglement occurred;
- Analysis to identify potential hotspot areas for cetacean entanglement and ingestion of marine debris, for example through ecological risk assessment methods or other mapping and modelling approaches; and
- Further investigation of the impacts of debris ingestion and entanglement at an individual and population level, including that of microplastics.

Finally, marine debris - and in particular plastics waste – should, as urged by Rochman et al. (2013), be re-appraised, recognised as a dangerous form of pollution and addressed as such. A determined and coordinated international effort will help to inform people of the true nature of this threat to conservation, fisheries and ecosystem stability. The time for dumping wastes directly into marine systems or allowing it to make its way there, as a result of inadequate controls and policies, has ended.

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[1] This workshop report was not available at the time of submission of this paper but will be submitted to the 2015 Scientific Committee.

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