Report of the 2013 IWC Scientific Committee workshop on Marine Debris

1. Introductory items

1.1 Welcome and Opening Remarks

The workshop was held from 13-17 May 2013 at the Quissett Campus of the Woods Hole Oceanographic Institution (WHOI). The first day was a public seminar consisting of a number of keynote presentations and question and answer sessions.

Michael Moore, the Director of the Marine Mammal Center at WHOI welcomed everyone. He gave a brief description of the Woods Hole scientific community and noted that Woods Hole village had been a small whaling port, with the old spermaceti factory extant, and still known as the Candle House.

Mark Simmonds, as workshop convener, thanked Michael and WHOI for hosting the workshop and everyone for coming. He commented that the old adage that things at sea tend to go on out of sight and out of mind certainly applied to a significant extent to marine debris. However, whale entanglement was a well-known phenomenon in this part of the USA and one that many here were working hard to respond to. He added that this is an historic meeting. Both the IWC and the Woods Hole Oceanographic Institution were born long ago (the IWC in 1949 and WHOI in 1930). Both are concerned with marine conservation but this the first time that they have joined together in an initiative, and the first time that the IWC had held a public seminar. He then thanked all the sponsors of the IWC's work on marine debris, including Oceancare, the World Society for the Protection of Animals, the US National Oceanic and Atmospheric Administration(NOAA), the United Kingdom, the Environmental Investigation Agency (EIA), Humane Society International and the WHOI Marine Mammal Center.

A list of attendees is provided at Appendix One.

1.2 Procedural Matters

Simmonds was elected as Chair and Baulch, Brockington, Hudak, Rosa, Saez and Thiele were appointed as rapporteurs.

The adopted agenda is given in Appendix Two

Review of documents: Simmonds drew attention to the documents which had been submitted to the workshop and were available through the IWC's document management website.

2. Keynote Presentations

2.1 Introduction to the work of the International Whaling Commission on environmental issues.

Simon Brockington, Executive Secretary of the IWC, introduced the range of environmental work being undertaken by the Commission. In particular, he highlighted progress to coordinate national programmes established to respond to whales entangled in marine debris. The IWC strives to facilitate a co-ordinated, global capacity for responding to entangled whales, where apprentices from more than 15 countries have already been trained in safe disentanglement procedures. Other environmental work includes development of measures to

reduce incidents of ship strikes, development of guidelines for sustainable whale watch operations and a range of dedicated conservation projects for small cetaceans.

The IWC recently introduced Conservation Management Plans (CMPs) as a practical tool to co-ordinate the diverse work being undertaken. To date, three CMPs have been prepared: one for gray whales *Eschrichtius robustus* in the western North Pacific, and two for southern right whales *Eubalaena australis* on the east and west coasts of South America. Additional plans are currently being developed. The successful implementation of the CMPs will depend on continued and increased partnership working between range states and the full range of stakeholder organisations.

2.2 Marine Debris in our oceans – an overview

Nancy Wallace, Marine Debris Programme (MDP) Director and Division Chief, US National Oceanic and Atmospheric Administration (NOAA) provided an introduction to the issues arising from marine debris in the world's oceans. The MDP was formed in 2006 after passage of the Marine Debris Research, Prevention and Reduction Act.

Wallace noted that, in 2006, Senator Daniel Inouye of Hawaii stood on the floor of the Senate chamber and introduced a bill he felt very passionate about; one that focused on a problem that he felt went unnoticed. That problem was marine debris. He said: "From the shore, our oceans seem vast and limitless, but I fear that we often overlook the impacts our actions have on the sea and its resources. In a high-tech era of radiation, carcinogenic chemicals, and human-induced climate change, the problem of the trash produced by ocean-going vessels and dumped at sea must seem old-fashioned by comparison. Sea garbage would seem to be a simple issue that surely cannot rise to the priority level of the stresses our 21st century civilization places on the natural environment. Regrettably, that perception is wrong. While marine debris includes conventional 'trash', it also includes a vast array of additional materials. It is discarded fishing nets and gear. It is cargo washed overboard. It is abandoned equipment from our commercial fleets. Nor does the 'low-tech'' nature of solid refuse diminish its deadly impact on the creatures of the sea. Dead is dead--whether an animal dies from an immune system weakened by toxic chemicals, or drowns entangled in a discarded fishing net." Senator Inouye proposed giving the United States the tools it needed to develop effective marine debris prevention and removal programs, and with that, the NOAA Marine Debris Program was formed.

Marine debris is a global problem, and it is an everyday problem. There is no part of the world that is untouched by debris and its impacts. It is pervasive, it is an eyesore, and it harms our natural resources. Marine debris is a threat to our environment, navigation safety, the economy, and human health.

Derelict fishing gear is a major marine debris issue that has a profound impact on natural resources. Discarded nets, rope, and monofilament fishing line continue to fish even as they drift through the ocean. They can entangle animals, maim them, or prevent them from hunting food. Lost or discarded traps and pots can continue to entrap animals for years after they are lost adding to resource and economic losses. Both primary sources and secondary sources of plastic are another major issue related to marine debris. Plastics can be ingested by marine life and can lead to starvation and death. There are also many questions related to the chemical impacts of plastics and research is underway to address these.

A majority of marine debris can be prevented but some cannot. Natural disasters such as Hurricane Katrina, the 2009 tsunami in American Samoa and the 2011 tsunami in Japan are examples of events that led to substantial amounts of debris entering the ocean. Working with federal, state, and local partners to implement response plans help to mitigate impacts from this type of debris.

While there are many challenges related to marine debris, there are also many efforts to reduce the impacts. The NOAA Marine Debris Program has established a presence throughout the United States and has formed partnerships with local organizations to carry out removal and prevention projects. As well, research projects are underway to address the impacts of microplastics and derelict fishing gear on marine life, and to understand the economic impacts of marine debris. Examples of these projects can be found at www.marinedebris.noaa.gov. Interagency collaboration is mandated by the Marine Debris Act and NOAA works very closely with US agencies such as the Environmental Protection Agency, the Department of Interior, and the Department of Defense, the US Coast Guard, the Department of State, as well as other federal agencies.

Marine debris is a global problem and solutions must be at the global level. Two years ago, NOAA, the United Nations Environment Programme, and stakeholders from all over the globe came together to draft the Honolulu Strategy1,, a global strategy for reducing marine debris.

2.3 Cetacean entanglement: detection and impacts

Michael Moore noted that entanglement of cetaceans can involve peracute underwater entrapment, or chronic debilitation, lameness, impaired gait, chronic infection, host immune responses and ultimately death. This usually begins by entanglement in actively fished gear, whereas debris is discarded material floating, in the water column or on the bottom. Where active gear is torn away by the power of the animal, or the entangled animal is cut out from the gear by the fisher, it could be defined at that point as debris. Fishing gear consists of rope, traps and floats from fixed trap fisheries, especially lobster gear, gillnet and its associated ropes and floats, monofilament and braided hook and line fishing gear, and mobile trawl gear. On the eastern seaboard of the United States and Canada, large whales (van der Hoop *et al*., 2013a), dolphins, porpoises and seals all get entangled in fishing gear. An annual average of 2,773 whales, dolphins and seals died in fishing gear in the NW Atlantic waters of the United States for the period 2005 to 2009 (http://www.nefsc.noaa.gov/nefsc/publications/tm/tm213/). Relocation of floating whale carcasses at sea has been successful using drift forecasts by the US Coast Guard SAR plot model assuming the carcass is a 70% submerged 40' container drift paradigm.

Entangled cetaceans can become asphyxiated when entrapped below the surface of the water; if the animal can surface, it can remain anchored in place, or if it is cut free or can break away, the result may be chronic entanglement, with resultant laceration, incision, constriction, feeding impairment, increased drag (van der Hoop *et al*., 2013b), loss of body condition, bony proliferation, infection and ultimate death (Cassoff *et al*., 2011). The timing of death can be minutes to years after the initial event (Moore *et al*., 2006). The symptoms can include acute distress in whales that cannot surface and therefore drown at some point soon after the normal dive duration, which ranges from minutes to more than an hour in the case of some whales. Chronic cases presumably suffer from severe and chronic pain (Moore and van der Hoop, 2012). Diagnosis of acute drowning entanglement often involves subtle surface markings from the gear, airway froth and systemic congestion, suggestive of a terminal struggle (Moore *et al*., 2013). Chronic entanglement cases often exhibit resultant wounds and emaciation. Mitigation can include reactive disentanglement on a case-by-case basis, which may be valuable for critically endangered species. This may include large whale disentanglement programs, with substantial tool innovation, which could perhaps be enhanced by available at-sea sedation techniques (Moore *et al*., 2010). Low impact tagging systems to enhance relocation of entangled animals would also enhance disentanglement response. Major challenges to addressing the issue of cetacean entanglement in fishing gear include: 1) cost to

[1] http://marinedebris.noaa.gov/projects/pdfs/HonoluluStrategy.pdf

the fishing industry of poorly tested but mandated gear modifications, or seasonal and area closures; 2) poor detection and reporting of entangled animals; and 3) competing agendas in terms of other regulatory priorities for fishing industry goals and stock management. Most efforts to reduce marine mammal entanglement have been driven by concerns over species and stock survival. There seems to be minimal legal or popular motivation to reduce these very serious welfare concerns for the sake of the individual animal. The welfare status of all cetaceans should be independent of their conservation status. For most whales, actively fished gear is the primary entanglement problem. Ingestion of macrodebris is a problem at least for sperm whales, *Physeter macrocephalus*. Mitigating debris interactions is politically easier than mitigating interactions between cetaceans and actively fished gear – hence the focus may be on the former when the latter may be the bigger problem.

2.4 Cetacean entanglement: scope and response

David Mattila, a technical adviser to the International Whaling Commission, noted that the IWC has a long history of investigating the scope and impacts of large whale entanglement, through the Human Induced Mortality (formerly Bycatch) working group of its Scientific Committee. Additionally, recent findings concerning both the welfare and conservation impacts of entanglement have brought the topic to the attention of both the Commission's Whale Killing and Associated Welfare Issues working group and its Conservation Committee. While the extent to which marine debris may contribute to cetacean entanglements is not fully understood, the impacts and potential responses once entangled are largely the same. In response to the growing awareness of the impacts of entanglement, Australia, Norway and the USA convened an IWC-endorsed workshop of experts on the topic (Maui, 2010). The workshop reviewed the scope, impacts and potential responses to large whale entanglement, and found that all large whales can become entangled anywhere in the world's oceans where they encounter rope and net in the water column (IWC/62/15). With respect to understanding whether entangling ropes and nets were in active use or not when entanglement occurred, it was noted that a large percentage of the materials removed are reported as being of "unknown" origin and only in a few instances (e.g. less than 5%), are the materials determined to have been lost, abandoned or otherwise discarded, prior to entanglement. However, given a current review of gear loss and continued ghost fishing, in some regions it may account for up to 30% of entanglements (Mattila and Lyman, 2006). In addition, given the cryptic nature of the entanglement events and the general lack of reporting infrastructure, it is generally agreed that the numbers of entanglements are widely and severely under-reported. The Maui 2010 workshop therefore recommended capacity building on the topic, better data collection, and ultimately prevention. In response to the Commission's endorsement of this report and its recommendations, the USA seconded a technical expert (Mattila) to the IWC Secretariat to focus on advancing work on this topic.

Given the strong recommendation for capacity building, a second IWC workshop was convened (Provincetown, 2011) to develop principles and guidelines for response to entangled whales, as well as a strategy and curriculum for capacity building (IWC/64/WKM&AWIRep1)2. In the 18 months since that workshop, the IWC entanglement response capacity building initiative has reached approximately 500 responders, managers and scientists, in 20 different countries. The capacity building curriculum includes exposure to techniques and methodologies for investigating the causes, scope and impact of large whale entanglements, including in marine debris, as well as current information on attempts to prevent it. During both conceptual and practical training, the consensus principles and guidelines are stressed, including human safety, animal welfare, and the collection of information about the whale and the entangling materials, which will ultimately be used to inform mitigation.

[2] http://archive.iwcoffice.org/_documents/commission/IWC64docs/64-WKM&AWI%20Rep%201.pdf

2.5 Microplastics

Cristina Fossi of the University of Siena reported that microplastics, plastic fragments smaller than 5 mm, is an emerging issue for cetaceans. The impacts of microplastics on baleen whales that are potentially ingested by filter-feeding activity, are largely unknown.

Fossi presented a case study on the fin whale, *Balaenoptera physalus*, in the Mediterranean Sea, one of the largest filter feeders in the world. These whales feed primarily on planktonic euphausiid species. With each mouthful, fin whales can trap approximately 70,000 litres of water, and their feeding activities include surface feeding. They could therefore face risks caused by the ingestion and degradation of microplastics. Micro-debris3 can be a significant source of lipophilic chemicals (primarily persistent organic pollutants – POPs) and a source of pollutants such as polyethylene, polypropylene and, particularly, phthalates. These chemical pollutants can potentially affect marine organisms and are potential endocrine disruptors.

This study, supported by the Italian Ministry for the Environment, is the first evidence of the potential toxicological impact of microplastics in a baleen whale and suggests the use of phthalates as a tracer of the intake of microplastics through the ingestion of microdebris and plankton. The toxicological effects of microplastics on fin whales were studied comparing two populations living in areas characterized by different human pressure: the Pelagos Sanctuary (Mediterranean Sea, Italy and France) and the Sea of Cortez (Mexico). The work was implemented through four steps: 1) collection/count of microplastics in the Pelagos Sanctuary (Mediterranean Sea); 2) detection of phthalates in superficial neustonic/planktonic samples; 3) the detection of phthalates in Mediterranean stranded fin whales; and finally 4) the detection of phthalates and biomarker responses (CYP1A1, CYP2B, lipid peroxidation) in skin biopsies of fin whales collected in the Pelagos Sanctuary and Sea of Cortez.

A high presence of plastic particles with high concentration of phthalates (Di(2-ethylhexyl)phthalate or DEHP and Mono(2-ethylhexyl) phthalate or MEHP) has been detected in superficial neustonic/planktonic samples collected in the Pelagos Sanctuary areas that were investigated (mean value 0.62 items/m^3). As well, MEHP concentrations were detected (57.9 ng/g) for the first time in blubber samples of five stranded fin whales collected along the Italian coasts. Finally, relevant concentrations of MEHP and elevated biomarker responses (CYP1A1, CYP2B, lipid peroxidation) were detected in the skin biopsies of fin whales collected in the Mediterranean areas in comparison to the specimens from whales in the Sea of Cortez. The results of this study support a strategy of using phthalates as a tracer of microplastics consumption in fin whales, and represent a warning signal for this emerging threat in baleen whales.

These preliminary investigations underscore the importance of future research on the detection of the toxicological impact of microplastics in filter-feeding species such as mysticete cetaceans, the basking shark and the devil ray. These results also underscore the potential use of these species in the implementation of Descriptor 10 (marine litter) in the European Union (EU) Marine Strategy Framework Directive as indicators of the presence and impact of micro-litter in the pelagic environment.

2.6 Closing the loop: Repackaging plastic debris as a hazardous substance

Mark Browne, of the National Center for Ecological Assessment and Synthesis (NCEAS), University of California, Santa Barbara, suggested that the policies for managing plastic waste were out dated and threatened the health of people and wildlife. Plastic debris can physically

[3] Throughout this document we use the following definitions: microdebris refers to plastic particles smaller than 5mm and macrodebris to plastic particles greater than 5mm

harm wildlife and many plastics can be chemically harmful in certain contexts. In 2012, 280 million tonnes of plastic were produced globally, less than half of which was consigned to landfill or recycled. Yet in the United States, Europe, Australia and Japan, plastics are classified as solid waste, and are therefore treated in the same way as food scraps or grass clippings. If countries classified the most harmful plastics as hazardous, their environmental agencies would have the power to restore affected habitats and prevent more dangerous debris from accumulating. If current rates of consumption continue, the planet will hold another 33 billion tonnes of plastic by 2050, filling about 2.75 billion standard rubbish-collection trucks. This could be reduced to just 4 billion tonnes if the most problematic plastics (e.g. polyvinyl chloride or PVC, polystyrene, polyurethane, polycarbonate) are classified as hazardous immediately and replaced with safer, reusable materials in the next decade.

2.7 Overview of cetacean interactions with marine debris

Sarah Baulch, of EIA, presented results from a literature review of published and unpublished data on debris interactions involving cetaceans. This review found that entanglement and ingestion interactions have been recorded in 46 cetacean species, equivalent to 53% of all cetacean species. The majority of records are from one-off stranding events, which represent a small but unknown proportion of interactions occurring unobserved at sea. Furthermore, there is much data that remains unpublished.

Baulch's review found that in the cases collated, items ingested were most commonly plastic (54%), with fishing gear comprising 20.7% and miscellaneous or unidentified items constituting the remainder (25.3%). Almost all of the entanglements in debris documented were caused by lost fishing gear (97%). The review indicated that ingestion of marine debris occurs in a large number of cetacean species (7 mysticete and 35 odontocete species) that employ a variety of foraging strategies at different levels of the water column. There appears to have been an increase in the number of cases reported per decade, with more than a seven-fold increase in the number of reported ingestion events in the last 50 years. As well, there has been an increase in the number of cetacean species that have been recorded ingesting debris. It is not clear to what extent the increase in records may be evidence of an increasing problem or whether it reflects increased detection and reporting rates. Notwithstanding the welfare concern of debris interactions at an individual level, there is a need to identify methods to determine whether there are population-level effects of marine debris ingestion and entanglement for cetaceans.

It was noted that another recent review came to similar conclusions, and also highlighted the possibility that deep-diving cetaceans (sperm whales and beaked whales) may be especially vulnerable to ingestion (Simmonds, 2012).

Discussion

The seminar concluded with a panel discussion that touched on the following topics:

- The legal requirements for monitoring and responding to marine debris vary around the world, and are also often complicated by a lack of capacity to enforce laws even if they exist;
- Cooperation with other international organisations and existing frameworks was **encouraged**, including but not limited to: the Convention on Migratory Species (CMS) Resolution on Marine Debris, the UNEP/GPA Global Partnership on Marine Litter, UNEP Regional Seas Programme, MARPOL[4], the UN Food and Agriculture Organisation (FAO) and the Convetion for Biological Diversity (CBD);
- The potential importance of fishing gear-marking strategies to the problem of derelict fishing gear;

[4] MARPOL is the International Convention for the Prevention of Pollution From Ships, 1973 as modified by the Protocol of 1978.

- How local actions may relate to a global problem; and
- How countries might best develop partnerships to execute recommendations and strategies related to this issue.

In closing, Simmonds noted that these and other matters would be considered during the workshop that would follow. It would focus on determining how to better understand the risks that marine debris poses to cetacean species and would also inform a second IWC workshop on marine debris directed by the IWC's Conservation Committee ,which will be concerned with addressing the threats posed by marine debris to cetaceans.

3 Entanglement

3.1 Overview of papers relating to entanglement

3.1.1 Entanglement records in Italy

Podesta presented an overview of information from the Italian cetacean stranding network and a summary of entanglement records. The Italian Stranding Data Bank, managed by the University of Pavia and the Natural History Museum of Milan on behalf of the Italian Ministry of the Environment, collects and validates stranding data5. Data collection started in 1986 and continues today; each record in the database is geo-referenced and provides information about the event (location, species, sex, length, etc.) The records also capture information on samples collected and the institutes where samples are stored. The database is linked to the Cetacean Tissue Bank of the University of Padova, where samples collected from the stranded specimens are stored and available for research6.

Podesta searched the Italian national database and summarised records of cetacean strandings that were related to entanglements in fishing gear over the last 11 years (2002-2012). A total of 99 "bycatch" events were recorded, representing nearly 8% of the total strandings and affecting seven different species. Verified entanglements in fishing gear were reported for 36 cetaceans within the total number of bycatch recorded. The majority of the entangled animals were found dead (23), while 13 were found alive and were successfully released (Pace *et al*., 2008). Nine of the live specimens were large cetaceans: 8 sperm whales and 1 humpback whale, *Megaptera novaeangliae*. No information about whether entangling debris was active or lost fishing gear was available. Also, the source of entangling gear was often difficult to determine and in many cases was classified as "unidentified fishing gear". Analyses of the data indicate that the number of entanglements were decreasing in the years considered, and represent a small percentage compared to the total number of strandings. Considering the bias in the data collection (different effort in different areas), Podesta stated that the number of entanglements has likely been underestimated in the considered period of time. Stranding data can be of help to report cetacean interactions with fishing gear, but dedicated studies are needed to analyze the problem in the whole Mediterranean area. Cooperation with researchers working on fisheries has to be improved in order to share data and information.
Podesta clarified that four entanglement cases involving sperm whales were determined to be in an active fishing nets, as opposed to lost gear, because the fishermen themselves contacted the Coast Guard for help. Podesta noted that fishing nets are not known to commonly wash up on the beaches as debris in Italy and that entangling gear is not retrieved in Italy for later analysis or archiving, primarily because people are not available to collect and do the categorization.

Discussion

In recognition of the importance of better understanding this issue, including the relative occurrence of derelict versus actively-used gear involved in cetacean entanglements, the

[5] Data available at available on line at http://mammiferimarini.unipv.it
[6] See http://www.mammiferimarini.sperivet.unipd.it

workshop **recommended** that all gear removed from cetaceans be retained, documented and detailed, archived, and analysed wherever feasible. Collection of entangling gear should not compromise human or cetacean safety.

It was noted in relation to assumptions about the survival of released animals, that not all disentangled whales will survive, and that they are less likely to survive if released by untrained individuals, as untrained individuals often leave small, but lethal wraps of gear on the animal as it swims away. The recommendation for disentanglement teams to work with experts to determine the origin of the gear removed was noted as a component of the IWC principles and guidelines for proper entanglement response (IWC/64/WKM&AW Rep1, 2011

The EU has conducted research using synthetic aperture radar (SAR) to successfully detect the presence of anchored gillnets after fishery management effort restrictions (Rosenthal and Lehner, 2011). SAR allows for remote detection of fishing effort without the need for traditional methods of recording effort, such as logbooks and vessel monitoring systems.

3.1.2 Overview of large whale entanglement records

Saez presented an overview of U.S. west coast (California, Oregon, and Washington) large whale entanglement records and the trends in associated entangling gear types. Whale entanglements on the U.S. west coast are reported from opportunistic on-water sightings, stranding records, and commercial fishery observers. Gray and humpback whales are the most commonly reported entangled large whale species. A switch in most common entangling gear types, from gillnet to trap/pot, is likely a reflection of management actions in California. Except for commercial fishery observer records, it is difficult to determine if the entangling gear was active gear or marine debris (lost gear) at the time of entanglement.

The co-occurrence of fixed gear commercial fisheries and large whales (blue, fin, gray, humpback, and sperm whales) off the U.S. west coast was modelled to look for areas where, and months when, large whales are more likely to encounter gear and becoming entangled. Fishery effort for 11 fixed gear fisheries was modelled by combining fishery landings data with areas defined by common fishing depths. The co-occurrence model showed that the highest risk for blue, fin, humpback, and sperm whales was during the fall, and for gray whales the highest risk was in January and May. The Dungeness crab trap fishery had the highest co-occurrence scores/entanglement risk for all whale species. There are multiple confirmed entanglements of gray and humpback whales in the Dungeness crab trap fishery; however, there have been no recorded entanglements of blue whales in any type of fishing gear on the U.S. west coast. Whale behaviour and morphology could possibly explain the discrepancy between the model results and what is in the entanglement records.

Saez noted that a Fixed Gear Guide was developed as part of a larger effort addressing the issue of marine mammal entanglements and to assist in classification of gear (active or lost)[7]. Photos, diagrams, and maps are used throughout the document in combination with written descriptions of gear, gear configurations, and management/regulations to characterize each fishery (Saez *et al*., 2012).

Discussion

The workshop noted that microchips that can be scanned to identify origins of the material could be inserted into plastic; chemical markers can also be used. Gear guides should be considered locally applicable and subject to regular revision. It was asked if fishing gear was regularly dumped and, in the case of trawl gear because of its cost, this seemed unlikely. In other fisheries there are a variety of reasons for gear being lost and/or dumped (McElwee *et al*., 2012; McElwee and Morishige, 2010).

[7] The guide is a living document and available online at http://swr.nmfs.noaa.gov/psd/fixed_gear.htm

In some fisheries, the value of catch is high enough to incentivize the fishermen to put out more gear than is needed. In such situations, discard occurs due to lack of capacity on the boat to haul the gear to port when some of it is full. The workshop recognized that reduced fishing effort can result in greater profit-for-unit investment, while substantially reducing entanglement risk.

The workshop **recommended** that fishery effort models should be coupled to lost gear recovery effort data to evaluate whether higher fishing effort is correlated with areas of higher densities of lost gear.

3.2 Review of the available marine debris entanglement data – consideration of species and data-types

3.2.1 Gear recovery in California and modelling impacts in Puget Sound, Washington, USA

Gilardi presented information on lost gear recovery efforts in California and also on a cost-benefit analysis for gear removal relating to loss of commercially valuable species in derelict nets in Puget Sound. The California Lost Fishing Gear Recovery Project, a program of the UC Davis Wildlife Health Center, has been removing lost commercial and recreational fishing gear from California coastal waters since 2006. Lost gear is located and recovered by contract divers (commercial urchin harvesters), and either repatriated to original owners or disposed. Data on location, gear type, and number of entanglements or entrapments are recorded. To date, the program has recovered more than 60 tons of gear and debris, and has documented more than 800 entanglements, including 5 small cetaceans and 1 pinniped.

The program has also conducted research to better understand the population-level impacts of derelict fishing gear on marine species. A retrospective epidemiologic investigation of more than 12,000 intake medical records of gulls, pelicans and pinnipeds admitted to wildlife rehabilitation centers in California revealed that, depending on location and season, more than 10% of gulls and up to 4% of pinnipeds were impacted by fishing gear entanglement or ingestion injuries (Dau *et al*., 2009).

In collaboration with the Northwest Straits Initiative, derelict nets in Puget Sound were monitored by divers over two-month periods to measure entanglement rates, in order to develop a predictive model for estimating total mortality caused by a net during its lifetime as derelict (Gilardi *et al*., 2010). This model was then used to estimate the cost-to-benefit ratio for commercial fisheries of derelict gear removal, based on true costs and market values. This evaluation suggested that, regarding entanglement of Dungeness crab in derelict gill nets specifically, the cost-to-benefit ratio was 1 to 14.5 . When the model was applied to grossly estimate total mortality of marine mammals in derelict gillnets in Puget Sound, and costs of gear recovery compared to costs to rehabilitate marine mammals impacted by oil spills, derelict gear removal was determined to be a highly cost-effective measure to mitigate anthropogenic impacts on marine mammals.

Discussion

The workshop **agreed** that lost gear recovery has saved thousands of animals, even ones that do not have a commonly associated monetary value. Combining government mandates to conserve endangered species and marine mammals with conservation of commercially valuable species makes a strong case for supporting lost gear recovery.

Although some people have considered lost gear as ‘artificial habitat’, recovery efforts result in the restoration of natural habitat and the removal of debris that will cause damage. The workshop noted that the entanglement risk of man-made materials on the sea bed and other environmental consequences likely exceed the perceived benefits that items such as tires, toilets and traps may have by creating artificial habitat.

The workshop **recommended** that when derelict fishing gear is removed from the marine environment, that a dedicated observer (biologist) is on board to collect data on the species, composition, and numbers encountered in the gear, as well as on the type and condition of the gear.

3.2.3 The work of the Consortium for Wildlife Bycatch Reduction

Werner reported the on-going research program of the Consortium for Wildlife Bycatch Reduction, a group he directs that comprises members from US east coast fishing groups and academic institutions. The Consortium supports the investigation of innovative fishing techniques that can potentially reduce endangered species bycatch. The focus of the presentation was on several research projects the Consortium is undertaking to examine potential fishing gear modifications for mitigating large whale entanglements, in particular for the North Atlantic right whale (NARW), *Eubalaena glacialis*, an endangered species with an estimated global population of only 500 individuals. These projects are evaluating: (1) ropes of different colour (and luminosity) to determine if NARWs show different avoidance behaviour; (2) ropes with reduced breaking strength that are still durable enough for fishing; (3) "stiff ropes," that may have reduced entanglement properties because they are materially stiffened (e.g. hard lay ropes) or are under higher tension (such as in the northeastern portion of Maine where buoy lines tend to be stiffer, pulled taught by the opposing forces of flotation at the sea surface and weight of bottom gear, both exposed to high current and tidal forces); and (4) rope-less fishing techniques, such as those that incorporate acoustic release technology to maintain buoy lines close to the sea floor until the time they are released to the surface for hauling. In addition, given that testing of experimental gear with large whales is impractical, especially noting the need for statistically adequate sample sizes, the Consortium is supporting the development of a computer model to evaluate and test bycatch mitigation techniques with large whales.

Although these projects are still on-going, as a justification for the research into reduced breaking strength ropes, Werner presented the results of analysis of ropes retrieved from disentangled right whales showing evidence that breaking strength of rope is a factor affecting the likelihood that a large whale can break free upon entanglement in fixed fishing gear. In addition, he shared knowledge about a fisherman in Australia who has incorporated acoustic releases into his lobster fishing gear. These kinds of examples help inform what is possible in terms of practical fishing methods that can also reduce entanglements, but need to be evaluated within the local fishing context. Considering the potential of reduced breaking strength rope, its application is probably only suitable in areas that can use "light duty" gear. Also, the appeal to an Australian lobster fisherman to use acoustic releases involves several unique local circumstances that include a high market price/kilo of product, a previous management action that reduced the number of fishermen in the fishery, and other factors. In the northeast US, lobster fishermen have raised their objections to using this technology by pointing out the high cost of the devices currently available on the market, and the increased probability of gear conflicts both within the fishery and with draggers.

The Consortium's research is directed at avoiding the incidence of whale entanglements in the first place, which workshop participants acknowledged as the preferred solution to the problem of marine mammal entanglements in fishing gear. One concern was that gear modifications mandated by federal regulators in the US in response to whale entanglements (such as "weak links" inserted between the top of a buoy line and the buoy, and groundlines attached to adjacent lobster traps that are negatively buoyant), whilst intuitively believed to reduce whale entanglements, have yet to produce scientific proof of their efficacy as deterrents. As such, they represent examples of often costly and perhaps even impractical modifications for fishermen that should be monitored to measure their effectiveness as entanglement deterrents and the consequences to fishermen.

These kinds of projects, involving collaboration among engineers, wildlife biologists, and fishers, highlight the advantages of engaging fishers as part of the solution to marine mammal entanglements. The idea for carrying out research into ropes with reduced breaking strength emerged from teams of fishermen and scientists who jointly studied gear retrieved from disentangled whales. Furthermore, it highlights that incentives exist for fishermen to modify fishing gear that reduce marine mammal bycatch, and that the problem can sometimes be solved without relying on new regulations enacted by government agencies.

The workshop **recommended** that ideas for reducing cetacean entanglements and the occurrence of derelict gear should be generated in collaboration with fishermen, recognizing that practical and sustainable bycatch solutions and reduction of loss of gear tend to emerge from partnerships between science and industry.

As well, the workshop **recommended** that fisheries managers consider the influence that fisheries management schemes (e.g. ITQs, TACs, etc8.) have on facilitating the incorporation of fishing methods that can be better for whales and that lead to a reduction of marine debris.

The workshop also **recommended** that in fisheries where regulatory actions and agencies are unlikely to exert a strong influence over local fishing practices (such as in small-scale artisanal or non-industrial fisheries) the onus should be on collaborative research with fishermen. This should aim to identify practical solutions that provide local incentives to adopt alternative fishing methods that reduce the generation of marine debris and entanglement risk for cetaceans.

The workshop also highlighted that prevention of entanglements is the preferred method, but stressed that concerted and well-funded research is required to evaluate fishing innovations for reducing marine mammal bycatch and generation of debris.

There are examples of programs that are currently removing derelict fishing gear in different parts of the world. These projects provide immediate benefits to marine animals, including cetaceans, by removing gear that is a threat to entanglement and ingestion (McElwee and Morishige, 2010). The knowledge and experience from these on-going programs could be beneficial to other countries that have not yet tackled the problem of derelict fishing gear.

The workshop **recommended** that a program is initiated through the IWC to provide an effective transfer of information and methods from on-going programs to countries interested in beginning new derelict gear removal programs and to stimulate the adoption of official programs for removing fishing gear as debris. This could be modelled after the IWC's disentanglement training program with guidance from the IWC's Scientific Committee and supported through the IWC.

The workshop **recommended** that the IWC should identify effective programs of derelict gear removal. Furthermore, the IWC should share knowledge gained on gear removal and its benefits.

It was noted that marine spatial planning and technological innovations might help to reduce conflicts between different maritime activities that may result in the creation of marine debris.

The workshop discussed the effectiveness of management measures such as sinking ground line requirement and weak links. The NOAA Fisheries Atlantic Large Whale Take Reduction

[8] An ITQ is an independent transferable quota and is part of a total allowable quota (TAC). Both are typically set each season for each fished stock.

Team (TRT) has compiled a matrix to summarize the gear research that has been proposed and conducted to reduce entanglements of large whales in the Atlantic (available at http://www.nero.noaa.gov/whaletrp/plan/gear/Gear%20Research%20Matrix_Oct%202010_final.pdf).

There was also a suggestion to revisit the feasibility of lipid-soluble rope for use in fisheries and other marine industries that rely heavily on the use of rope. The concept of lipid-soluble rope was not practical when originally researched in the past, but technological advances may make it possible today.

In some countries efforts are made to reduce bycatch, but rarely is it noted that sometimes these actions increase the amount of gear (marine debris) in the environment. This message should be shared with the next entanglement workshop.

The workshop **strongly encouraged** continued research and development into alternative fishing techniques, strategies to reduce the entanglement of cetaceans in active fishing gear, and validation of the effectiveness of existing fishing practices that lower the risk of entanglement incidence and severity. The workshop **further encouraged** that the assessment of such alternatives in active fishing gear include evaluation of their potential to alter the contribution of marine debris in the environment and the risk of entanglement or ingestion by cetaceans.

Furthermore, the workshop **recommended** that future efforts to both understand and mitigate cetacean entanglement should include participation from multiple stakeholders (e.g. manufacturers, fishers and other relevant ocean users).

3.3 Distinguishing active fishing gear entanglements from entanglement in marine debris.

With regard to the issue of cetacean entanglement in man-made materials, a growing body of evidence indicates that the vast majority of entanglements occur in synthetic ropes and nets associated with fishing (e.g. Jonson *et al*., 2005). Entanglements have been reported for most cetacean species in a wide variety of fishing gear, but predominantly in gear that is either drifting or anchored. While the relative entanglement risk posed by actively fished gear versus that posed by lost, abandoned or otherwise discarded fishing gear, is unclear, it is very clear that the solution to both can only be reached through full engagement with the manufacturers of fishing gear and the raw materials used to produce it, fishers and other involved parties.

A number of potential methods of distinguishing active gear from derelict gear were discussed. These included: gear marking; modelling fisheries activity, identifying geographic positions exhibiting high gear loss (through reporting and gear retrieval programs), and using information on rates of gear loss to predict likelihood of gear being derelict; consideration of fouling organisms; engagement with fisheries to collate further information on potential methods of distinguishing active from derelict gear, as well as to identify key causes for loss or dumping of gear; and consideration of the number of different gear types (where multiple gear types are found on an animal they are likely to have been derelict at the time of entanglement).

With respect to gear marking, the workshop **recommended** that every effort should be made to distinguish whether the entangling gear was active or derelict at the time of entanglement. Recognising the difficulty involved in this, the workshop **recommended** further research to assist this process.

When considering the entanglement risk of debris: if gear is lost, there is an unknown period of time during which it may pose the same entanglement risk as active gear (McElwee and Morishige, 2010). Fishing gear, whether active or derelict, often lacks traceability to owner or fishery, and is comprised of materials and components designed to optimize fishing, but with the potential to injure or kill cetaceans.

The workshop **recommended** combining existing fisheries knowledge and appropriate fishing techniques with applied research and innovation to engineer and utilize fishing gear that ideally is: 1) traceable; 2) generates less debris; and 3) causes fewer injuries and mortality to cetaceans.

It was suggested that the workshop remain mindful of the idea of overall reductions of volume of man-made material in the ocean.

3.4 Pathology protocols: Recommendation for Diagnosis of Entanglement and Ingestion Impacts of Fishing Gear and Aquatic Debris in Cetaceans

In situ examination of entangling and ingested debris and associated traumatic injuries in live and dead animals is essential for revealing pathologic impacts of fishing gear and debris on cetaceans. Changes can include laceration, amputation, and constriction-related injuries externally, and/or, ileus, strangulation, ulceration, impaction, emaciation, and/or rupture internally. Evidence of chronic effects (e.g. emaciation) or prior trauma from entanglement and debris interaction, where material is no longer present, can also be obtained through careful clinical or post-mortem examinations by scientists and through subsistence harvest monitoring. In addition to the information provided for impacts assessment, this information will be beneficial for assessment of actual synthetic material/ debris interactions (exposures) for cetaceans. Potential chemical exposure should be evaluated, and may or may not be accompanied by gross or histologic changes due to transfer of monomers, additives and sorbed priority pollutants from the plastic into the tissues (Rochman *et al*., 2013).

The workshop **recommended** the following diagnostic approach:

Evaluating possible impacts due to entanglement and ingestion impacts of fishing gear and debris should be done using a classical differential diagnostic approach when possible, to enable: a) detection of trauma, chemical exposure and other sequelae related to exposure; and b) analysis of their roles in contributing to morbidity and mortality in the context of other potential causes, such as infectious or non-infectious disease, nutrition, and other possible etiologies. In situations when a full differential diagnostic approach is not possible, efforts to document the presence of marine debris, both ingested and entangled, are still very important. Most efforts focus on macrodebris but efforts should also focus on microdebris. Efforts should be made to include the following components in the examination of all live and dead wild cetaceans as appropriate:

1. Gross necropsy examination and report: description, sketches, images, measurements, collection and preservation of entanglement/ debris, and affected body part(s). The entire gastrointestinal tract should be opened and examined. Standard cetacean necropsy protocols should be followed (see (Pugliares *et al*., 2007) (Barco and Moore, In Press) and (McLellan *et al*., 2004).

2. Debris characterization: Material should be categorized as rope, net, floats, monofilament, braided line, hooks, packaging, cigarette butts, plastics and other anthropogenic material. Size, shape (image analysis of digital photographs), mass, volume, and polymer type if plastic (e.g. vibrational spectrometry) should all be recorded, and all evidence should be identified as to source using established techniques (Browne *et al*., 2010) as practical and in collaboration

with the relevant industries, to maximize the integration of data into these industries, such as plastics and fishing.

3. Confirmatory diagnostics: Further analyses as practical and indicated should be undertaken, such as histopathology, imaging, analytical chemistry, blood test and organ function tests, to document presence of and type of debris as well as possible impacts to the animals. It would be useful to provide resources to develop techniques to identify particles of plastic in the tissues of animals. Criteria for the assignation of degree of confidence of findings (e.g. quality of data) of entanglement or ingestion contributing to or causing morbidity and mortality have been recently published and should be applied (Moore *et al*., 2013). Chain of Custody documentation should be maintained as required or possible.

4. Training designed for specific countries and regions, and database maintenance would both enhance understanding of these problems.

3.5 Classification of debris types

The group noted that classifying marine debris is essential for understanding its sources, distribution, and impact on cetaceans. The workshop **recommended** a two-part classification system to address this requirement. The first aspects should include characteristics adequate to understand the use, configuration, and other aspects of the debris while it is still in active use. Largely, these characteristics will map to the industrial function of the item – holding liquids, catching fish, providing buoyancy. The second aspect of the classification system should focus on characteristics of the item after it has left human possession and contribute to the harm the item might cause to cetaceans. For instance, this might include colour (i.e. visibility), flexibility, sharp edges, size, strength, density, site in water, flexibility, shape/aspect ratio, and a host of other aspects that affect its ability to harm cetaceans.

Currently there are projects to classify debris to a source in the Northwest Hawaiian Islands and Australia. Clean-up efforts are very labour intensive and expensive; therefore recent efforts in the Hawaiian Islands have focused more on removing gear. Local fishermen involved in lost gear recovery in California and on the U.S. east coast have assisted in identifying a fishery and sometimes a specific fisherman. Fishermen may also be useful in determining active versus derelict gear in entanglement cases. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) in Australia has developed a cluster analysis of the physical origination sources of debris. Debris from commercial and recreational fisheries can be difficult to identify, especially if trying to trace to a certain area.

4 Ingestion

4.1 Papers relating to ingestion

Baulch presented an analysis of data collated on published and unpublished cases of debris ingestion from across the globe (1960-present). Ingestion of debris has been reported in the literature from 43 cetacean species, comprising 7 mysticete and 35 odontocete species. The chances of detecting the ingestion of debris may be lower in mysticete species due to lower stranding and necropsy rates. Hence, the low number of mysticete species documented ingesting debris to date should not be taken as evidence that it does not occur. A number of studies (where sample size was >10) have assessed occurrence rates of cetaceans observed to have ingested debris. The occurrence rates of debris ingestion ranged from 2.2% in harbour porpoises, *Phocoena phocoena*, that stranded on the UK coast (Deaville & Jepson, 2010) to 31% in Franciscana dolphins, *Pontoporia blainvillei*, bycaught in Argentina (Bastida *et al*., 2010). It was noted that publications have consistently showed high rates of debris ingestion in Franciscana dolphins and given that these studies were based on animals captured as bycatch, ingestion of debris is unlikely to be over-represented as compared to strandings data.

Baulch presented maps showing where interactions have been reported. A relatively high number of cases have been reported in the U.S., Japan, Australia, South America, and parts of Europe, but records are lacking from Africa and Asia. Such differences in reporting rates between different regions are likely to influence perceptions of the severity, distribution and frequency of debris interactions at a global scale. Google fusion tables (Google forms and open data kit) were presented as a potentially valuable tool for collating global data in the future(see Fig. 1) . Data collection forms can be designed and sent to stranding networks and responses can then automatically populate an online table. This would greatly facilitate data collection and collation and thereby aid understanding of the threat of marine debris. It was further emphasised that it would be important to collect information on rates of debris occurrence in animals necropsied (presence/absence) as well as rate and type of pathology (impact on animal) to gain a better understanding of the extent of the threat it poses to different species and populations.

Figure 1: Distribution of debris ingestion events reported in the literature (1960-2012).

Discussion

The workshop noted that there will be low reporting levels for ingestion of debris in some areas, and that even where data are collected, there may be poor accessibility to and collation of the data at a national and international scale. Possible formats for a global database were discussed, including the use of freely accessible databases such as that presented by Baulch, the IWC's Cetacean Emerging and Resurging Diseases (CERD) website, and the inclusion of this data within countries progress reports to the IWC.

Therefore, noting the poor coverage of global data on rates of debris ingestion, the workshop **recommended** that where possible, full investigation of the gastrointestinal tract should be part of necropsy procedures. It also **recommended** that information on rates of debris occurrence in animals necropsied (presence/absence) as well as the rate and type of related pathology (impact on animal) should be collected in order to better understand potential population-level threats. Also, it **recommended** that data collected on debris interactions should be submitted to a global database, for which a standardised data form should first be designed.

As a first step, the workshop **recommended** that rates of marine debris interactions with cetaceans be reported by IWC member countries, in the appropriate data fields within their National Progress Reports (e.g. stranding and bycatch), and that the data be recorded in such a way that it is available for future analysis. The workshop also **recommended** that the Scientific Committee revisit the possibility of including a link to a marine debris

reporting/data aggregation site on the CERD homepage at the upcoming IWC meeting or, if this was not viable for the Scientific Committee to recommend, an appropriate format for future data management.

4.3 Review of the available marine debris ingestion data

4.3.1 Case Studies: Italy

Podesta reported the results of gastric analyses performed on stranded cetacean species in Italy, focusing on those where ingestion of marine debris had been documented. The most interesting case was of seven sperm whales that stranded together in 2009 (Mazzariol *et al*., 2011). Gastric contents were examined in six of the seven sperm whales. Stomach contents consisted of cephalopod beaks and synthetic materials, including fishing gear and hooks, ropes and various plastic objects. No evident obstruction or perforation of the alimentary tract was noted, suggesting that marine debris was not the cause of death in these cases. Weight of synthetic materials varied from 9.5 g in one individual to nearly 5 kg in one of the stranded animals. Plastic was found in the stomachs of all six specimens and fishing nets, lines and one hook were found in two animals. Marine debris was documented in the stomachs of seven out of twelve additional sperm whale strandings recorded in the Mediterranean Sea (de Stephanis *et al*., 2013; Roberts, 2003).

Among the other species studied, only two of 10 Cuvier's beaked whales, *Ziphius cavirostris*. stranded in Italy have been recorded to have plastic debris in their stomachs. Marine debris was not found in any of the 50 striped dolphins, *Stenella coeruleoalba* studied and only two of 24 bottlenose dolphins, *Tursiops truncatus*, had fishing net in their stomachs, most likely as a result of depredation on fishing gear.

The preliminary results support the idea, as reported in other papers (Laist, 1997; Evans and Hindell, 2004; Jacobsen *et al*., 2010), that sperm whales seem particularly affected by marine debris ingestion. Small dolphins were never found with ingested plastic, and while some had fishing nets, these were probably linked to depredation. Podesta urged that more detailed studies on debris ingestion should be a priority for the whole Mediterranean area, which is highly polluted by plastic debris. Fossi noted that the problem of marine debris in this area is supported by the high occurrence of marine debris in the stomach contents of Mediterranean turtles. See also Garibaldi and Podestà (2013)

Discussion

It was noted during discussion that ingestion of marine debris is not always an accidental process for cetaceans and that depradation on fishing gear may result in ingestion of fishing gear. A workshop on marine mammal bycatch in longline fishing gear sponsored by the Consortium for the Wildlife Bycatch Reduction and NOAA's Office of International Affairs is being held in October 2013[9]. It should be noted that ingestion of fishing gear due to depradation presents a different management problem to the passive ingestion of marine debris.

The workshop **recommended** that identifying the sources and fates of plastic debris would help improve and support extended producer responsibility (EPR) initiatives by the manufacturer or distributor of the plastic. EPR is an effective tool for informing product design and could be used to raises awareness of the issue.

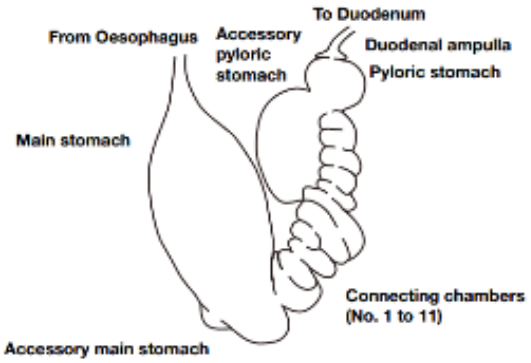
4.3.2 The structure of ziphiid stomachs

Yamada presented his research with collaborators, which finds that cetaceans, and especially ziphiids, may be particularly susceptible to ingesting plastic debris because of their stomach structure. These studies were based on stranding data from Japan. Yamada introduced the

[9] http://www.bycatch.org/node/796

anatomy of cetacean digestive tracts: the existence of connecting chambers was highlighted as a potential hindrance factor for the passage of non-digestible material, including debris, through the digestive tract (Fig. 2.).

Figure 2. Schematic illustration of the stomach of *Mesoplodon ginkgodens*.
The number of connecting chambers varies between 8 and 11 and the minimum diameter of the passage aperture between chambers is less than 15 mm (Tamada pers obs.).



The flow of digestive material into connecting chambers may be prevented when the main stomach is full. In ziphiids, the connecting chambers are divided into many smaller chambers, with more then 10 small chambers in some species (Mead, 2007), which may limit the passage of large items. In necropsies of 80 stranded ziphiid carcasses, 73.8% of *Mesoplodon stejnegeri*, 50% of *M. ginkgodens*, 33.3% of *M. carlhubbsi*, 66.7% of *M. densirostris*, 100% of *Indopacetus pacificus* and 33.3% of *Ziphius cavirostris* had foreign substances in their stomachs. In most animals, quantities of foreign material in these stomachs were not seriously large; however some individuals had a huge volume of man-made debris that filled the main stomach. These animals would have suffered from the blockage of their digestive tract and may have been malnourished and lost body condition as a result, similar to the case of Inky, a pygmy sperm whale, *Kogia breviceps,*, treated in National Aquarium of Baltimore (Stamper *et al*., 2006). Yamada noted that debris had also been observed in finless porpoise, *Neophocaena phocaenoides*, rough-toothed, *Steno bredanensis*, and spotted, *Stenella attenuata*, dolphins stranded in Japan. Yamada also presented the results of acoustic research conducted by the National Research Institute of Fisheries Engineering.

Discussion
During discussion it was noted that in addition to recording attributes of ingested debris, such as the weight, volume and type of debris, its size in relation to that of the digestive tract should be noted in different species, and that an index that quantifies or qualfies how full the stomach is would be useful. The issue of whether ziphiids were able to regurgitate synthetic materials ingested was raised. It is unclear whether this is possible. It was also noted that sub-lethal pathology can occur when the quantities of debris are lower and that this should also be investigated and noted in necropsies. Effects may include dietary dilution and reduced appetite with resulting reductions in body condition and other fitness-related pathology. While these may be less readily observed, it is important that such impacts are considered in cases of sub-lethal debris ingestion.

Moore noted that D-tags on beaked whales have been used to image the acoustic signature of their prey items at foraging depths up to 1800 m (Madsen, *et al*., 2005). With further information on the acoustic signature of plastic items versus prey items, it might be possible to establish whether and which debris items were being selectively ingested by cetaceans.

The workshop **commended** the valuable work conducted by Yamada and colleagues and **recommended** further research in the following areas: obtaining acoustic information on how marine debris is perceived by cetaceans, which would help understanding of the causes of ingestion; determining the distribution of debris within the habitat of deep diving whales; and given the overall paucity of information on rates of debris ingestion in wild cetacean populations, non-lethal research and evaluation of strandings to measure rates of occurrence of debris ingestion and the pathological impacts would be valuable in a range of species and areas.

The workshop noted and **expressed concern** regarding the high rates of debris ingestion in certain species (e.g. ziphiids, sperm whales and certain populations of Franciscana dolphins). The workshop **agreed** that, depending on severity, ingestion of debris is a welfare concern at an individual level. While it remains unclear whether there are any species or areas where it is a population- level concern, the conservation threat should be assessed in the context of the local population size, where even low mortality levels may be of concern.

The workshop noted that the impact on cetaceans of entanglement and debris in the Arctic may increase as industries move into higher latitudes with climate change-driven ice recession opening up new areas for industrialization. In this regard Reeves *et al*. (2011) noted that in 2009, the North Pacific Fisheries Management Council closed the Arctic Management Area (federal waters in the US Arctic) to commercial fishing. This area will be closed until more data are collected (largely absent at present), so that fishing can be conducted sustainably and with due concern for other ecosystem components. The workshop **recommended** the benign collection of benchmark data on the impacts of marine debris on cetaceans in this area at the earliest opportunity.

4.4 Recommended pathology protocols

The workshop's recommended pathology protocols are given at section 3.4.

4.5 Categorisation of ingested debris types

See section 3.5

4.6 Toxicological effects of plastic additives

Panti presented information on the toxicological effects of plastic additives on cetaceans. The assessment of toxicological risk in marine mammals requires the development of sensitive biomarkers to evaluate the exposure to plastic additives, such as bisphenol A (BPA) and phthalates. BPA and phthalates are widely distributed in the marine environment, acting as agonists or antagonists for endocrine receptors. To propose new gene expression biomarkers in cetaceans Panti and collaborators have developed an *ex vivo* approach (organotypic cultures), exposing cetacean skin biopsies to increasing doses of mixture of contaminants. Organotypic cultures collected fromfin whales, killer whales, sperm whales and bottlenose dolphins were exposed to increasing concentrations of BPA and phthalates. Two potential biomarker genes were selected, the peroxisome proliferator-activated receptors α and γ (PPAR α and γ), which belong to a superfamily of ligand-dependent nuclear receptors that regulate physiological processes of lipids homeostasis, inflammation, adipogenesis, reproduction, etc. The mRNA levels of the two PPARs were quantified in response to the two different treatments in the four species. The results revealed that the BPA and phthalates treatments induce the expression of the genes PPARα and PPARγ, showing a dose-response trend. Based on these results, the gene expression biomarkers were also measured in skin biopsies from free-ranging Mediterranean fin whales and bottlenose dolphins from Mediterranean Sea and Sea of Cortez. The study was carried out in order to validate the *ex-vivo* approach, but more importantly, to assess the potential exposure of the two species to plastic additives. Due to the up-regulation of the PPARγ gene (an early warning signal), both

fin whales and Mediterranean bottlenose dolphin appear to be exposed to plastic additives. These data represent the first evidence of emerging contaminant exposure in free-ranging fin whales and bottlenose dolphins, suggesting the potential use of these diagnostic markers as an early warning signal of exposure to plastic released compounds in marine mammal monitoring.

Panti noted that their research currently focuses on mysticetes and that there is a need to develop a suite of specific biomarkers. There are unresolved questions regarding the relative rates of leaching of contaminants from microplastics versus macro-debris. Initial research suggests that in cases of macro-debris ingestion, there is no evidence of phthalate exposure and this is borne out by research in sea turtles, and stranded sperm whales along the Italian coast, that presented with macro-plastic debris in their stomachs.

The workshop recommended that further work on surface filter feeders, particularly the North Atlantic right whales, should be undertaken. As surface feeders, right whales may be exposed to high quantities of microplastics in the surface microlayer. The workshop also commended the work of researchers at the University of Sienna and **encouraged** further work of this kind.

By 2050, an extra 33 billion tonnes of plastic is expected to be added to our planet (Rochman *et al*., 2013). This material enters and persists in environments from the poles to the equator and down to the depths of the sea. Slow degradation into smaller particles means that microplastics have been accumulating in the environment (Thompson *et al*., 2004; Browne *et al*., 2007; 2010; 2011). Once ingested by animals, such microplastics can accumulate within the guts of organisms where it can be engulfed and stored by cells (Browne *et al*., 2007; 2008). This provides a feasible pathway for microplastic to transfer sorbed contaminants, constituent monomers and additives into the tissues of animals and affect physiological processes that sustain health (Teuten *et al*., 2007; 2009). At least 78% of priority pollutants listed by the EPA and 61% listed by the European Union are associated with plastic debris (Rochman *et al*., 2012; 2013). While there are established techniques for quantifying other contaminants in tissues of cetaceans, strikingly, there is still little information on the uptake and toxicological consequences of microplastics (e.g. endocrine disruption). Preliminary research suggests fin whales (Fossi *et al*., 2012) may contain large quantities of phthalates (potentially derived from microplastic) with possible alterations to the expression of genes associated with endocrine disruption.

Discussion

The workshop expressed concern regarding the potential impact of microplastics and made the following **recommendations** with regards to further research:

- develop and validate the use of direct (vibrational spectroscopy) and indirect (e.g. contaminants associated with plastic: phthalates, PCBs, PBDEs) measures of ingested microplastic in baleen whales;
- examine whether ingested micro- and nano-plastic can transfer into the food chains of cetaceans;
- evaluate the use of established biomarkers of exposure to assess the toxicity of microplastics, including endocrine disruption; and
- conduct laboratory and field experiments to investigate the bioavailability and toxicity of priority pollutants and additives from microplastic.

It is also important that future research on the uptake and toxicological impacts of microplastics in filter-feeding species of mysticetes includes both species with intense surface feeding activities (e.g. right whales) and species with feeding related to the sediment (e.g. grey whales).

The workshop also noted that baleen whales and other large filter feeders should be considered in national and international marine debris strategies (e.g. Descriptor 10 (marine

litter) in the EU Marine Strategy Framework Directive) as critical indicators of the presence and impact of microplastics in the marine environment.

In conclusion, the workshop agreed that ingestion and inhalation of marine debris may sometimes be lethal, that sub-lethal pathology may also occur, and that intake of debris is a problem, both as an individual welfare concern and potentially for some populations and species. Therefore, the workshop encouraged further non-lethal research on the individual and potential population-level impacts of ingestion of debris and, noting the promising research on biomarker development, the group **recommended** further work in this field.

5 The distribution of debris

5.1 Request for papers relating to investigating the distribution of marine debris.

Known marine debris databases were described with the caution that not all will have geo-referenced locations and may not pertain exclusively to cetaceans. The Marine Debris Monitoring and Assessment Project (MD MAP) is expanding the use of standardized shoreline survey protocols and building our understanding of debris types and abundances across geographies. The efforts of the MDMAP partner organizations, including volunteer coordination, field surveys, and data submission, are critical for this type of large-scale data collection. The many shoreline monitoring teams have uploaded their survey data to the md-map.net database. A pending NOAA Marine Debris Monitoring Tech Memo will be outlining protocols for monitoring marine debris. An additional source of a long-term database comes from the Norwegian survey and derelict gear removal program, which has been systematically removing derelict fishing gear from their waters from 1983 to the present time.

5.2 Modelling approaches to identify spatial overlap between cetaceans and harmful debris.

Wilcox presented three projects on risk analysis for marine debris impacts on wildlife. The first focused on derelict fishing gear impacts on marine turtles. This project involved modelling the spatial overlap between drifting gear and marine turtles as a proxy for entanglement risk. The model was validated against both known tracks of drifting gear and data on locations where turtles were entangled and stranded. The model was a ble to make accurate predictions of catch. Based on the analysis it was possible to identify cost effective areas in which to conduct surveillance and recovery of abandoned gear. The second two projects involved analyzing the spatial overlap of marine debris more generally, with either marine turtles or seabirds, respectively. In this case, the researchers used a global model of marine debris distribution, based on oceanographic drift patterns and population density. This was overlain with species distributions to predict relative encounter rates for species as a measure of risk. These predictions were then compared to literature data on stomach contents as a measure of plastic ingestion. The comparison revealed that consideration of species ecology was an important component of making accurate predictions, but in general encounter rates were a reasonable predictor of ingestion rates. It was suggested that this approach could be used to make predictions of relative entanglement or ingestion rates for cetaceans, although it is important to be aware of the limitations of the large-scale analyses in making local predictions.

Discussion

Risk analysis provides a framework for complex problems. Simple encounters appear to be a good measure of risk and models help with making informed decisions (e.g., where to do surveillance or interceptions). It was noted that the the ecology of the species concerned is also important in the analysis and that traits are useful for making predictions. The solutions are complex and incentives and alternative income sources are going to be a powerful tool

(especially for developing nations). For example, derelict fishing gear has been turned into art, or used fishing rope has been turned into doormats. In addition, risk analysis models potentially could reduce management costs. Debris density plots with vertical aspects (layers of debris) were also discussed with potential benefits from the analysis. Further applications of risk analysis can be extended to other fisheries (besides "ghostnets"), which would be beneficial to numerous regions (e.g. Brazil's marine debris problems with active and derelict long-lines).

Potential projects will be looking at a global dataset of fisheries spatial data overlaid with range maps of marine mammals. However, caution should be used regarding known entanglement events due to the limited number of known events as well as the caveat that the comparison may apply to small cetaceans, but not necessarily to large whales due to the ability to drag gear for longer ranges.

The workshop **recommended** an increase in the usage of theoretical global models that help identify locations where there is greater potential for interactions of cetaceans with debris.

The workshop also **recommended** engagement with international aid agencies and international financial institutions (such as World Bank) involved in the development of fisheries management in developing countries to ensure they take into account the impacts to cetaceans from unintended consequences of the various types of gear being brought into communities as an economic development strategy.

DeForce presented the work of the Sea Education Association (SEA), which has been collecting data on floating plastic debris for more than 25 years. These data are typically collected on six-week long educational research cruises as part of the undergraduate SEA Semester program. From the data collected on the research cruises, the longest and most extensive data set on floating plastic debris in the open ocean was published in 2010 (Lavender Law *et al*., 2010).

Discussion
In 2010, the Plastics at SEA: North Atlantic Expedition set out to document for the first time the easternmost extent of plastic accumulation in the North Atlantic and measured the highest concentration of plastic debris ever recorded (26 million pieces per square kilometer) and found that high plastic concentrations extend at least as far as the middle of the Atlantic Ocean. To expand our knowledge of how plastic marine debris is affecting the ecosystem, the Plastics at SEA: North Pacific Expedition set sail from San Diego to Hawaii in Oct 2012. This cruise sampled not only the concentration of plastic but also micro/macro organisms growing on plastic, plastic submerged in the water column due to wind (Kukulka *et al*., 2012), environmental persistent organic pollutants, and surveys for potential tsunami debris. This research program continues, and plastic concentrations from 11 years of data collected by SEA in the North Pacific subtropical gyre are currently being analyzed for publication.

In reference to microorganisms on marine debris, several sources of health biomarkers were discussed by the workshop, including research on microorganisms on whales, and research of barnacles on sea turtle carapaces. One future line of investigation could be investigating the correlation of mean sea state and plastic distribution. Another project could be applying gear degradation assessment technology to gear removed during disentanglement. A potential collaboration on the filtration of baleen whales and plastics density/buoyancy/shape was also mentioned.

Mindful of emerging technologies such as deep DNA sequencing, the workshop **recommended** that the scientific community continue to use novel approaches to support further research on the interaction between cetaceans and marine debris.

Drinkwin presented an overview of Washington State's Derelict Fishing Gear Database. This database is used to collect and store data on derelict fishing gear: debris locations, and the species and habitats documented to be impacted by the debris. In particular, most of this data relates to the Northwest Straits Initiative's Derelict Fishing Gear Program in Puget Sound, an inland sea in Northwest Washington, but also includes data from Oregon and British Columbia. The Initiative's program has removed over 4,400 derelict fishing nets and more than 2,900 derelict crab pots from Puget Sound since 2002. The removal protocols include an on-board biologist on every removal vessel documenting and cataloguing data about the gear removed, the species found entangled, and the habitat it is affecting. The state-wide derelict gear database operates on a Structured Query Language (SQL) web platform. It is accessible through the internet to approved users. The database includes all data related to removal efforts of derelict fishing gear as well as the locations and disposition of reported gear. Data retrieval is partitioned between confidential data (not available to the public) and non-confidential data. Access to non-confidential data is routinely approved for researchers, resource managers, and interested citizens. Through an Access™ interface, the uploaded data are quality checked before officially being entered into the database for retrieval. The data can be queried in multiple ways and may be exported for spatial display and analysis.

Discussion
The requirement that fishermen report lost nets was addressed, referencing the requirement of reporting based on recent implemented laws in the state of Washington, U.S.A. A point was raised regarding using existing marine debris databases frameworks and the possibility of cloning pre-existing frameworks to maintain consistency. A short discussion pertained to the active versus passive participation in providing marine debris data to a central database. The utilization of technology, in particular sonar, was discussed and it was determined that the expertise of the sonar operator is very important in correctly identifying gear. In the continuation of discussion of database programs, several participants have provided several references of field database programs (see below), which will reduce the error of data transfer from paper format as well as provide a unique identifier for each entry and forces the entering of a complete data form. The participants also recognize the difficulty in identifying and retrieving derelict gear in deep water.

The workshop **recommended** the promotion and utilisation of existing database frameworks and protocols with the aim of establishing a centralised database for a comprehensive picture of global marine debris impacts on cetaceans.

5.3 The application of quantitative field sampling techniques to investigate prevalence of marine debris in cetacean habitats, including seas.

The workshop **recommended** a general broadening of cetacean boat-based surveys to include marine debris data collection.

6 Population Level Impacts of Marine Debris

The workshop noted that a significant amount of information on entanglement exists and can be cross-referenced from past IWC efforts. Welfare concerns related to cetacean entanglement in active fishing gear and marine debris have been well recognized by the IWC following publication of the extended time-to-death of chronic entanglement in right whales (Moore *et al*., 2006). Recent publications have reinforced this concern (Moore, 2013; Moore and van der Hoop, 2012).

Recent research indicates that North Atlantic right and humpback whales have lower apparent survival after entanglement than other cetacean species (Robbins *et al*., 2012; Robbins and Knowlton, 2012, Knowlton *et al*., in press). The number of observed entanglement deaths has

the potential to impact population viability (e.g., van der Hoop, 2013, Glass *et al*., 2012). In the case of North Atlantic right whales, research suggests that reproductive rates are also impacted by entanglement (Knowlton *et al*., in press). The degree to which marine debris *per se* is responsible for individual and population-level entanglement impacts is an important issue that requires further study.

Several welfare concerns related to the ingestion of marine debris in cetaceans were recognized. Evidence of significant gastrointestinal impaction and other damage following the ingestion of debris as described by Yamada and reviewed by Baulch in this workshop suggest that there is a welfare concern for ingestion comparable to entanglement, especially for sperm and beaked whales. While it was noted that several of the workshop presentations and For Information (FI) papers contributed to the current state of research in this area, the group **recommended** additional research to further detail both the physical and toxicological/physiological impacts of debris ingestion.

The workshop group recognized the significant impact that marine debris can have on cetacean welfare and **recommended** that additional research be undertaken to further evaluate the impacts of ingested debris on cetacean welfare and population health.

Modelling of debris "tracks" was noted to be of potential use in cetacean marine debris interaction estimations. There was discussion of the potential application of fishing net track models, that are currently being applied in sea turtle debris interaction studies, to cetaceans. This modelling considers the path of debris that the animal encounters as well as general distribution of debris, and uses this information to make projections that may be applicable to stock assessment. These models would allow estimation of the number of animals dead but not recovered/seen. Knowledge of the "floating characteristics" of cetaceans is considered critical to these models and it was noted that the UK has performed research on drifting body information that could inform these models.

The workshop **recommended** additional investigation into the applicability of debris track modelling with particular emphasis on the scaling up of models from the regional level to a level that would benefit stock assessment and allow the determination of population level impacts.

7 Cetaceans in freshwater habitats.

Most of the information considered at the workshop related to cetaceans in the marine environment, but it was noted that the threats posed by man-made debris applied equally to freshwater cetaceans. Evidence from studies of river dolphins (e.g. *Inia geoffrensis* and *Sotalia fluviallis*) indicates that debris, including derelict fishing gear and actively fished gear, occurring in freshwater habitats can entangle or become ingested by cetaceans, with both lethal and sub-lethal effects (e.g. Iriarte and Marmontel, 2011) . In comparison with marine cetaceans, freshwater species tend to occur within more contained bodies of water often downstream of, or adjacent to, large urban areas that are a major source of debris within these aquatic habitats.

The workshop **encouraged** further research into the impacts of man-made debris on freshwater cetaceans, as well as effort to mitigate the threats to these animals, some of which are amongst the most endangered of all cetaceans.

8 Overarching evaluation of data and recommendations

The application of science-based information can often be sensitive, especially considering that this information will be utilized by, and potentially impact the lives of, a diverse group of stakeholders. Thus, science-based information must be objective, transparent, and of high integrity. This requires appropriate structures (e.g., databases, networks) and personnel (e.g.,

scientists) to maintain the integrity of data in terms of its acquisition, analysis, storage, and maintenance. The workshop **recommended** that these structures and personnel should be well-established in order to create and develop the best science-based approaches and/or solutions.

The workshop group strongly supported augmented datasharing and encouraged improved coordination with respect to marine debris data and research. The group **recommended** that marine debris interactions with cetaceans be reported by IWC member countries, in the appropriate data fields within their National Progress Reports (e.g. stranding and bycatch), and that the data be recorded in such a way that it is available for future analysis.

8.1 Recommendations for Future Research and Priorities

The workshop **agreed** that the overall goal of any marine debris-related research endeavour should be designed to help build risk assessment model(s) and address the issues raised in the risk models, which can be applied to other cetacean species with different geographical ranges.

The work group **encouraged** debris sampling when conducting cetacean research at sea and the reporting of these results to relevant groups such as the IWC.

The workshop **recommended** that the IWC promote research on debris-related impacts from fisheries and **encouraged** that data reported via fisheries be collected in a format more amenable to stock assessment and risk assessment analyses (i.e., via FAO guidance).

The workshop **recommended** that industry partners be involved in marine debris prevention, research and response to ensure success in reducing marine debris impacts on cetaceans; and

In the context of addressing global marine debris impacts on cetaceans, the workshop **recommended** that the IWC utilize existing national and intergovernmental platforms for responding to the issue.

The workshop **encouraged** governments and industry to support all the research identified by this workshop (and the workshop noted that none of its recommendations would require cetaceans to be taken).

The workshop found that: entanglement of whales can involve peracute underwater entrapment, chronic debilitation, impairment of mobility, chronic infection, and ultimately death; recent findings concerning both the welfare and conservation impacts of entanglement have brought the topic to the attention of both the IWC's Whale Killing and Associated Welfare Issues working group and its Conservation Committee; the extent to which marine debris may contribute to whale entanglements is not fully understood; andlost gear recovery has saved thousands of animals, even ones that do not have a commonly associated monetary value

The workshop therefore **recommended** that ideas for reducing large whale entanglements and the occurrence of derelict gear be generated in collaboration with fishermen, recognizing that practical and sustainable solutions to minimize bycatch tend to emerge from partnerships between science and industry.

The workshop recognized the influence fisheries management schemes (e.g., ITQs, TACs, etc.) have on facilitating the incorporation of fishing methods that can be better for cetaceans and that lead to a reduction of marine debris.

The group recognized that it may be difficult to exert influence over small-scale artisanal or non-industrial fisheries and, as such, the onus should be on collaborative research with fishermen to identify practical solutions that provide local incentives to adopt alternative fishing methods.

The group highlighted that fact that, while prevention of entanglements is the preferred approach, concerted and well-funded research is required to evaluate fishing innovations for reducing marine mammal bycatch.

The workshop **recommended** the collection of small-scale commercial and artisanal data on total global distribution of fisheries effort extrapolated from global catch, as it was noted that there are limitations to the data that FAO collects.

In addition, it was noted that estimates of gear loss from relevant fisheries would be very helpful toward understanding the relative risk of active versus derelict gear.

The workshop **recommended** that fishery effort models should be coupled to lost gear recovery effort data to see if increased effort is correlated with higher densities of lost gear.

The group **encouraged** the IWC-supported entanglement prevention workshop to review and incorporate appropriate recommendations from the marine debris workshops into their report, and underlined the importance of understanding how both workshops' recommendations will impact each other.

The workshop found that: the distribution of marine debris is dependent on the distribution of sources (e.g. urban areas, tourist beaches, shipping routes, fishing grounds) and oceanographic processes, with, for example, coastal marine areas receiving sewage, having 250% more microplastic than those not receiving sewage (Browne *et al*., 2011); greater than 60% of priority pollutants are found sorbed to plastic debris at concentrations that may be hundreds of times that found in sediments and millions of times that occurring in seawater (Rochman *et al*., 2013), likely causing greater impacts to cetacean species living in areas adjacent to large human populations; there is minimal understanding of the extent of exposure of plastics ingested by cetaceans and the impact that such exposure has on fitness; all cetaceans must use the upper water-column and penetrate the surface to breathe; and low density microplastics (e.g. polypropylene) and concentrated lipophillic pollutants may become airborne (Wallace & Duce 1978; Grammatik & Zimmerman 2001) and be available for inhalation above the air-water interface for risk of inhalation.

Therefore, using existing expertise within and external to the IWC, the workshop **recommended** that the IWC Scientific Committee evaluate the risks of ingestion and inhalation based upon (1) the spatial distribution of microplastics and macro debris and (2) the feeding strategies and location of feeding areas of cetaceans, and that the Scientific Committee prioritize studies of those cetacean that are likely at greatest risk of ingesting or inhaling macro- and micro- debris and associated pollutants (Fossi et a., 2012). The workshop thus **recommended** that the initial focus of research be on three species of filter-feeding whales: the North Atlantic right whale, the fin whale in the Mediterranean Sea, and the gray whale in the eastern North Pacific.

Assessment of the impact of ingested debris on the welfare and fitness (e.g. contaminants and biomarker responses) of cetacean populations should also be explored, including translocation and storage of microplastic in the tissues of whales (Browne *et al*., 2008). The workshop noted that additional research is needed on sub-lethal effects of ingested debris.

The workshop identified the following **priority mitigation measures:**

Entanglement:
Since both active and derelict gear are largely responsible for cetacean entanglements, focus should be to mitigate the impacts of both of these sources on cetaceans. The workshop **recommended** a consideration of how different managerial regimes affect (i.e., facilitate or hinder) the feasibility of implementing actions, regulatory or otherwise, intended to reduce the risk of entanglement to cetaceans, maximize the return of lost viable gear to fishers, and avoid the introduction of derelict fishing gear into aquatic environments. These actions include: (1) targeting reduction of fishing effort; (2) modifying of fishing gear; (3) developing a response system to respond to and retrieve lost gear; and (4) implementing time-area closures and marine spatial planning.

Ingested debris:
As impacts are largely dependent on species group, we strongly recommend research that allows prioritization of relevant cetacean populations as data does not exist at this time to allow this. The group **encouraged** modelling approaches that examined the relationship between marine debris "hot spots" and information on distributions, feeding strategies and mortality rate data already collected by the IWC and other organisations. The group also **recommended** the determination of hazard function of specific debris with subsequent connection with the modelling data.

9 The IWC Response

9.1 Work being undertaken by other IGOs

9.1.1 Europe's Response to Marine Debris

de Ruiter presented a summary of efforts addressing the debris problem in Europe. Information on debris in European seas is very scarce. The CleanSea project started in 2013 and its aim is to assess distribution, fate and impact of marine litter, with 17 international parties involved. OSPAR Beach Litter Monitoring has been conducted in nine European countries since 2002. On average, volunteers collect 700 litter items per 100 meters of beach.. Ropes, nets, balloons and bottle caps are found most commonly along the beaches that are monitored. Research has shown that >90% of all Northern Fulmars, *Fulmaris glacialis*, have an average of 30 pieces of plastic in their stomach (J.A. Van Franeker – IMARES personal communication). The Northern Fulmar is an indicator species for the Marine Strategy Framework Directive.

The OSPAR Convention is the current legal instrument guiding international cooperation on protection of North-East Atlantic marine environment. The Helsinki Commission (HELCOM) works to protect the Baltic Sea's marine environment from all sources of pollution through intergovernmental co-operation. ASCOBANS is the Agreement on the Conservation of Small Cetaceans of the Baltic, North East Atlantic, Irish and North Seas. A working group on marine debris formed in 2012. The aim of the Marine Strategy Framework Directive (MSFD) is to achieve good environmental status of the EU's marine waters by 2020. The MSFD Task Group Marine litter aims for a measurable and significant decrease (10% / year on coastlines) in the total amount of litter in the environment by 2020[10]. NGOs (European Environmental Bureau, Marine Conservation Society, Surfrider Foundation, Birdlife Sweden, LPN, Bund, North Sea Foundation, Seas At Risk (SAR)) advised the MSFD on a stronger aim: a 50% reduction in 2020, compared to 2012 and problem solved within one generation: 2038.

In Norway, the Directorate of Fisheries organises retrieval surveys of gill nets annually since 1980. Within the KIMO project Fishing for Litter in the UK, Baltic and Netherlands, fisherman are provided large bags to remove litter from the sea. Within The Netherlands a

[10] See: MSFD GES Technical Subgroup on Marine Litter 2011.

group of divers remove ghost nets from shipwrecks. The Surfrider Foundation organizes beach clean-ups worldwide. The Marine Conservation Society organizes beach clean-ups with thousands of volunteers: they do litter surveys, published a Good Beach Guide and have campaigns on specific items, such as balloons and plastic bags. The North Sea Foundation focuses on tackling the problem at the source, with lobbying, beach surveys (OSPAR) and several campaigns. Such as Beat The Micro Bead, Coastwatch (education) and MyBeach (awareness).

9.1.2 CMS/UNEP Presentation

Thiele provided an overview of the Convention on Migratory Species (CMS) including its organizational structure, legal framework, and cetacean specific agreements and activities, including ASCOBANS, ACCOBAMS, the Pacific Islands Cetacean MOU, Western African Aquatic Mammals MOU, the Global Programme of Work on Cetaceans, and the Resolution on Marine Debris. The presentation included ideas for strengthened collaboration and opportunities for future engagement. In summary, there are 119 parties to CMS, across the globe, and species are listed in either Appendix I (endangered) or II (unfavorable status). A total of 15 cetaceans are listed in Appendix I and 43 cetaceans listed in Appendix II. The Pacific Cetacean MOU was negotiated in collaboration with SPREP and includes an action plan that mirrors the Secretariat of the Pacific Regional Environment Programme (SPREP) regional Whale and Dolphin Action Plan, illustrating a successful model of streamlined efforts between CMS and existing regional agreements. Similar MOUs could be created in other regions, provided funds and capacity to implement are provided.

CMS Resolution 10.4. on Marine Debris11 highlights the negative impacts of marine debris on migratory species, whether caused by ingestion, entanglement and habitat degradation. It calls for the identification of hotspots where marine debris accumulates and originates; encourages Parties to develop and implement their own national plans of action to address this problem, and to report available information on the amounts, impacts and sources of marine debris within their waters in their national reports. Because so much of the workshop's conversation included reference to bycatch and entanglement, Thiele also shared CMS Res. 10.14 on Reducing Bycatch from Gillnets which calls for national assessments of the risk of bycatch arising from gillnet fisheries and urges the implementation of best practice mitigation measures tailored to each particular situation.

Thiele presented an overview of UNEP's Global Initiative on Marine Litter, including the Regional Seas Reports & Assessments on Marine Litter, the Fifth International Marine Debris Conference (www.5imdc.org) and respective conference outcomes. Major conference outcomes included the Honolulu Strategy & Honolulu Commitment, the Global Partnership on Marine Litter (GPML), which was launched at the 3rd Intergovernmental Review of the GPA, and associated online tools such as the Marine Litter Network which was created to help track progress on the implementation of the Honolulu Strategy. The GEF/STAP produced a workshop summary report on "Marine Debris as a Global Environmental Problem: Introducing a solutions based framework focused on plastic." Another example of the growing global attention to marine debris is a specific reference to it made at the UN Conference on Sustainable Development ("Rio +20") (A/66/L.56, para. 163). UNEP's Regional Office of North America together with NRDC UNEP & NRDC convened a Marine Litter Workshop on "Legal, Policy and Market-Based Approaches to Prevent Marine Litter at the Source." Last, a technical report commissioned by CBD and GEF/STAP called "Impacts of Marine Debris on Biodiversity " played an important role in informing the 11th CBD COP decision to formally recognize the impacts of marine debris on marine and coastal biodiversity (Section I, para 25-27). These activities provide just a snapshot of what it happening globally. The take-away is that it is important for IWC to build on the existing

[11] http://www.cms.int/bodies/COP/cop10/resolutions_adopted/10_04_marinedebris_e.pdf

platforms and information gathering efforts of institutions like UNEP and others so as not to be duplicative in its good efforts to address marine debris impacts on cetaceans specifically.

Discussion
The discussion that followed considered ways to better include developing countries in the IWC's conservation and management activities, and the relevance of the West African Marine Mammal MOU was noted along with the other CMS daughter agreements and MOUs that relate to cetaceans. Thiele on the behalf of CMS encouraged support from IWC on capacity building efforts in the area of marine mammal disentanglement and training strategies.

The workshop noted the availability of numerous Regional Seas Marine Litter Assessments and UNEPs Global Initiative on Marine Litter.

A participant noted that there were many international frameworks and conventions during the presentation, but not much information on status of implementation. Thiele noted that the Global Partnership on Marine Litter will help track these efforts in the future and pointed out that money and collaboration are needed to get action on many of the initiatives that had been discussed.

It was noted that the Honolulu-based conference (5IMDC) had recognized a globally accepted definition of marine debris and the workshop **recommended** that this discussion about comparisons between marine debris terminology might be considered by the next IWC workshop on marine debris.

9.1.3 GESAMP Structure
The workshop noted that the Transboundary Waters Assessment Programme (TWAP; a Large Size Project of the Global Environmental Facility12) included two components relevant to the interests of the workshop participants: i) mapping the distribution of plastics in the open ocean; and ii) describing the distribution of persistent, bio-accumulating and toxic compounds in beached plastic resin pellets (linked to the International Pellet Watch Programme www.pelletwatch.org), based on Large Marine Ecosystems. Responsibility for completing these components lies with the Joint Group of Experts on Scientific Aspects of Marine Protection13 (GESAMP), an inter-agency body of the United Nations comprised of independent scientists working under the direction of UNESCO-IOC. In addition, GESAMP has a working group on 'Sources, fate and effects of micro-plastics – a global assessment', running from 2012-2015 that receives support from several UN Agencies, NOAA, Plastics Europe and the American Chemistry Council. GESAMP welcomes closer collaboration with IWC on the effects of plastics on cetaceans, including the potential impacts of micro-plastics on baleen whales.

Discussion
Discussion followed on the types of collaboration being sought by GESAMP. It was clarified that, secondary to budgetary constraints, GESAMP was looking for collation and analysis of existing literature/data only and that they would not be gathering new data on priority contaminants.

9.2 Proposals for future actions by the IWC and opportunities for intergovernmental collaboration
Brockington commented upon the strategic opportunities for the IWC to engage in the marine debris issue. He recalled that the Commission's Conservation Committee had discussed marine debris at its meetings in 2011 and 2012, and that the welfare concerns associated with

[12] http://twap.iwlearn.org
[13] www.gesamp.org

entanglement of large whales had been considered separately through the Welfare Sub-committee. Following these discussions the Commission had established an intersessional programme of working to develop applied research and management actions to reduce the impacts of marine debris on cetaceans.

At the international level there is an absence of a single overarching agreement or Convention dealing with the issue of marine debris. The lack of a central document led to calls for increased partnership working between intergovernmental organisations (IGOs), and this was especially relevant for the IWC. Accordingly, the IWC may wish to form partnerships with IGOs in the following categories: (1) Fisheries Management Organisations, including for example FAO and CCAMLR, (2) Multilateral Environmental Agreements, e.g. CMS, CBD, UNEP; (3) Regional Seas Agreements and (4) other Conventions competent in the management of debris including for example MARPOL and the Basel Convention. In addition to greater interlinkages with other IGOa, partnerships working with the full range of stakeholders including industry groups, NGO observer organisations and national governments would also be essential to progressing action on marine debris.

Brockington noted that the IWC was in a key position to contribute scientific knowledge on the extent and severity of the impacts of debris on cetaceans through the work of its Scientific Committee. This knowledge base could be further enhanced by expansion of national government progress reports to include actions taken to measure and mitigate the impacts of debris on cetaceans. With knowledge as a basis for action, the IWC possessed considerable strategic opportunities for creating partnerships to progress action on marine debris

Discussion
The workshop suggested an exchange of personnel and information between the IWC and other IGOs (i.e., UNEP/CMS). It was noted that the IWC presently maintains observer status at several Conventions and with regard to interacting has recently expanded its activities into new partnership actions on entanglement and other human impacts in the Caribbean and South Pacific (UNEP-CEP-SPAW, SPREP, CPPS, etc.). It was also noted that this mechanism seems to work best when IWC brings its particular expertise to a joint activity. It was noted that IWC and CMS has an existing collaborative agreement. An inquiry as to mechanisms for reporting into UNEP/CMS was made: specific recommendations and suggested mechanisms such as participating in meetings and respective working groups (i.e., CMS aquatic mammals working group) were shared.

A number of inter-governmental organizational including ICES, NOAA, CCAMLR, North Pacific Marine Science Organization (PICES) were identifies as potentially important in future collaborative efforts.

It was noted that, in addition to the second workshop on marine debris, there is an entanglement prevention workshop being planned by IWC, and it was **recommended** that the marine debris workshop coordinate with them on recommendations and cross-workshop impacts of recommendations.

The unique strengths of the IWC's Scientific Committee (SC) were mentioned, including its range of expertise, experience with environmental threats and regular annual meeting cycle.

The workshop encouraged IGOs with overlapping mandates to work together collaboratively on common goals.

It was noted that the identification of priorities by the IWC Scientific Committee could potentially help NOAA prioritize the marine debris work it funds, and help local governments to more fully recognize the marine debris problem and implement response activities,

acknowledging the current lack of funding and infrastructure. The CMS resolution on marine debris was noted14.

The workshop **agreed** that a brief document summarizing priority recommendations for potential funders was a good idea and stressed that they ideally should be prioritized, brief and feasible.

9.3 Recommendations for the 2nd IWC Workshop on Marine Debris

- The workshop **recommended** that the second marine debris workshop perform a careful review of recommendations from this workshop in order to determine if they were acted upon and, if not, identify the factors related to the failure of implementation;

- The workshop **encouraged** greater outreach to the public and scientific community; the next workshop is urged to carefully consider its audience and how best to engage;

- The workshop also **recommended** increased engagement with intergovernmental bodies and industry (plastics, fisheries, etc.) prior to and during the next workshop, and better representation/good engagement with representatives from developing countries. This would bring increased presence from those involved in non-industrial/artisanal fisheries, which were felt to be an underrepresented component of the marine debris problem at the current workshop (include a session specific to this problem). Related to this, conveners of the next workshop should seek additional funding in order to be able to provide support to participants from developing countries.

- The workshop recognized the utility of the IWC web portal and **encouraged** the further use of portal and development of an updated bibliography of material relevant to the next workshop, including mitigation. It was also noted that it will be provided in ample time for review by attendees.

- The worshop **recommended** that the turtle modelling work currently performed by CSIRO be presented at the second workshop.

- The workshop noted the significant challenges in communicating scientific information about the impact of marine debris on cetaceans, with interactions typically occurring far removed from the lives of most people. There is an urgent need for scientists to relay information about the detrimental impacts of marine debris to a variety of audiences, including decision-makers, industry officials/representatives, policymakers and the public. Thus, the workshop **recommended** dedicating significant time and resources at the next workshop to develop effective communications strategies to address this need. Consideration could also be usefully given to educational programmes for adults and children.

- Consideration should be given to reviewing programs that are currently removing derelict fishing gear in different parts of the world. These projects provide immediate benefits to marine animals, including cetaceans, by removing gear that is a threat to entanglement and ingestion. The knowledge and experience from these on-going programs could be beneficial to other countries that have not yet tackled the problem of derelict fishing gear.

The workshop **recommended** that a program be initiated and supported through the IWC that would provide an effective transfer of information and methods from on-going programs to countries interested in beginning new derelict gear removal programs and stimulate the

[14] http://www.cms.int/species/pacific_cet/pacific_cet_bkrd.htm

adoption of official programs for removing fishing gear as debris. This could be modeled after the IWC's disentanglement training program with guidance from the IWC SC and supported through the IWC.

- The workshop acknowledged that natural but catastrophic climatic or seismic events (e.g., hurricanes/typhoons, earthquakes, tsunamis) can result in pulses of tremendous amounts of debris into the ocean. The workshop **recommended** that the IWC support a globally applicable but scale-able contingency plan for assessing impacts of such events on cetaceans, which offers member states guidance on mitigation options.

10 Conclusion: Priority Recommendations

Given that:

- Legacy and contemporary marine debris have the potential to be persistent, bioaccumalative and lethal to cetacean populations and represent a global management challenge; and

- Entanglement in and intake of active and derelict fishing gear and other marine debris have lethal and sub-lethal effects on cetaceans,

the workshop **agreed** that marine debris, and its contribution to entanglement, exposures including ingestion, and associated impacts, including toxicity, is both a welfare and a conservation issue for cetaceans on a global scale.

Therefore, the workshop **recommended:**

Research and experimentation to develop and evaluate the efficacy of alternative fishing practices, including innovative methods, gear and management regimes, because fishing gear, both active and derelict, is a major cause of injury and mortality in cetaceans;

Microplastics, their associated chemical pollutants and microbes, and macrodebris ingestion should be prioritized for research because they represent a potentially significant but poorly understood threat to cetacean populations; and

That, while governments, industry groups and organizations are making progress to address the threat of marine debris on local/regional scales, due to the migratory nature of cetaceans; these efforts should be advanced globally;

11 Close of meeting

All recommendations included in this document were reviewed and agreed before the workshop closed and a small editorial team (consisting of Simmonds, Gilardi, and Landrum) was appointed to tidy up the text before it was submitted to the IWC Scientific Committee.

Simmonds thanked everyone for their contributions and especially the rapporteurs for their hard work.

He also thanks the IWC secretariat team who had done so much to make the workshop a success, including Julie, Sandra, Brendan, Jessica and Kate. He also thanked Michael Moore for the kind invitation to use the excellent WHOI facilities at no charge and Andrew Daly and Michael for the support they provided during the meeting. Simmonds was thanked for chairing the meeting and at 16.20 on 17/5/2013 he brought the gavel down and closed the meeting.

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Appendix 2: Workshop Agenda

1 Introductory items
1.1 Welcome and Opening Remarks
1.2 Procedural Matters

2 Keynote Presentations
2.1 Introduction to the work of the International Whaling Commission on environmental issues.
2.2 Marine Debris in our oceans – an overview
2.3 Cetacean entanglement: detection and impacts
2.4 Cetacean entanglement: scope and response
2.5 Microplastics
2.6 Closing the loop: Repackaging plastic debris as a hazardous substance
2.7 Overview of cetacean interactions with marine debris

3 Entanglement
3.1 Overview of papers relating to entanglement
3.2 Review of the available marine debris entanglement data – consideration of species and data-types
3.3 Distinguishing active fishing gear entanglements from entanglement in marine debris.
3.4 Pathology protocols: Recommendation for Diagnosis of Entanglement and Ingestion Impacts of Fishing Gear and Aquatic Debris in Cetaceans
3.5 Classification of debris types

4 Ingestion
4.1 Papers relating to ingestion
Review of the available marine debris ingestion data
4.4 Recommended pathology protocols
4.5 Categorisation of ingested debris types
4.6. Toxicological effects of plastic additives

5 The distribution of debris
5.1 Request for papers relating to investigating the distribution of marine debris.
5.2 Modelling approaches to identify spatial overlap between cetaceans and harmful debris.
5.3 The application of quantitative field sampling techniques to investigate prevalence of marine debris in cetacean habitats, including seas.

6 Population Level Impacts of Marine Debris

7. Cetaceans in freshwater habitats.

8 Overarching evaluation of data and recommendations

9 The IWC Response
9.1 Work being undertaken by other IGOs
9.2 Proposals for future actions by the IWC and opportunities for intergovernmental collaboration
9.3 Recommendations for the 2nd IWC Workshop on Marine Debris

10 Conclusion: Priority Recommendations

11 Close of meeting