



Convention on the Conservation of Migratory Species of Wild Animals

Secretariat provided by the United Nations Environment Programme



Contribution from the Convention on the Conservation of Migratory Species of Wild Animals (CMS) to the Report of the Secretary-General on Oceans and Law of the Sea

Marine Debris, Plastics, Microplastics

The Convention on Migratory Species (CMS) is an intergovernmental treaty, concluded under the aegis of the United Nations Environmental Programme (UNEP), concerned with the conservation of wildlife and habitats on a global scale and in particular terrestrial, aquatic and avian migratory species throughout their range.

Marine debris is a significant concern for species and populations of animals that spend all or part of their life-cycles in or near the marine environment. The key threats are through entanglement and ingestion, as well as from the pollutants transferred into the food chain through microplastics.

The 10th Meeting of the Conference of the Parties (Bergen, Norway, November 2011) adopted Resolution 10.4 on [Marine Debris](#) which sets a clear mandate for the work of the Convention on the impact of marine debris on migratory species. In particular, the Resolution instructs the Convention's principal technical advisory body, the Scientific Council to:

- a) Identify knowledge gaps in the management of marine debris and its impact on migratory species
- b) Identify best practice strategies for waste management used on board commercial marine vessels, taking into account the extensive work being undertaken by the International Maritime Organization, FAO and the International Standards Organization to avoid duplication, identify existing codes of conduct and determine the need for the improvement and/or development of new codes of conduct
- c) Facilitate an analysis of the effectiveness of current public awareness and education campaigns to identify gaps and areas for improvement

The resulting reports, published as UNEP/CMS/COP11/Inf.27 [Report I: Migratory Species, Marine Debris and its Management](#), UNEP/CMS/COP11/Inf.28 [Report II: Marine Debris and Commercial Marine Vessel Best Practice](#) and UNEP/CMS/COP11/Inf.29 [Report III: Marine Debris: Public Awareness and Education Campaigns](#), provide a thorough analysis of the state of knowledge on each of these subject areas, identify knowledge gaps relevant to the management of the issue and its impacts, and make recommendations on the way forward for the Convention collectively and the Parties individually.

Based on the recommendations contained in these reviews, Resolution 11.30 on [Management of Marine Debris](#) was adopted by the 11th Meeting of the Conference of the Parties (Quito, Ecuador, November 2014).

The resolution recognizes that entanglement and ingestion of marine debris are both conservation and welfare concerns, recognizes also the knowledge gaps with regard to debris and its effects on wildlife, and makes recommendations for addressing this issue in collaboration with the other regional and global instruments working on this subject.



CONVENTION ON MIGRATORY SPECIES

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MANAGEMENT OF MARINE DEBRIS

Adopted by the Conference of the Parties at its 11th Meeting (Quito, 4-9 November 2014)

Recalling CMS Resolution 10.4 on Marine Debris and *reiterating* the concern that marine debris has negative impacts on many species of migratory marine wildlife and their habitats;

Welcoming the Resolution 1/6 on Marine Plastic Debris and Micro Plastics adopted by more than 150 countries at the first United Nations Environment Assembly (UNEA), concluded on 27 June 2014;

Aware that entanglement in and ingestion of marine debris are both conservation and welfare concerns;

Acknowledging the substantial work on this subject being undertaken by other regional and global instruments, including *inter alia* the UNEP Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA-Marine), the Regional Seas Conventions and Action Plans (RSCAPs), the Global Partnership on Marine Litter (GPML), the Global Partnership on Waste Management (GPWM), the International Convention for the Prevention of Pollution From Ships (MARPOL), the International Maritime Organization (IMO), the Convention on Biological Diversity (CBD), the International Whaling Commission (IWC), the London Convention, London Protocol, the Food and Agriculture Organization (FAO), the International Organization for Standardization (ISO), and the Inter-American Convention for the Protection and Conservation of Sea Turtles;

Further acknowledging actions undertaken by States to reduce the negative impacts of marine debris in waters within their jurisdiction;

Noting with gratitude that the extensive reviews called for in CMS Resolution 10.4 have been carried out with financial support from the Government of Australia;

Recognizing that information on marine debris remains incomplete, especially regarding the quantity present in the ocean and entering the ocean annually, as well as its sources, pathways, prevalence in different sea compartments, and fate in terms of fragmentation, decomposition, distribution and accumulation;

Concerned that currently available information is not sufficient in order to generally understand which populations and species are the most affected by marine debris, especially the

specific effects of marine debris on migratory as opposed to resident species, and that population level effects of marine debris are unknown in many cases;

Emphasizing that preventing waste from reaching the marine environment is the most effective way to address this problem;

Further emphasizing that despite the knowledge gaps relating to marine debris and its impacts on migratory marine wildlife, immediate action should be taken to prevent debris reaching the marine environment;

Recalling that in the outcome document of the United Nations Conference on Sustainable Development, held in Rio de Janeiro, Brazil, in June 2012, entitled “The Future We Want”, States committed “to take action to, by 2025, based on collected scientific data, achieve significant reductions in marine debris to prevent harm to the coastal and marine environment”;

Aware that a significant proportion of marine debris is the result of discharges of ship-generated waste and cargo residues into the sea, lost or abandoned fishing gear, and that the protection of the marine environment can be enhanced significantly by reducing these;

Recognizing that a range of international, regional and industry-based measures exist to manage waste on board commercial marine vessels and prevent the disposal of garbage at sea;

Also recognizing that the International Maritime Organization is the authority regulating shipping on the High Seas; and

Conscious that a wide range of target audiences needs to be addressed through effective public awareness and education campaigns in order to achieve the behavioural change necessary for a significant reduction of marine debris;

*The Conference of the Parties to the
Convention on the Conservation of Migratory Species of Wild Animals*

1. *Takes note* of the reports on Management of Marine Debris published as UNEP/CMS/COP11/Inf.27, Inf.28 and Inf.29, which cover (i) Knowledge Gaps in Management of Marine Debris; (ii) Commercial Marine Vessel Best Practice; and (iii) Public Awareness and Education Campaigns;

2. *Encourages* Parties that have not yet done so to join other relevant Conventions such as MARPOL Annex V and the London Protocol, to join Protocols to Regional Seas Conventions on Pollution from Land Based Sources, and to include the prevention and management of marine debris in relevant national legislation;

3. *Further encourages* the Parties to engage, as appropriate, with other global marine initiatives such as the UNEP’s Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA-Marine), the Regional Seas Programmes, the Global Partnership on Marine Litter (GPML), the Global Partnership on Waste Management (GPWM);

4. *Further encourages* Parties to continue working on the issue of management of marine debris in order to reach agreed conclusions on this subject;

Knowledge Gaps in Management of Marine Debris

5. *Encourages* Parties to consider within any monitoring programmes established giving particular regard, using standardized methodologies, to the prevalence of all the types of debris that may, or are known to, have impacts on migratory species; sources and pathways of these types of debris; geographic distribution of these types of debris; impacts on migratory species, within and between regions; and population level effects on migratory species as appropriate to national circumstances;

6. *Invites* Parties to consider implementing cost-effective measures for the prevention of debris, such as levies on single-use carrier bags, deposit refund systems for beverage containers and obligations for the use of reusable items at events as appropriate to national circumstances;

7. *Encourages* Parties to establish public awareness campaigns in order to assist in preventing waste from reaching the marine environment and set up management initiatives for the removal of debris, including public beach and underwater clean-ups;

8. *Calls upon* Parties to incorporate marine debris targets when developing marine debris management strategies, including targets relating directly to impacts on migratory species, and to ensure that any marine debris management strategies plan for and carry out evaluation;

9. *Encourages* the Scientific Council, with support from the Secretariat, to promote the prioritization of research into the effects of microplastics on the species ingesting them, and support research on the significance of colour, shape or plastic type on the likelihood of causing harm, in order to be able to focus management strategies in future;

10. *Invites* the Secretariat to work with the UNEP Regional Seas Programme to support standardization and implementation of methods for studies monitoring impacts in order to produce comparable data across species and regions that will allow robust ranking of debris types for risk of harm across different species groups;

11. *Requests* the Scientific Council, with support from the Secretariat, to further the Convention's work on the marine debris issue and investigate the feasibility of close cooperation with other biodiversity-related agreements by means of a multilateral working group;

12. *Further requests* that working groups established under the Scientific Council incorporate the issue of marine debris where relevant, drawing on the work already undertaken by the Convention;

13. *Further requests* that the Secretariat ensure appropriate links are made with other regional and global instruments working on marine debris in order to share information and avoid duplication of effort;

Commercial Marine Vessel Best Practice

14. *Strongly encourages* Parties to address the issue of abandoned, lost or otherwise discarded fishing gear (ALDFG), by following the strategies set out under the FAO Code of Conduct for Responsible Fisheries;

15. *Further encourages* Parties to promote measures such as the Clean Shipping Index and marine environmental awareness courses among shipping operators;

16. *Invites* the United Nations Environment Programme to continue and increase its leading role in acting as a moderator between the different stakeholders in the maritime industry, and facilitating coordination to enable best practice measures to be implemented;

17. *Encourages* shipping operators and other key industries involved with the international transport of goods to drive environmental demands, including adopting the indirect fees system in ports, supporting the improvement of port waste reception facilities in general, adopting, where possible, the use of waste-to-energy systems on vessels and implementing relevant ISO standards;

Public Awareness and Education Campaigns

18. *Strongly encourages* Parties to note the examples of successful campaigns provided in UNEP/CMS/ScC18/10.4.3 when considering campaigns to address the most pressing needs in their area of jurisdiction, and to support or develop national or regional initiatives that respond to these needs;

19. *Recommends* that Parties planning to implement regulatory measures or economic instruments in order to reduce the amount of waste entering the environment to accompany these with behavioural change campaigns aiding their introduction by communicating the rationale for introducing the measure, and therefore increasing the likelihood of support;

20. *Encourages* Parties and the Secretariat to cooperate with organizations currently campaigning on marine debris, and seek to engage organizations dealing with migratory species to promote campaigns and raise awareness of marine debris amongst their members;

21. *Further encourages* Parties, the Secretariat and stakeholders to develop marine debris campaigns of specific relevance to migratory species;

22. *Invites* industry bodies to promote debris prevention measures across their industries; and

23. *Calls on* campaign organizations to survey the campaign reach, message recognition and impact upon the target behaviour or levels of marine debris in order to evaluate the success of a campaign and readily share that information to enable future campaigns to be effective.



CMS



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REPORT I: MIGRATORY SPECIES, MARINE DEBRIS AND ITS MANAGEMENT

Review Required under CMS Resolution 10.4 on Marine Debris

Report I: Migratory Species, Marine Debris and its Management

Review Required under CMS Resolution 10.4 on Marine Debris

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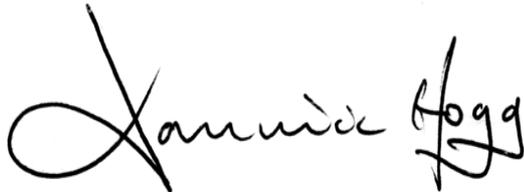
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Disclaimer

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03/03/2014

EXECUTIVE SUMMARY

Eunomia Research & Consulting (Eunomia) has worked in partnership with the International Union for the Conservation of Nature (IUCN) and the Marine Conservation Society (MCS) to prepare three reports for the Convention on the Conservation of Migratory Species of Wild Animals (CMS) for ‘Reviews required under Resolution 10.4 on Marine Debris’. The three reports are as follows:

- Report I: Migratory Species, Marine Debris and its Management;
- Report II: Marine Debris and Commercial Marine Vessel Best Practice; and
- Report III: Marine Debris Public Awareness and Education Campaigns.

E1.0 Approach

Report I was undertaken principally, in accordance with UNEP/CMS/Resolution 10.4, to

“Identify knowledge gaps in marine debris management and impacts on migratory species”

The report first outlines knowledge gaps regarding types, sources and pathways for marine debris, and its impacts on migratory species. Where possible, regional distinctions were made, and impacts were considered for the different high level species groups relevant to migratory species (i.e. mammals, reptiles, birds and fish).

Initially a brainstorming approach was used as a tool to explore the different potential item types, materials, sources, pathways and impacts of marine debris. The result was an inventory of possible characteristics of marine debris and its impacts. This allowed the extension of the subsequent literature review to explore currently un-documented or under-documented types and impacts of debris.

The literature review used academic and ‘grey’ literature to outline the present state of knowledge as regards these different aspects of marine debris and its impacts. The brainstorm and subsequent review were used to draw conclusions regarding which areas of the topic currently exhibit knowledge gaps.

A review was then undertaken on the management of marine debris, which included monitoring, removal and prevention strategies. Knowledge gaps with regard to these strategies were evaluated by reviewing both academic and grey literature, as well as other web-based sources of information.

Finally, challenges in the management of marine debris’ impacts on migratory species were outlined and recommendations were made for opportunities for CMS to engage and assist in filling the identified knowledge gaps and overcoming the indicated challenges.

E2.0 Key Findings

In “Origins and Pathways” (Section 2.0) the knowledge gaps regarding types of marine debris and their origins are assessed. Although there are many sources of data on marine debris, when considered globally, the key findings are:

- There is very limited information available regarding debris prevalence by source and pathway;

- Information regarding prevalence of marine debris by material type is not collected systematically in most regions, even where there is monitoring effort;
- There is slightly better information available regarding the prevalence of marine debris by item type. However, some key types, particularly microplastics, are not yet included in systematic monitoring attempts;
- Monitoring of prevalence of debris types in different marine compartments such as the sea bed, the water column and the surface is poor relative to the monitoring of beach debris;
- There are no robust data regarding the amount of debris in the ocean or how much enters the ocean each year;
- There are not yet robust data regarding the geographical distribution of debris or its distribution between marine compartments;
- The fate of debris in terms of fragmentation, decomposition, distribution and accumulation is not well characterized;
- Knowledge of these characteristics of marine debris is constrained both by methodological limitations and uneven geographical distribution of monitoring and research effort; and
- Studies in different geographical regions and sea compartments currently tend to produce incomparable data because standardized methods either do not exist or are not applied.

In “Impacts on Migratory Species” (Section 3.0) the current state of knowledge regarding the impacts of marine debris on migratory species are surveyed and knowledge gaps assessed. The key findings, in terms of knowledge gaps, are as follows:

- There is not enough quantitative information on the prevalence of impacts within populations to understand which species are the most affected by marine debris;
- The mechanisms and extent of harm associated with sublethal impacts of marine debris are poorly characterized;
- Interaction between sublethal impacts of marine debris and other stressors are unknown;
- The reporting of impacts does not take into consideration measures of animal welfare;
- There are almost no data on the population level effects of marine debris;
- The specific effects of marine debris on migratory as opposed to resident species are poorly understood;
- Further research would be needed to establish if associations between vulnerability to marine debris and life history stage or habits warrant targeted approaches;
- Absence of evidence regarding debris impacts generally reflects uneven allocation of monitoring resources rather than regional distinctions; and
- Impact studies currently tend to produce incomparable data because standardized methods do not exist.

Additionally, the contribution of different types of debris to the different impacts is evaluated. It is found that:

- The scoring of impacts according to marine debris type is not undertaken on a sufficiently comparable basis to allow robust ranking of debris types for risk of harm across different species groups and impacts, even though some trends within specific impact types are evident;
- Scoring is likely to be biased towards conspicuously identifiable items;
- The effect of microplastics on the species ingesting them is not yet fully characterized; and
- Apart from a few specific examples (such as items designed specifically for catching wildlife, or soft plastics) the effects of colour, shape or plastic type on the likelihood of causing harm are not well enough understood to warrant focussing of management strategies at present.

In “Management of Debris in Marine Ecosystems” (Section 4.0) knowledge gaps specific to monitoring, removal and prevention of debris are considered.

Concerning monitoring and with particular regard to migratory species, the following areas were found to have significant gaps:

- Prevalence of all the types of debris that may, or are known to, have impacts on migratory species;
- Sources and pathways of these types of debris;
- Geographic distribution of these types of debris;
- Impacts on migratory species, within and between regions; and
- Population level effects on migratory species.

The kind of information gaps most relevant to the impacts on migratory species as regards debris removal management initiatives are:

- Efficacy in terms of impact on stock and flow of marine debris;
- Efficacy in terms of mitigating impacts on marine species, specific to migratory species if possible;
- Efficacy in terms of public awareness and behaviour change – whether regarding the public, fishermen, industry, and other stakeholders; and
- Cost-effectiveness.

Regarding preventing waste reaching the marine environment, there are a number of aspects of the different strategies that are as yet poorly characterized. The key areas are:

- Effectiveness in terms of flow of marine debris;
- Effectiveness in terms of impacts on marine species, specific to migratory species if possible; and
- Cost-effectiveness.

However, preventative measures focused on land-based sources will inevitably reduce the amount of debris reaching the marine environment in the first place, and these should be pursued even in the absence of more robust information.

Economic instruments and other measures preventing litter (such as deposit-refunds on beverage containers, and levies on single-use carrier bags) have the added benefit of tackling

the disamenity impacts of litter on land, which given the identification of emerging evidence on *indirect* costs of litter in respect of crime and mental health, are considerable. Therefore the benefits are not just of relevance to the marine environment. In the context of uncertainty regarding sources of marine debris, they are ‘no regrets’ measures with a range of additional benefits. Focus should also be directed on management strategies that deal with debris known to be of high impact on marine species – such as fishing gear, soft plastic and (micro)plastic fragments. The numbers we do have on debris abundance also suggest that prevention must be addressed before removal can be effective.

This report also reviewed the jurisdictional, legislative and financial challenges in the management of marine debris. The jurisdictional challenges relate to the transboundary nature of both marine debris and migratory species. There are a number of relevant multilateral agreements that could provide an adequate framework for tackling marine debris such as

- The Convention on Migratory Species itself, its Family Agreements and MoUs relevant to marine species
- The UNEP Regional Seas Conventions and Action Plans (RSCAPs);
- MARPOL Annex V;
- The London Convention; and
- UNEP’s Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA-Marine).

However each of these has significant gaps in coverage, for example:

- Only around 60% of countries with a coastline are Parties to the Convention on Migratory Species, Family Agreements or MOUs with relevance to a marine species. This leaves many range states for marine migratory species outside the influence of the Convention with regard to marine debris;
- RSCAPs do not cover every marine region, with the South West Atlantic, North West Atlantic and the northerly parts of the Pacific not included. Some of the Regional Seas do not yet have legally binding Conventions detailing how Regional Action Plans will be implemented. Not all countries within RSCAPs have ratified the existing Protocols relevant to marine debris. RSCAPs also do not cover landlocked countries which may be contributing to marine debris via estuarine litter;
- Many countries are not parties to MARPOL Annex V or the London Convention (for more detail, see Report II). These Conventions only address at-sea sources of debris;
- Many countries do not yet have action plans for the implementation of GPA-Marine, which covers land based sources of debris; and
- Addressing marine debris already present in the high seas is outside the scope of any of these agreements, and there are limitations to how effective they are at controlling the activities of flag vessels on the high seas.

With the exception of the high seas, the different agreements are otherwise able to complement each other to provide full coverage of the issue geographically and in terms of sources of debris, but in order to do so they must be ratified by every relevant country.

In terms of the legislature itself, the main problems are that agreements or action plans:

- Are generally not legally binding;

- Often lack specific mention of marine debris; and
- Usually lack a mechanism for enforcement.

Because there are few legally binding instruments regarding marine debris at the national level, enforcement issues are exacerbated.

Financially, the mandatory and voluntary contributions available to conservation-related Conventions are of a scale suitable for supporting strategic actions, such as those covered in the Recommendations below. However, filling knowledge gaps requires sustained concerted effort and funding, and obtaining this kind of funding is in itself one of the greatest conservation challenges. Some suggestions regarding funding sources have been made in Section 6.4.2.

E3.0 Recommendations

The challenges for the management of marine debris are many. The following opportunities for the Convention on Migratory Species to assist in overcoming these have been identified. The recommendations have been prioritized according to the rationale that global frameworks are an important foundation for action, but concrete management actions are needed to reduce impacts of marine debris; Parties to the Convention are the principal actors in this regard and finally, that land based activities are the predominant source of debris.

Parties and Signatories could

- Address their commitments under the Convention relevant to marine debris and/or implement relevant provisions of Conservation Plans by:
 - Implementing specific actions directly such as
 - Deposit-refund schemes;
 - Levies on single-use carrier bags;
 - Obligations for the use of reusable items at events; and
 - Marine debris awareness and action campaigns.
 - Engaging with other global marine initiatives such as:
 - GPA-Marine – including completion of GPA-Marine National Plans of Action, and to ensure these have specific mention of marine debris;
 - Regional Seas Programmes – including conclusion of specific Protocols on protection of the marine environment from land-based activities, and completion of Regional Action Plans either containing specific mention of marine debris, or completion of a specific Action Plan exclusively on marine debris;
 - The Global Partnership on Marine Litter (GPML);
 - The Global Partnership on Waste Management (GPWM); and
 - The Honolulu Commitment and the Honolulu Strategy on marine debris.
 - Ratifying other relevant Conventions such as MARPOL Annex V and the London Convention;

- Amend, if necessary, existing Action Plans to make more specific reference to marine debris.
- Appoint a dedicated Councillor for Marine Debris to the Scientific Council.

The Scientific Council, with support from the Secretariat of CMS and where applicable the assistance of the Secretariats and Coordinating Units of relevant Family Agreements and MOUs could:

- Propose that Parties appoint a dedicated Councillor to the Scientific Council and establish a specific marine debris working group to develop the Convention's marine debris work;
- Co-operate with other biodiversity-related agreements such as the UNEP Regional Seas Conventions, the Convention on Biological Diversity or the International Whaling Commission to establish an approach to encourage Parties to tackle marine debris, via an inter-convention working group;

The Secretariat could:

- Expand the network of organisations it works with to include as great a variety of stakeholders with relevance to marine debris as possible. UNEP RSCAPs are a high level example; on a smaller scale field projects could be used to engage with stakeholders of particular relevance to or having particular contact with migratory species;
- Co-ordinate, encourage the creation of, or give endorsement to, marine debris campaigns of specific relevance to migratory species;
- Remind Parties of their commitments under the Convention with relevance to marine debris; i.e. the commitment to conserve habitats and reduce the impacts of activities that endanger species or impede migration;
- Remind MOU Signatories of the elements of agreements they have made relevant to marine debris such as the protection of species and conservation of habitats;
- When future Agreements and Action Plans are developed, encourage that these contain specific reference to marine debris in;
- Endeavour to increase the number of Parties to the Convention, especially coastal nations;
- Strive to ensure that all the countries relevant to Family Agreements and Memoranda of Understanding with relevance to marine species respectively become Parties of or Signatories to these agreements;
- Use all of the fora it participates in to make policy-makers aware that marine debris is an important issue, and therefore:
 - Marine debris should be included in relevant legislation;
 - Funding should be provided for measures; and
 - Enforcement mechanisms should be put in place.

Based on the extensive research conducted outlining what is, and what is not known about marine debris and its impacts on migratory species, the following recommendations were made for opportunities the Convention could assist in regarding filling the identified knowledge gaps.

Parties to the Convention or Family agreements should;

- Participate in marine debris monitoring programmes in the Regional Seas areas; Parties in Regional Seas areas that have not yet assessed current status should be encouraged to implement marine monitoring strategies;
- Plan for and carry out evaluation of any marine debris management strategy undertaken and make the data available to the Secretariat, especially if carried out under the auspices of the Convention or Family Agreements.

Parties to Family agreements could:

- Use National Reporting mechanisms for Family Agreements to return data related to the impacts of marine debris on migratory species relevant to the Agreements;

The Secretariat of CMS could:

- Develop the CMS Initiative on Marine Debris further so it can provide a framework for helping to co-ordinate scientific research programmes on debris and migratory species by;
 - Facilitating the sharing of information relevant to marine debris and research programmes between Family Agreements;
 - Supporting impact monitoring and its standardization by encouraging cooperation between organizations that carry out this kind of monitoring;
- Support the standardization of monitoring in partnership with the Regional Seas Programmes. IOC/UNEP and Regional Seas guidelines are a good foundation for this standardization. It is important for the management of marine debris and its impacts on marine species that:
 - Both weight and count be recorded;
 - Microplastics monitoring is implemented; and
 - Monitoring of impacts on marine species should be implemented where possible.
- Use the return of information about marine debris under the request to Parties made in CMS resolution 10.4, item 6, as an opportunity to focus attention on, and request data which are deemed necessary in the future;
- Support where possible the development of a relational database to translate information on marine debris into risk presented to wildlife; and
- Support the setting of marine debris targets, which encourages the implementation of monitoring programs. These targets should include targets relating directly to impacts on wildlife.

Secretariats and Coordinating Units of relevant Family Agreements and MOUs could

- Request partner organizations such as NGOs or research groups to give access to much needed data;

As a final and overarching recommendation regarding the issue of marine debris, it is considered very important that CMS Parties or any other stakeholder do not delay actions to prevent debris reaching the marine environment in the first place, while information gaps are filled. Care must be taken to discriminate against strategies and tactics that are ineffectual or counterproductive. However sufficient information is available to be sure that the recommended actions on marine debris will have a positive effect on marine debris and its impacts.

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1.0 Knowledge Gaps in Management of Marine Debris

Marine debris is a global problem with many negative environmental, social and economic consequences. The nature, scale and extent of these impacts are an area of active research and the knowledge serves the purpose of building a solid case for action in addressing marine debris. It also helps to define the action that needs to be taken. The Scientific Council of the Convention on Migratory Species was instructed, in Resolution 10.4 on Marine Debris, to identify knowledge gaps in marine debris management and impacts on migratory species.

The Convention on Migratory Species considers marine debris to include:¹

Any anthropogenic, manufactured or processed solid material, irrespective of its size, discarded, disposed of or abandoned in the environment, including all materials discarded into the sea, on the shore, or brought indirectly to the sea by rivers, sewage, storm water or winds

This report serves to outline what we know about marine debris and its impacts on migratory species, and what, conversely, represents knowledge gaps in this regard. It also describes challenges in the management of marine debris, and provides recommendations, relevant to the role of the Convention on Migratory Species, for addressing these challenges and filling information gaps.

1.1 Approach

Initially, a brainstorm was carried out for the four properties of marine debris under consideration here – i.e. material, type, source and pathway. This generated lists of the different potential kinds of marine debris. The lists were used as a framework for considering whether there are gaps in our knowledge in respect of any of these properties of marine debris. We also assessed the state of knowledge regarding marine debris in different regions, as defined by the 18 Regional Seas Programme areas.

Regarding the impacts of marine debris on migratory species, a brainstorm was also undertaken, to produce a framework for assessing knowledge gaps. It covered both impacts that could be applicable to marine mammals generally, as well as those that were hypothesised to be more specific to migratory species.

With these frameworks in mind, a literature review was undertaken to outline the current state of knowledge regarding these areas. Internet searches were conducted (using Google) to reveal grey literature such as reports and information on websites. Web of Science and Google Scholar were used to make more specific searches in the academic literature regarding particular topics, especially regarding impacts on migratory species. Information on migratory species was provided by CMS and also

¹ UNEP, and CMS (2011) Resolution 10.4 Marine Debris. UNEP/CMS/Resolution 10.4

obtained from the IUCN Redlist. Literature recommendations were collated from the client and the collaborator's prior knowledge and references pursued from the bibliographies of already identified references ("snowballing"). No limitations were placed on literature in terms of date or amount of quantitative information.

Information on management approaches was gathered in the same way.

2.0 Origins and Pathways

There are little to no empirical data on the quantity of marine debris in or entering the marine environment. Early estimates from the National Academy of Sciences (NAS) put the influx at approximately 6.4 million tons annually.² This estimate was derived from the amount of waste generated from ocean vessels (i.e. maritime sources alone), prior to MARPOL Annex V which prohibits and restricts the dumping of garbage at sea, coming into force in 1988.³ Therefore this may now be an overestimate of maritime sources of waste, although an increase in maritime traffic in the intervening period may counterbalance any overestimation. Also, between 80-90% of marine debris is thought to originate from land-based sources,^{4,5} and post-consumer waste has increased markedly since 1975 when the estimate was made by the NAS. Even single events can cause dramatic point-source increases of a comparable magnitude, such as the 2011 Japanese tsunami which created an estimated 1.5 million tons of floating debris.⁶ Therefore there are potentially very large quantities of debris still entering the ocean every year from both at sea sources such as marine vessels, and land-based pathways with vectors such as rivers, tides and the wind carrying away waste that is not adequately controlled.

Debris accumulates in five main oceanic gyres, and gathers in drift lines and convergence zones, which are also important feeding areas for many oceanic species, such as sea birds, pelagic fish and sea turtles.⁷

² National Academy of Sciences (1975) *Assessing Potential Ocean Pollutants: A Report of the Study Panel on Assessing Potential Ocean Pollutants to the Ocean Affairs Board, Commission on Natural Resources, National Research Council.*, 1975

³ <http://www.imo.org/About/Conventions/ListOfConventions/Pages/International-Convention-for-the-Prevention-of-Pollution-from-Ships-%28MARPOL%29.aspx>

⁴ Faris, J., and Hart, K. (1994) *Seas of Debris: A Summary of the Third International Conference on Marine Debris: A Summary of the Third International Conference on Marine Debris*

⁵ Equating the classes "Shoreline & recreational activities", "Smoking related litter", "Dumping" and "Medical/Hygiene" summed together to land based sources. Ocean Conservancy 2012 Data Release, CSV files <http://www.oceanconservancy.org/our-work/international-coastal-cleanup/2012-ocean-trash-index.html>

⁶ NOAA (2013) *Japan Tsunami Debris FAQs*, accessed 5 November 2013, <http://marinedebris.noaa.gov/tsunamidebris/faqs.html>

⁷ Lebreton, L.C.-M., Greer, S.D., and Borrero, J.C. (2012) Numerical modelling of floating debris in the world's oceans, *Marine Pollution Bulletin*, Vol.64, No.3, pp.653-661

2.1 Marine Debris – Sources and Pathways

2.1.1 Sources

Many different classifications of sources exist within marine debris monitoring programs, and these classifications define what information is available about prevalence. The only global monitoring program that has a standardized data recording method is the International Coastal Clean-up (ICC), which has been coordinated internationally by the Ocean Conservancy (a US environmental advocacy group) since 1989. The ICC categorizes debris items into five sources:⁸

- Shoreline & Recreational Activities – e.g. food-related litter, plastic and paper bags, clothing, shoes, toys, shotgun shells;
- Ocean/Waterway Activities – e.g. bait containers, strapping bands, tarps and plastic sheeting, pallets, nets, line, rope, and traps, light bulbs, oil bottles, cleaner bottles, fishing lures;
- Smoking-Related Activities – e.g. filters, lighters, tobacco packaging
- Dumping Activities – e.g. appliances, batteries, building materials, car parts, drums, tyres; and
- Medical/Personal Hygiene – e.g. condoms, diapers, syringes, tampons/applicators.

Worldwide prevalence from the different sources is presented in Table 1. On the whole, shoreline and recreational activities are the source of most debris (65%), with smoking-related activities making the next largest contribution (22%).

Table 1: Prevalence of Litter Items by Source (based on item counts)

Sector	Prevalence of items by source
Shoreline & Recreational Activities	65%
Ocean/Waterway Activities	9%
Smoking-Related Activities	22%
Dumping Activities	2%
Medical/Personal Hygiene	2%

Source: *The Ocean Conservancy 2012 The Ocean Trash Index*

Ocean/waterway activities on average appear to be contributing only 9% to the total debris count. This is of note given that fishing equipment is so prevalent, apparently disproportionately so, when it comes to impacts on marine species (see Section 3.0). It is important to bear in mind however that these data are mostly derived from beach clean-ups, with surveys under the waterline/by watercraft making up only 6% of the

⁸ Ocean Conservancy (2012) *The Ocean Trash Index - Results of the International Coastal Cleanup (ICC)*, 2012, <http://www.oceanconservancy.org/our-work/marine-debris/2012-icc-data-pdf.pdf>

distance covered by the surveys.⁹ This will affect the debris composition recorded and hence the prevalence of different sources of litter.

Regionally, further distinctions can be made (Table 2) although the overall pattern of waste source is similar across most regions. Items categorized under 'shoreline and recreational activities' are most common in the Western Africa Region at 82% and least common in the Black Sea Area (16%). By contrast the Black Sea Area is the most afflicted by smoking-related litter (80%), while the least affected is the Western Africa Region. The North West Pacific and the North East Atlantic have the highest proportions of ocean and waterway activity derived debris. For dumping activities, the South East Pacific is the worst afflicted (9%), while the Black Sea is the least (<1%). And for medical/personal hygiene items, the East Asian Seas, the Red Sea Area and Gulf of Aden Region and the South East Pacific are the worst affected.

Table 2: Sources of Marine Debris by Region

RSCAP	Shoreline & Recreational Activities	Ocean/ Waterway Activities	Smoking-Related Activities	Dumping Activities	Medical/ Personal Hygiene
Baltic Sea	57%	3%	38%	3%	0%
Black Sea	16%	2%	80%	0%	1%
Caspian Sea	52%	3%	44%	2%	0%
East Asian Seas	63%	18%	12%	1%	6%
Eastern African Region	77%	12%	8%	2%	1%
Mediterranean	31%	5%	62%	2%	1%
North-East Atlantic	55%	20%	23%	2%	1%
North-East Pacific	74%	5%	19%	1%	1%
North-West Pacific	55%	22%	20%	3%	0%
Pacific	59%	6%	32%	2%	1%
Red Sea & Gulf of Aden Region	71%	12%	13%	1%	3%
ROPME Sea Region	63%	11%	21%	4%	2%
South Asian Seas	70%	13%	14%	2%	2%
South East Pacific	67%	11%	11%	9%	3%
Western Africa Region	82%	11%	5%	1%	1%
Wider Caribbean	67%	5%	25%	2%	1%
Grand Total	64%	7%	26%	2%	1%

Source: The Ocean Conservancy 2012 The Ocean Trash Index.

⁹ 1,119 miles out of a total of 17,719 miles. Ocean Conservancy (2012) *The Ocean Trash Index - Results of the International Coastal Cleanup (ICC)*, 2012, <http://www.oceanconservancy.org/our-work/marine-debris/2012-icc-data-pdf.pdf>

Another informative way of categorizing debris by source is by defining it simply as derived from land-based versus sea-based sources. As discussed in the introductory Section (2.0), approximate global proportions, of which there are few estimates, are given as 80-90% coming from land-based sources. In terms of regional distinctions, from this dataset, if we consider shoreline, smoking, dumping and medical waste as land-based, the area with the lowest proportion of land-based debris is the North West Pacific at 78%, and the highest is the Black Sea, with 98%. This range shows how predominant land activity derived debris is likely to be. However there are many items which could in theory be scored against more than one source category, so this should be taken into consideration when interpreting these data; the proportion of land derived debris is likely to be overestimated to a moderate extent because of this. Some of the item types within this category could conceivably be sourced from passenger shipping, other commercial shipping or recreational boating, for example. In the US, the National Marine Debris Monitoring Program (NMDMP) recognized this by assigning their 31 indicator items into three categories – sea-based, land-based and general, the general category including mostly packaging. The resultant split from 2007's data was 49% land-based, 33% general and 18% sea-based, which gives an indication as to the extent to which the ICC figures for land-based debris are maxima.¹⁰ For example, if the assumption was made that half of the items in the general category are actually land-based and half sea-based, the proportion of land-based to sea-based debris would be 64% and 38% respectively.

The ICC scoring method, because it is based on the attribution of item types to sources, has limitations regarding the information it can provide about the sources of marine debris. The choice of item type and its attribution will cause some sources to be underestimated or neglected, and others to be overestimated. Because it does not (and cannot) include all item types (e.g. plastic pellets), it cannot estimate the contribution of the corresponding source to marine debris (the manufacturing industry). There are also many items that it does not consider because it is difficult to assign them exclusively to one particular source. An example is plastic sheeting, which might derive from the agricultural sector as covering for polytunnel greenhouses, from use as tarpaulins from commercial shipping or fishing activities, or as covering for building materials in the construction industry. Many item types it does consider could derive from multiple sources. There will always be limitations to the extent to which it is possible to assign items to a source.

An interesting methodology to overcome the limitations of marine litter monitoring methods as regards determination of source was used in a pilot study for the European Commission. The aim was to determine points at which plastic waste was escaping legitimate management systems in the EU through a mixture of workshops and interviews with stakeholders in Member States and data modelling.¹¹ Fifteen

¹⁰ Ocean Conservancy, and Sheavley (2007) *National Marine Debris Monitoring Program - Final Program Report, Data Analysis and Summary*, 2007

¹¹ Arcadis (2012) *Case studies on the plastic cycle and its loopholes in the four European regional seas areas*, Report for DG Environment, 2012

different sectors were identified, contributing to marine debris via 27 different pathways and five different vectors. The 15 sectors were:

- Agriculture;
- Aquaculture;
- Construction and demolition (C&D);
- Coastal/Beach Tourism;
- Dump sites/landfills;
- Fishing;
- General Household;
- Other industrial activities;
- Other maritime industries;
- Ports;
- Recreational Boating;
- Recreational Fishing;
- Sewage;
- Shipping; and
- Waste collection/treatment.

A set of assumptions was made about the probability that a particular item type is associated with each sector. This was used to relate item types as recorded by local marine litter monitoring schemes to the 15 sources. The probabilities were informed by OSPAR 'indicator-item' types (which are considered to be attributed to certain sources) as well as interview/workshop information to help validate the assumptions made about the probabilities. The result was a semi-quantitative framework allowing attribution of litter types to sources and hence the determination of the contribution of different sources to marine litter, as presented in Table 3. Only the four categories that together accounted for most of the debris (>90%) are shown).

Table 3: Marine Debris by Source, presented as ranges across four EU locations. Regional Sea Area represented by each location in brackets.

Sector	Oostende (North Sea)	Barcelona (Mediterranean)	Riga (Baltic Sea)	Costanta (Black Sea)
Recreation and tourism	39%	41%	34%	59%
Sewage	1%	26%	29%	0.3%
Waste Collection/Treatment/Landfill/Household	10%	17%	19%	28%
Shipping, fisheries	41%	10%	12%	8%

Source: Arcadis (2012) *Case studies on the plastic cycle and its loopholes in the four European regional seas areas*, Report for DG Environment, 2012

This method suggests that in the North Sea, ocean/waterways activities are responsible for more debris (41%) than perhaps suggested by the ICC results (20% for the North East Atlantic). It ascribes much higher proportions of debris to the Sewage Sector for the Mediterranean and Baltic (26 and 29% respectively) than the ICC results (1 and 0% respectively). Also it allows attribution to the Waste Management Sector, which is a quite significant proportion, at 10-28%. The comparison between the two methods demonstrates what a difference different methodologies – i.e. item types and attributions – make to estimates of source and hence what we assume about the relative importance of different sources.

An overview of Regional Seas reports catalogued major sources of marine litter.¹² The list is reproduced below and features an even more detailed breakdown than the above. Aside from the approaches used above to attribute item types to the categories, much of the information that exists about these sources is simply related to reports that support the fact that they exist, or anecdotes, with scarce quantitative information, or simply ‘common sense’ about what is possible and likely. This list does not distinguish source (as in sector of society/industry) and pathway (means by which debris reaches the ocean).

- Land based sources:
 - Wastes from legal and illegal dumpsites located on the coast or river banks;
 - Rivers and floodwaters;
 - Industrial outfalls;

¹² UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

- Discharge from storm water drains;
- Untreated municipal sewerage;
- Littering of beaches and coastal picnic and recreation areas;
- Tourism and recreational use of the coasts;
- Fishing industry activities;
- Ship breaking yards; and
- Others
- Sea based sources:
 - Shipping;
 - Merchant;
 - Public transport;
 - Pleasure;
 - Naval;
 - Research;
 - Fishing;
 - Vessels;
 - Angling;
 - Aquaculture;
 - Offshore mining and extraction;
 - Vessels;
 - Offshore platforms;
 - Authorized and unauthorized dumping at sea;
 - Fishing gear (ALDFG);
 - Illegal, unreported and unregulated fishing activities; and
 - Tsunamis, hurricanes and other natural disasters.¹³

Disparate information was found regarding a number of sources of marine debris, and this is provided below. At the very least, this provides evidence that these sectors contribute to marine debris (which the above methods are mostly not taking into account, or considering as separate categories), and therefore provides useful information. Global estimates of absolute amounts are few and far between, and are often outdated. Generally the information found does not allow either the absolute or

¹³ Thompson, R., Moore, C., Andrady, A., Gregory, M., Takada, H., and Weisberg, S. (2005) New Directions in Plastic Debris, *Science*, Vol.310, No.5751, pp.1117–1117

relative contribution of a sector to be determined, whether global estimates or regional distinctions.

- Agricultural activity – Around 75% of material by weight found in the stomach of a stranded Sperm Whale in the Mediterranean was estimated to come from coastal greenhouse agriculture (prevalent in the region), with plastic sheeting, rope, plastic burlap sacking, plastic mulch, hosepipe and plant pots all prominent items.¹⁴
- Aquaculture – In some areas of the South East Pacific, debris mainly comes from aquaculture activities, so the Chilean government added regulations to laws governing fishing and aquaculture assigning responsibility to centres of aquaculture for keeping adjacent waters litter-free, and requiring aquaculture centres to use flotation systems that avoid the release of styrofoam fragments¹⁵
- Coastal landfill sites – in the UK, there are 184 current and 1561 historic landfills in the coastal flood zone.¹⁶ It is likely that worldwide, there are many landfills that risk creating debris either through coastal erosion, or via poor containment and wind-blown debris. However the size of this problem is not quantified. Perhaps Arcadis' estimation of the contribution of debris derived from Waste Collection/Treatment/Landfill/Household for the four EU regions as 10-28% represents a maxima for the size of this problem in this region.
- Construction –The ICC debris counts scores building materials (such as siding, shingles, lumber, bricks, roofing material, rebar) as 1.4% of the number of items of debris collected, suggesting a figure for the contribution of this sector to the marine debris problem. It is unknown whether plastic items such as fencing or piping are included, so this may be an underestimate. However this method does not allow correct attribution to erosion and wave damage to property versus poorly contained materials or waste on building sites or dumping by the industry; this may mean that it is an overestimate.
- Fishing - There is some quantitative evidence regarding the number of fishing nets, line or traps lost for at least nine Regional Sea Areas.¹⁷ The data available are however very fragmented. One estimate was found of 135,400 tons of plastic fishing gear and 23,600 tons of packaging material from the

¹⁴ de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., and Cañadas, A. (2013) As main meal for sperm whales: Plastics debris, *Marine Pollution Bulletin*, Vol.69, No.1-2, pp.206-214

¹⁵ Núñez, P., Pacheco, A.S., and Vásquez, N. (2011) Anthropogenic litter in the SE Pacific: an overview of the problem and possible solutions, *Revista Da Gestão Costeira Integrada*, Vol.11, No.1, pp.115-134

¹⁶ CIRIA (2013) *Guidance on the management of landfill sites and land contamination on eroding or low-lying coastlines*, Report for Defra and the Environment Agency, 2013

¹⁷ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

fishing industry dumped into the sea in 1975.^{18,19} No robust global estimate exists of total amounts.

- Industrial processing – It is evident that pre-processing plastic pellets do escape the manufacturing cycle. Some surveys have put the prevalence of pellets as high as 10% of small plastics sampled.²⁰ However this is subject to wide variation depending on the location. For example, on the Belgian coast, the prevalence of pellets was low except in harbour areas, suggesting also that shipping of raw materials is a source here too.²¹
- Medical sector – we can infer from items recorded in (e.g., the ICC clean-ups) that medical waste does find its way into the oceans, and the proportion of debris that comes from this source (0.1%). However it may be a step too far to attribute medical debris to the hospital sector in particular. In one example, the “Syringe Tide” that affected New Jersey and New York in the late ‘80s, was traced to improper waste management at the Fresh Kills Landfill on Staten Island.²² This illustrates the difficulty with making assumptions regarding source from item type alone.
- Military activity – There are many marine sites historically used for dumping military waste such as munitions, constituting hundreds of thousands if not millions of tonnes of debris. The fate and movement of this kind of debris is unknown but natural disasters such as tsunamis may increase the distribution of debris of this nature.²³
- Nuclear sector – prior to international treaties banning ocean dumping, thirteen countries used ocean disposal as a method for dealing with radioactive waste, both spent fuel, contained and uncontained, and parts of reactors. This is likely to have been at least hundreds of thousands of tons of material.²⁴

¹⁸ Goldberg, E.D. (1997) Plasticizing the Seafloor: An Overview, *Environmental Technology*, Vol.18, No.2, pp.195–201

¹⁹ Derraik, J.G. (2002) The pollution of the marine environment by plastic debris: a review, *Marine Pollution Bulletin*, Vol.44, No.9, pp.842–852

²⁰ McDermid, K.J., and McMullen, T.L. (2004) Quantitative analysis of small-plastic debris on beaches in the Hawaiian archipelago, *Marine Pollution Bulletin*, Vol.48, No.7–8, pp.790–794

²¹ Claessens, M., Meester, S.D., Landuyt, L.V., Clerck, K.D., and Janssen, C.R. (2011) Occurrence and distribution of microplastics in marine sediments along the Belgian coast, *Marine Pollution Bulletin*, Vol.62, No.10, pp.2199–2204

²² http://en.wikipedia.org/wiki/Syringe_Tide

²³ Stauber, R. (2011) Research effort to document military munitions disposal sites worldwide, *Technical Proceeding of the 5th International Marine Debris Conference (2011)* and <http://www.globalissues.org/news/2011/04/14/9280>

²⁴ IAEA (1999) *Inventory of Radioactive Waste Disposals at Sea, 1999*, http://www-pub.iaea.org/MTCD/Publications/PDF/te_1105_prn.pdf

- Recreational vessels vs naval vessels - Recreational vessels were considered to be the source of 52% of all rubbish and U. S. Naval vessels responsible for around 20%, according to an estimate made around 1994.^{25,26}
- Shipping – although detailed statistics are not kept, the World Shipping Council made an estimate, based on industry interviews, of 675 containers being lost per year on average, out of 100m containers transported per year.²⁷ Other figures of 2,000-10,000 containers are popularly cited but it has not been possible to substantiate these. In 1982 it was estimated that 639,000 plastic containers were dumped by merchant ships each day.^{28,29} The ICC's 9% for debris relating to 'ocean/waterway activities' is potentially an overestimate because it includes all marine activity such as fishing, yet may by contrast be an underestimate because it is unlikely to include cargo.
- Water treatment sector – Untreated sewage may get into waterways via combined sewage overflows or incorrectly connected plumbing.³⁰ There are also many places in the world where there is no sewage treatment. However it is not clear what percentage of wastewater this applies to. It is not just untreated sewage that is potentially a source of marine debris. Treated sewage may also be contributing to debris entering the marine environment, simply because treatment is unable to capture all the relevant material. One example is clothing fibres derived from washing clothes, which were determined by one study as a dominant source for the microplastic particles sampled.³¹ Microplastic particles in exfoliants or cleaning agents can also get into the water system via legitimately treated sewage, though there is no systematic monitoring in this regard.³² Another source of marine debris identified from sewage treatment is the accidental release of sewage discs (used to increase the surface area for treatment bacteria to grow on) from plant discharge outlets. In Hooksett, New Hampshire, up to 8 million plastic

²⁵ Goldberg, E.D. (1997) Plasticizing the Seafloor: An Overview, *Environmental Technology*, Vol.18, No.2, pp.195–201

²⁶ Derraik, J.G. (2002) The pollution of the marine environment by plastic debris: a review, *Marine Pollution Bulletin*, Vol.44, No.9, pp.842–852

²⁷ World Shipping Council (2011) Containers Lost at Sea

²⁸ Goldberg, E.D. (1997) Plasticizing the Seafloor: An Overview, *Environmental Technology*, Vol.18, No.2, pp.195–201

²⁹ Derraik, J.G. (2002) The pollution of the marine environment by plastic debris: a review, *Marine Pollution Bulletin*, Vol.44, No.9, pp.842–852

³⁰ <http://www.theguardian.com/environment/2013/jul/07/england-polluted-beaches-tide-of-filth>

³¹ Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T., and Thompson, R. (2011) Accumulation of microplastic on shorelines worldwide: sources and sinks, *Environmental Science & Technology*, Vol.45, No.21, pp.9175–9179

³² Fendall, L.S., and Sewell, M.A. (2009) Contributing to marine pollution by washing your face: Microplastics in facial cleansers, *Marine Pollution Bulletin*, Vol.58, No.8, pp.1225–1228

discs were released.³³ Two other incidents were also identified, in Groton, Connecticut (a million discs released)³⁴ and Mamaroneck (New York).³⁵ Another example is cotton bud sticks – treatment plant filter mesh size is inadequate to stop all of them.³⁶ Cotton bud sticks are an item type not scored by the ICC, yet have been shown to be a significant item in surveys in the North-East Atlantic and the Mediterranean where they are a counted item type (in OSPAR and MAP litter surveys).³⁷ Microplastics are also not scored by the ICC. This shows the types of knowledge gaps that can arise simply as a result of scoring methodology. The relevant ICC category (medical/personal hygiene) may therefore be underestimating the extent of the contribution of this sector to marine debris.

The remainder, which the project team hypothesised were significant sources, but for which no specific information was found, are as follows:

- Beach establishments and coastal hotels – items that would be generated by this sector are likely to be included within ‘Recreational and shoreline activities’ in the ICC monitoring scheme – yet it is not clear whether they are responsible for a significant proportion of these.
- Informal Waste Sector – in many countries, informal waste operatives contribute significantly to waste management. Whether there are practices in this sector that make the creation of marine debris more likely, such as lack of containment, is unknown, and their general contribution to marine debris, likewise. This however is unsurprising given that even the relative size of this sector globally represents an unknown.³⁸
- Industrial outfall – the identification of ‘Taprogge balls’, small abrasive sponges used for cleaning pipes in power stations and other industrial systems, in marine debris is evidence that this sector is a source of marine debris; though there is no measure of how significant this source is globally.³⁹
- Off-shore platforms – no information was found in this regard.
- Passenger vessels – Cruise ships generate a large amount of waste (see Report II) which is likely to be similar in type to household waste. It therefore

³³ <http://www.gloucestertimes.com/local/x814643010/City-advances-sewage-disc-cleanup/print>

³⁴ <http://www.nashuatelegraph.com/news/913108-196/disks-in-the-river-wasted-material.html>

³⁵ <http://theloopny.com/blog/news/larchmont-beach-mystery-once-hit-block-island/>

³⁶ Berkley, C., and ENCAMS (2007) *Sewage related litter: flushing toilets onto beaches* : research report, 2007

³⁷ InterSus, University of Trier, Milieu, UBA, and COM (2013) Issue Paper to the ‘International Conference on Prevention and Management of Marine Litter in European Seas’

³⁸ Lange, U., and Linzner, R. (2013) Role and size of informal sector in waste management – a review, *Proceedings of the ICE - Waste and Resource Management*, Vol.166, No.2, pp.69–83

³⁹ <http://www.sas.org.uk/campaign/ufos/>

will not feature in the attributions made by the ICC and so the amount of debris generated by passenger ships remains an unknown quantity.

- Ports and harbours – Although it is logical that ports and harbours can be a source of debris, most work so far has been in evaluating the costs of debris to them.⁴⁰ Also, it is difficult to see how waste sourced from ports and harbours could be differentiated from ocean/waterway activity type waste, so litter counts are not going to be able to provide information about this.
- Recreational Angling – a US based initiative for collecting and recycling monofilament line from marinas, camps and boating access points has processed 9 million miles of line since 1990, indicating how much might otherwise be ending up in the environment. There are several examples of campaigns targeting anglers, which is evidence that this is considered a significant source of debris.⁴¹ However there is no way of quantifying this via the monitoring currently undertaken.
- Shipbreaking yards – South East Asia has a growing ship-breaking industry and there is concern at the marine debris this generates.⁴² One study examined microplastics found adjacent to a shipbreaking yard, but it is not clear what sort of contribution ship-breaking yards are making to marine debris in quantitative terms.⁴³ Whether other types of scrapyards that happen to be located coastally make significant contributions to debris is unknown.

2.1.2 Pathways

Various different pathways exist by which debris is released into the marine environment. Evidence for them tends to be anecdotal or qualitative, so it is difficult to determine how prevalent the different mechanisms are. Below we summarize the main pathways and information available about them, or rather lack thereof. We also give a selection of miscellaneous pathways for which there is evidence. We then consider what constitutes the knowledge gaps for this topic.

An overview of Regional Seas reports characterized the major pathways by which marine litter was considered to find its way into the sea. The resulting list was as follows:⁴⁴

- Negligent – Loss;

⁴⁰ KIMO (2000) *Impacts of Marine Debris and Oil: Economic and Social Costs to Coastal Communities*, 2000

⁴¹ NOAA (2007) *Reeling In Marine Debris - A Reference Guide to Recycling Monofilament Fishing Line*

⁴² UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

⁴³ Reddy, M.S., Basha, S., Adimurthy, S., and Ramachandraiah, G. (2006) Description of the small plastics fragments in marine sediments along the Alang-Sosiya ship-breaking yard, India, *Estuarine, Coastal and Shelf Science*, pp.656–660

⁴⁴ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

- Negligent - System failures;
- Negligent - Outdated and inadequate waste management practices; and
- Intentional - Public behaviours leading to illegal waste disposal/indiscriminate littering and dumping.

Vectors can also be considered

- Human - By direct dumping;
- Water - Transported by storm water, via drains and rivers towards the sea; and
- Wind - Blown into the sea.

No quantitative information is provided in the report. Clearly part of the difficulty is that establishing pathway is not easy and each category given above, for example, cuts across many sectors and will have a huge range of point sources and possible pathways that fall within those broad categories. There can only be very disparate information available for each one and many different types of research projects would be needed to provide the necessary data. We are not aware of any major monitoring program or standardized methodology for determining the amounts of material travelling via these pathways or vectors.

The modelling approach taken within the EU by Arcadis (2012) concluded that for areas representing the Baltic, the Mediterranean and the North Sea, only around 40% of litter could possibly represent accidental loss, while for the Black Sea region, this went down to 17%. According to these numbers, this means that most debris in all areas derives from intentional littering or dumping, with the Black Sea being the poorest in that regard. This modelling approach perhaps represents the only effort to establish relative contributions of pathway that we are aware of.

In addition, we found some evidence for the following potential pathways for debris to make its way into the ocean.

- Negligent - Loss/Intentional - Illegal: Commercial Fishing activity

The UNEP/FAO report into abandoned, lost or discarded fishing gear noted that there were many factors contributing to gear loss, including the intentional, such as lack of convenient shoreside disposal leading to at sea dumping, and aggravating factors in unintentional loss such as poor weather, illegal fishing, and operational incidents such as snagging on the sea bed or on debris, tangling of lines, gear conflict, gear failure and discards from repair. The pathways were different for each fishery.⁴⁵ Therefore aside from indications from the litter counts (overall 9% debris from ocean related activities), there are no estimates of the relative contributions of the different pathways in the fishing industry. Specific examples of particular relevance to marine species are as follows.

Sections of fishing net that are damaged are sometimes temporarily repaired with contrasting coloured twine (to allow easy relocation of damaged area when the net is

⁴⁵ UNEP, and FAO (2009) *Abandoned, Lost or Otherwise Discarded Fishing Gear*, 2009

retrieved). During subsequent permanent repair, the damaged areas are cut out in a square; Zavadil et al's 2007 study of entangled Northern Fur Seals (*Callorhinus ursinus*) in Alaska, draws attention to the fact that over the years, these two-colour net fragments have been retrieved repeatedly. Anecdotal evidence suggests that net fragments left on deck after mending are easily swept overboard, or may be discarded at sea, in contravention of MARPOL Annex V. Net with large ragged holes or hand stitched repairs was also noted in the stomach contents of Sperm Whales.⁴⁶

A recognized pathway via which seabirds ingest fishhooks is via the eating of offal from fishing boats (particularly that from longline fishing) containing discarded hooks.⁴⁷

➤ Negligent – Loss: Wreckage and cargo

UNESCO estimated that there are 3m shipwrecked vessels lying on the seabed.⁴⁸ A number of this magnitude suggests they could be a considerable source of debris. When the Concordia, a cruise ship, grounded off the coast of Tuscany in 2012, the debris that was produced from the ship's contents gradually floating away was considerable enough that it was requested that a plan be drawn up to manage it.⁴⁹ The evidence related to lost cargo is provided in Section 2.1.1

➤ Negligent - System failures: Sewage treatment and industrial outfalls

Examples of these types of losses might include the ones mentioned above relating to the inability of the water treatment system to deal with microplastics and other items; and incidents such as the loss of sewage treatment discs or pipe cleaning balls. There is no centralised source of information about these kinds of outfalls globally.

➤ Negligent - Outdated and inadequate waste management practices: lack of formal waste management

A UN report states that half the refuse generated in urban areas is uncollected in developing countries.⁵⁰ Where urban centres are close to the coast, this represents a risk for the production of marine debris. It was not possible to find any further analysis of the amount of solid waste generated on coastlines and the percentage covered by formal waste management.

➤ Negligent - Outdated and inadequate waste management practices: Disposing of solid waste down toilets

A survey in the UK revealed that 57% of the population had disposed of solid items down the toilet in the past year, which, given the significant contribution of sewage

⁴⁶ Jacobsen, J.K., Massey, L., and Gulland, F. (2010) Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*), *Marine Pollution Bulletin*, Vol.60, No.5, pp.765–767

⁴⁷ UNEP, and FAO (2009) *Abandoned, Lost or Otherwise Discarded Fishing Gear*, 2009

⁴⁸ <http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/the-underwater-heritage/wrecks/>

⁴⁹ <http://blog.marine-conservation.org/2012/01/debris-from-costa-concordia-wreckage.html>

⁵⁰ UN Habitat (2010) *Collection of Municipal Solid Waste in Developing Countries*, 2010

and medical related items to marine debris, gives an indication of part of the pathway via which they tend to reach the sea.

➤ Intentional - Public behaviours leading to indiscriminate littering

No quantitative statistics exist on littering in terms of the amount of material generated by this behaviour. Inferences can be made based on the frequencies of typically littered items, and that is the basis of the estimation of marine debris generated from shoreline and recreational activities by the ICC; the item types also would likely cover estuarine litter from inland sources too. The proportion was estimated as 65%. One might assume that most of the items counted constitute litter rather than accidentally lost items; the figure could be viewed as a maxima of the contribution of public littering to marine debris.

➤ Intentional: Release of items into the sky

Weather balloons have recently received recognition as a potentially significant source of marine debris. In Australia, an estimated 68 weather balloons are released every day in coastal regions; if half ended up in the ocean, it would equal 12,410 per year.⁵¹ In the UK, the RSPCA and MCS have released statements regarding the danger of balloons to wildlife.^{52,53} They point out the scale of the problem – in the US, the largest balloon release was 1.5 million balloons; in the UK, the number of balloons found on beaches has increased three-fold in 10 years.

The following information was found regarding vectors:

➤ Water - Transported by storm water, via drains and rivers towards the sea

There is scattered estuarine monitoring data. For example, after one storm, 81g/m³ of plastic debris was recorded in storm water running from the land to the sea, and this was considered a major vector for marine debris as a result.⁵⁴ In California, Total Maximum Daily Loads (TMDL) are being established for river pollutants including rubbish; one study measured litter loadings in run off after storms as between 3 and 17 kgs per hectare of catchment area, in order to provide information for the setting of these TMDLs for litter.⁵⁵ Another instance of water as a vector was the Japanese

⁵¹ O'Shea, O.R., Hamann, M., Smith, W., and Taylor, H. (2014) Predictable pollution: An assessment of weather balloons and associated impacts on the marine environment – An example for the Great Barrier Reef, Australia, *Marine Pollution Bulletin*

⁵² RSPCA (2005) Wildlife factsheet: Balloon Releases

⁵³ Marine Conservation Society (2006) What happens to balloons after they are released?

⁵⁴ Ryan, P.G., Moore, C.J., Franeker, J.A. van, and Moloney, C.L. (2009) Monitoring the abundance of plastic debris in the marine environment, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.1999–2012

⁵⁵ Kim, L.-H., Kayhanian, M., and Stenstrom, M.K. (2004) Event mean concentration and loading of litter from highways during storms, *Science of The Total Environment*, Vol.330, No.1–3, pp.101–113

tsunami of 2011, which was estimated to have deposited 1.5m tonnes of marine debris in the ocean.⁵⁶

➤ Water – Coastal Erosion

There are no data available on this, save for the indirectly informative information about coastal landfill sites in the UK discussed above. To what extent coastal erosion leads to debris via its action on coastal property or developments is not known. Coastal erosion is expected to increase as a result of climate change and resultant sea level rise and increased extreme weather events.⁵⁷

➤ Human – by direct dumping

One significant example found was disposal of vessels and platforms at sea. Disposal of vessels and platforms at sea is permitted by the Protocol to the London Convention, given the satisfaction of various criteria and the granting of a permit. In the US, a general permit from the EPA allows ex-naval vessels to be sunk to provide target practice for the military as well as a method of disposal for the ships – this is the SINKEX navy program.⁵⁸ In the past 10 years 70% of all naval vessel disposals were carried out in this way. Thousands of other items such as cars, buses, train carriages, tyres, tanks and oil rigs have also been disposed of under permit from the EPA, even though it is acknowledged that these items can contain asbestos, PCBs and lead. This neglects obligations under international law. The sheer scale of this type of dumping suggests it may be a significant source of marine debris.

According to the US Coast Guard Office of Compliance, the Marine Pollution Act (MARPOL) does not regulate the disposal of fiberglass wrecks at sea. Although MARPOL (1) considers fiberglass as plastic because of the resin in it and (2) makes it illegal to dump plastic anywhere in the ocean, the disposal of fiberglass hulls at sea is not prohibited by this act because MARPOL applies only to "shipboard-generated garbage."⁵⁹

It was not possible to find global figures of how many vessels are dumped using these exceptions and omissions.

The ICC makes its estimate of the contribution of dumping to marine debris (2%) via the monitoring of indicator item types such as car parts, tyres, building materials, drums and appliances. Illegal dumping however encapsulates a broader range of items including general household waste that would not really be accounted for by the indicator item types, as well as the type of vessel, vehicle and platform dumping

⁵⁶ NOAA (2013) *Japan Tsunami Debris FAQs*, accessed 5 November 2013, <http://marinedebris.noaa.gov/tsunamidebris/faqs.html>

⁵⁷ Zhang, K., Douglas, B.C., and Leatherman, S.P. (2004) Global Warming and Coastal Erosion, *Climatic Change*, Vol.64, No.1-2, pp.41–58

⁵⁸ BAN (2011) *Dishonorable Disposal - The Case Against Dumping U.S. Naval Vessels at Sea*, 2011, http://ban.org/library/Dishonorable%20Disposal_BAN%20Report.pdf

⁵⁹ <http://www.epa.gov/region2/water/oceans/wrecks.htm#Fiberglass>

described above. Therefore the estimate of 2% may well be an underestimate of the contribution of illegal dumping to marine debris. Data regarding illegal dumping generally are not easy to obtain and it is likely that only a fraction of countries keep records of it. In the UK, local authorities reported 744,000 incidents of illegal dumping in 2011/2012, two-thirds of which involved household waste.⁶⁰ 1,885 (0.25%) were recorded in watercourses and 25,255 (3.5%) in the 'other' category, which includes sea-fronts and harbour mouths.⁶¹ However although this shows that this is very likely a pathway for marine debris, making estimates of the relative contribution of illegal dumping to marine debris is very difficult.

➤ Wind

It is not difficult to imagine why there is little information on wind as a vector for marine debris, given the sheer number and geographical spread of point sources it could be affecting. Wind features in a number of reports about possible vectors for marine debris but there has been no monitoring found.

We conclude that there is some disparate data available about pathways, but it is not enough to integrate into a very coherent picture of the most significant ways that debris is reaching the sea either globally or in different regions.

2.2 Marine Debris – Types and Prevalence

2.2.1 Material

The availability of robust, comparable data on the prevalence of material types in marine debris is limited by the fact that not every survey methodology completely categorizes items by material. Furthermore, some items are of mixed materials and therefore defy straightforward categorization. As plastic is very much the predominant material type, sometimes scoring even only takes the form of 'plastic versus other material types'.

A review of many studies suggested that 60-80% of marine debris is comprised of plastic.⁶² This trend, from coastline data, is also seen on the seabed, where in one study, in the North Sea, plastic debris was the most prevalent by material type (58%) with metal, wood and textiles making up the remainder.⁶³ On European coasts, sea floor data revealed that plastics (mainly bags and bottles) came to more than 70% of the total item count.⁶⁴ Similar predominance of plastic is observed even in the deep

⁶⁰ Environment Agency (2012) *Official Statistics - Fly-tipping Statistics for England, 2011/12*, Report for DEFRA, 2012

⁶¹ Environment Agency (2009) *Flycapture Guidance*

⁶² Derraik, J.G. (2002) The pollution of the marine environment by plastic debris: a review, *Marine Pollution Bulletin*, Vol.44, No.9, pp.842–852

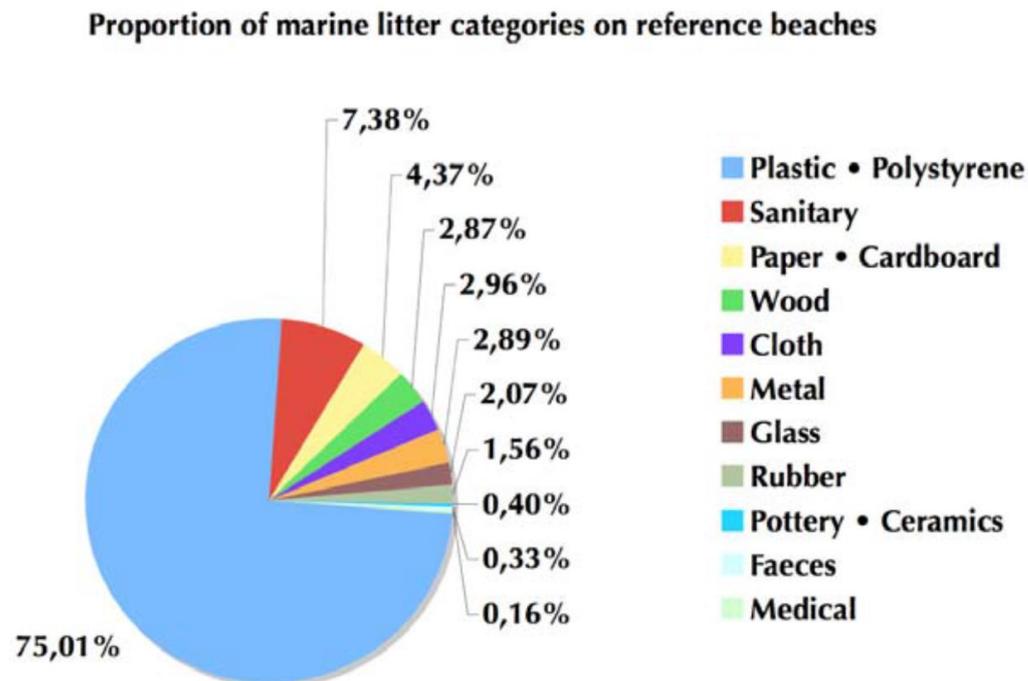
⁶³ KIMO (2008) *Fishing for Litter Scotland Final Report 2005-2008*, 2008

⁶⁴ Galgani, F., Leaute, J.P., Moguedet, P., et al. (2000) Litter on the sea floor along European coasts, *Marine Pollution Bulletin*, Vol.40, No.6, pp.516–527

sea, for example off the west coast of Japan and also off the Californian coast, however this is less marked, with the lowest percentage of plastic observed of 33%.⁶⁵

Figure 1 presents one of the few litter monitoring initiatives that categorizes by material type, for beaches in the North East Atlantic. Plastic is again predominant at 75% and the breakdown into other materials is visible.

Figure 1 Proportion of marine debris by material, 2001-2006, data for OSPAR (North East Atlantic) reference beaches.



Source: ¹ OSPAR, UNEP, and KIMO (2007) *OSPAR Pilot Project on Monitoring Marine Beach Litter: Preventing a Sea of Plastic*, 2007, http://qsr2010.ospar.org/media/assessments/p00306_Litter_Report.pdf

This scheme leaves few materials unmonitored, but perhaps leaves a few questions unanswered about the prevalence of significant sub-types of material such as different types of plastic (e.g., bioplastics and biodegradable plastics – though this is very difficult to evaluate during beach counts), composite materials such as fibreglass (made of glass and plastic – probably scored as a type of plastic) or composite woods such as chipboard (made of wood and glue) or treated wood, that may contain additives that are toxic, such as creosote or preservatives.

⁶⁵ Miyake, H., Shibata, H., and Furushima, Y. (2011) Deep-sea litter study using deep-sea observation tools, *Interdisciplinary Studies on Environmental Chemistry-Marine Environmental Modeling and Analysis*, pp.261–269. Schlining, K., von Thun, S., Kuhn, L., et al. (2013) Debris in the deep: Using a 22-year video annotation database to survey marine litter in Monterey Canyon, central California, USA, *Deep Sea Research Part I: Oceanographic Research Papers*, Vol.79, pp.96–105

Significantly, this kind of monitoring is not carried out in different regions either in a comparable format, or at all. It is not possible therefore to readily make regional distinctions save perhaps to say that plastic is consistently the predominant material. Also there are specific materials for which it might be informative to have information about their global distribution, such as polystyrene, for example, yet this information is not available.

2.2.2 Object Type

The ICC clean-up scorecard focuses on 43 different item types. The global prevalence of each according to 2012 data is shown in Table 4. The most common items by count are cigarette butts (19%), food wrappers/containers (10.2%), beverage bottles (10%), plastic bags (9%) and caps/lids (9%).

This is not necessarily proportional to the impacts they have on marine species. This point has already been made regarding fishing debris, which is not always a large percentage, but is particularly prevalent in terms of impacts (see Section 3.2.2). We also note that glass bottles, at around 5% are a significant item type, yet glass tends not to be recorded in relation to impacts on animals, perhaps because it tends to sink and is also an inert material.

Table 4: Prevalence of Item by Type; within and across Sectors.

Sector/Item type	Prevalence within Sector	Overall Prevalence
Shoreline & Recreational Activities		
Bags(Paper)	4%	2.7%
Bags(Plastic)	14%	9.1%
Balloons	1%	0.6%
Beverage Bottles (plastic) 2 liters or less	15%	9.5%
Glass Beverage Bottles	7%	4.7%
Beverage Cans	5%	3.0%
Caps, Lids	13%	8.6%
Clothing, Shoes	4%	2.6%
Cups, Plates, Forks, Knives, Spoons	10%	6.2%
Food Wrappers/Containers	16%	10.2%
Pull Tabs	1%	0.7%
6-Pack Holders	0%	0.2%
Shotgun Shells/Wadding	0%	0.3%
Straws, Stirrers	8%	5.5%
Toys	1%	0.9%
Ocean/Waterway Activities		
Bait Containers/Packaging	5%	0.4%
Bleach/Cleaner Bottles	5%	0.5%
Buoys/Floats	7%	0.7%

Sector/Item type	Prevalence within Sector	Overall Prevalence
Crab/Lobster/Fish Traps	2%	0.2%
Crates	1%	0.1%
Fishing Line	13%	1.2%
Fishing Lures/Light Sticks	3%	0.3%
Fishing Nets	7%	0.6%
Light Bulbs/Tubes	2%	0.2%
Oil/Lube Bottles	5%	0.4%
Pallets	1%	0.1%
Plastic Sheeting/Tarps	19%	1.7%
Rope	24%	2.2%
Strapping Bands	6%	0.5%
Smoking-Related Activities		
Cigarettes/Cigarette Filters	86%	18.9%
Cigarette Lighters	3%	0.6%
Cigar Tips	7%	1.5%
Tobacco Packaging/Wrappers	5%	1.1%
Dumping Activities		
Appliances (refrigerators, washers, etc.)	4%	0.1%
Batteries	10%	0.2%
Building Materials	65%	1.4%
Cars/Car Parts	8%	0.2%
55-Gallon Drums	2%	0.0%
Tires	12%	0.3%
Medical/Personal Hygiene		
Condoms	12%	0.2%
Diapers	65%	1.3%
Syringes	6%	0.1%
Tampons/Tampon Applicators	17%	0.4%

Source: The Ocean Conservancy 2012 The Ocean Trash Index.

To illustrate regional distinctions between item prevalence, the top 10 items found for 6 different regions (the ones with most weight of trash collected per person per mile) are presented in Table 5. As can be seen, there is no great variation in the most common types of item found, these being smoking or food related debris. The regions where ocean activity related debris makes the top ten are therefore perhaps notable. These regions are the North-East Atlantic, the Eastern Africa Region, the Caspian Sea, the North-West Pacific, the Red Sea & Gulf of Aden Region, the South Asian Seas and the Western Africa Region.

Table 5: Regional Top Ten Items Found During Beach Clean-ups.

Item type	Wider Caribbean
Cigarettes/Cigarette Filters	22%
Beverage Bottles (plastic) 2 liters or less	14%
Caps, Lids	11%
Bags(Plastic)	9%
Food Wrappers/Containers	9%
Cups, Plates, Forks, Knives, Spoons	5%
Glass Beverage Bottles	5%
Beverage Cans	4%
Straws, Stirrers	3%
Bags(Paper)	2%

Item type	North-East Atlantic
Cigarettes/Cigarette Filters	22%
Food Wrappers/Containers	12%
Caps, Lids	10%
Rope	9%
Clothing, Shoes	7%
Beverage Bottles (plastic) 2 liters or less	6%
Bags(Plastic)	6%
Fishing Nets	5%
Beverage Cans	4%
Fishing Line	3%

Item type	North-East Pacific
Bags(Plastic)	17%
Caps, Lids	15%
Beverage Bottles (plastic) 2 liters or less	14%
Cigarettes/Cigarette Filters	14%
Cups, Plates, Forks, Knives, Spoons	6%
Straws, Stirrers	5%
Cigar Tips	4%
Glass Beverage Bottles	4%
Food Wrappers/Containers	3%
Clothing, Shoes	3%

Item type	Mediterranean
Cigarettes/Cigarette Filters	60%
Caps, Lids	6%
Straws, Stirrers	4%
Beverage Bottles (plastic) 2 liters or less	4%
Bags(Plastic)	3%
Beverage Cans	3%
Food Wrappers/Containers	3%
Bags(Paper)	2%
Cups, Plates, Forks, Knives, Spoons	2%
Glass Beverage Bottles	1%

Item type	Baltic Sea
Cigarettes/Cigarette Filters	30%
Bags(Plastic)	10%
Caps, Lids	9%
Food Wrappers/Containers	8%
Beverage Cans	7%
Tobacco Packaging/Wrappers	6%
Glass Beverage Bottles	6%
Beverage Bottles (plastic) 2 liters or less	6%
Bags(Paper)	4%
Clothing, Shoes	3%

Item type	ROPME Sea Region
Cigarettes/Cigarette Filters	19%
Pull Tabs	10%
Beverage Bottles (plastic) 2 liters or less	10%
Cups, Plates, Forks, Knives, Spoons	6%
Bags(Plastic)	6%
Food Wrappers/Containers	6%
Straws, Stirrers	6%
Glass Beverage Bottles	5%
Caps, Lids	5%
Beverage Cans	4%

Source: The Ocean Conservancy 2012 The Ocean Trash Index

Monitoring defined item-types such as the 43 chosen by the ICC is essential for standardization. However it makes it impossible to detect changes in non-target items. For example, the important category of unidentifiable items such as large items >50cm, fragments and microplastics, is unaddressed by the ICC survey.

Microplastics have been defined as particles of less than 5mm in size, an arbitrary threshold based on the propensity for ingestion.⁶⁶ They derive either from the breakdown of larger items (from hard plastics, to fibres in clothes and fishing gear)⁶⁷ or are manufactured as such (e.g. nurdles, cosmetic exfoliants or sandblasting particles). Particles down to 2µm have been isolated from the marine environment but limitations in the ability to detect such fragments limit knowledge regarding their abundance.⁶⁸ Microplastics have been found in all types of marine environment, from deep sea areas of the North and South Atlantic and the Mediterranean,⁶⁹ the shoreline on six continents,⁷⁰ floating in open waters with a prevalence of 88% in the North Atlantic for particles <10mm,⁷¹ and 89% prevalence in the South Pacific for particles 1-5mm;⁷² and in the water column in the North Sea and the East Pacific.^{73,74} Additionally, they have been found in freshwater environments.^{75,76} Their known

⁶⁶ Arthur, C., Baker, J., and Bamford, H. (2009) Proceedings of the International Research Workshop on the Occurrence, Effects and Fate of Micro-plastic Marine Debris, Sept 9-11, 2008 (2009)

⁶⁷ Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T., and Thompson, R. (2011) Accumulation of microplastic on shorelines worldwide: sources and sinks, *Environmental Science & Technology*, Vol.45, No.21, pp.9175–9179, Murray, F., and Cowie, P.R. (2011) Plastic contamination in the decapod crustacean *Nephrops norvegicus* (Linnaeus, 1758), *Marine Pollution Bulletin*, Vol.62, No.6, pp.1207–1217

⁶⁸ Ng, K.L., and Obbard, J.P. (2006) Prevalence of microplastics in Singapore's coastal marine environment, *Marine Pollution Bulletin*, Vol.52, No.7, pp.761–767

⁶⁹ Van Cauwenberghe, L., Vanreusel, A., Mees, J., and Janssen, C.R. (2013) Microplastic pollution in deep-sea sediments, *Environmental Pollution*, Vol.182, pp.495–499

⁷⁰ Browne, M.A., Crump, P., Niven, S.J., Teuten, E., Tonkin, A., Galloway, T., and Thompson, R. (2011) Accumulation of microplastic on shorelines worldwide: sources and sinks, *Environmental Science & Technology*, Vol.45, No.21, pp.9175–9179

⁷¹ Law, K.L., Morét-Ferguson, S., Maximenko, N.A., Proskurowski, G., Peacock, E.E., Hafner, J., and Reddy, C.M. (2010) Plastic Accumulation in the North Atlantic Subtropical Gyre, *Science*, Vol.329, No.5996, pp.1185–1188

⁷² Eriksen, M., Maximenko, N., Thiel, M., et al. (2013) Plastic pollution in the South Pacific subtropical gyre, *Marine Pollution Bulletin*, Vol.68, No.1-2, pp.71–76

⁷³ Dubaish, F., and Liebezeit, G. (2013) Suspended Microplastics and Black Carbon Particles in the Jade System, Southern North Sea, *Water, Air, & Soil Pollution*, Vol.224, No.2, pp.1–8

⁷⁴ Lattin, G.L., Moore, C.J., Zellers, A.F., Moore, S.L., and Weisberg, S.B. (2004) A comparison of neustonic plastic and zooplankton at different depths near the southern California shore, *Marine Pollution Bulletin*, Vol.49, No.4, pp.291–294

⁷⁵ Eriksen, M., Mason, S., Wilson, S., et al. (2013) Microplastic pollution in the surface waters of the Laurentian Great Lakes, *Marine Pollution Bulletin*

⁷⁶ Imhof, H.K., Ivleva, N.P., Schmid, J., Niessner, R., and Laforsch, C. (2013) Contamination of beach sediments of a subalpine lake with microplastic particles, *Current Biology*, Vol.23, No.19, pp.R867–R868

distribution roughly reflects the distribution of marine debris generally (higher concentrations in northern hemisphere than southern, for example),⁷⁷ and appears to be limited only by the locations until now assayed; it is to be expected that wherever they are searched for, they will be found. As microplastics are in part derived from fragmentation of larger items, their abundance is liable to continue to increase.⁷⁸

Pre-manufactured plastic pellets are a debris type that has received some attention owing to their recognisability as such, and their abundance. Some surveys have put the prevalence of pellets as high as 10% of small plastics sampled.⁷⁹ However this is subject to wide variation depending on the location. For example, on the Belgian coast, the prevalence of pellets was low except in harbour areas (incidentally suggesting a source for them).⁸⁰

For most debris that we could think of, at least some indication of its existence was found, even though the high-level significance of them was not always known. Some of the items feature in regional marine debris monitoring initiatives. These include: cotton buds,⁸¹ rubber gloves,⁸² skylanterns,⁸³ hooks,⁸⁴ packing peanuts,⁸⁵ bubblewrap,⁸⁶ PPE (personal protective equipment),⁸⁷ pallets,⁸⁸ flares,⁸⁹ fireworks,⁹⁰ large fragments such as pieces of boats,⁹¹ disposable barbecues,⁹² toothbrushes, floss,⁹³ bagged dog faeces,⁹⁴ printer cartridges⁹⁵ and golf balls,⁹⁶

⁷⁷ Ivar do Sul, J.A., and Costa, M.F. (2014) The present and future of microplastic pollution in the marine environment, *Environmental Pollution*

⁷⁸ Barnes, D.K.A., Galgani, F., Thompson, R.C., and Barlaz, M. (2009) Accumulation and fragmentation of plastic debris in global environments, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.1985–1998

⁷⁹ McDermid, K.J., and McMullen, T.L. (2004) Quantitative analysis of small-plastic debris on beaches in the Hawaiian archipelago, *Marine Pollution Bulletin*, Vol.48, No.7–8, pp.790–794

⁸⁰ Claessens, M., Meester, S.D., Landuyt, L.V., Clerck, K.D., and Janssen, C.R. (2011) Occurrence and distribution of microplastics in marine sediments along the Belgian coast, *Marine Pollution Bulletin*, Vol.62, No.10, pp.2199–2204

⁸¹ OSPAR, UNEP, and KIMO (2007) *OSPAR Pilot Project on Monitoring Marine Beach Litter: Preventing a Sea of Plastic*, 2007, http://qsr2010.ospar.org/media/assessments/p00306_Litter_Report.pdf

⁸² http://marinedebris.noaa.gov/sites/default/files/photo_guide.pdf

⁸³ <http://balloonsblow.org/flaming-litter>

⁸⁴ UNEP, and FAO (2009) *Abandoned, Lost or Otherwise Discarded Fishing Gear*, 2009

⁸⁵ http://www.scdhec.gov/environment/ocrm/marine_debris.htm

⁸⁶ Tangaroa Blue Foundation (2012) *Marine Debris Identification Manual*

⁸⁷ <http://www.bsee.gov/Regulations-and-Guidance/Notices-to-Lessees/2012/2012-BSEE-G01-pdf/>

⁸⁸ <http://sero.nmfs.noaa.gov/pr/pdf/Marine%20Debris%20in%20GOM.pdf>

⁸⁹ <http://sanctuaries.noaa.gov/science/condition/pmm/pressures.html>

⁹⁰ http://thegardenisland.com/news/local/article_6b47c3e2-a60f-11e0-8e55-001cc4c03286.html

⁹¹ <http://www.kpfaalaska.org/wp-content/uploads/2013/05/2013-04-30-Kullluk-Debris-Removal-from-Sitkalidak-Island.pdf>

There were few for which no real information was available at all. These included: industrial platforms, off-shore wind turbines, small Waste Electrical and Electronic Equipment (WEEE) such as phones, fishing spears or harpoons, sails, EPIRBs (distress radio beacons), geotextiles for mitigation of coastal erosion, lagging foam and insulation. Obviously any type of item can become marine debris, but it was felt worthwhile exploring whether any of these had been signalled as significant for any reason. It is difficult to distinguish whether lack of information signifies low frequency and low impact, or just no information.

2.3 Knowledge Gaps

2.3.1 Absence of Data - Flow and Stock

There is a very significant general knowledge gap regarding the amounts of marine debris in and entering the sea. There is no reliable estimate of the total amount of debris already in the ocean (the 'stock' of debris) nor of the amount of debris entering the ocean each year (the 'flow' of debris). There are rare examples of estimates of inputs to the ocean by item type, item source or pathway that may be either regional or global. However often they are based on scarcely more than assumptions or guesses educated by little in the way of hard information.

Strategies to address this type of knowledge gap will be of limited success because global spatial distribution and movements of debris in both vertical and horizontal dimensions occur on such a large geographical and temporal scale, that they dwarf the extent of sampling coverage that is practicable or affordable by researchers. The information that exists reveals wide variation in some of the debris monitoring measures used, such as floating litter. One study that reviewed data from over 6,000 trawls of the North Atlantic gyre over a period of 22 years found that the values fluctuated massively, to a degree that appeared random.⁹⁷ There was no trend visible at this time scale because of the variability of the data. Another study of 22 years' worth of deep sea data also saw no trend, and large fluctuations year on year.⁹⁸ The authors, with the expectation that the data would instead have reflected debris accumulating indefinitely in the ocean, suggested that there were fluxes out of the

⁹² http://www.doeni.gov.uk/marine_litter_watch-edition_1.pdf

⁹³ <http://www.amazon.com/Hawaiian-Islands-Marine-debris-toothbrushes/dp/B00AEFH70>,
<http://www.uvnsw.net.au/galleries/marine-debris?page=1>

⁹⁴ <http://nhmarinedebris.blogspot.co.uk/>

⁹⁵ Tangaroa Blue Foundation (2012) Marine Debris Identification Manual

⁹⁶ <http://www.cleanwater.org/feature/problem-of-marine-plastic-pollution>

⁹⁷ Law, K.L., Morét-Ferguson, S., Maximenko, N.A., Proskurowski, G., Peacock, E.E., Hafner, J., and Reddy, C.M. (2010) Plastic Accumulation in the North Atlantic Subtropical Gyre, *Science*, Vol.329, No.5996, pp.1185–1188

⁹⁸ Schlining, K., von Thun, S., Kuhnz, L., et al. (2013) Debris in the deep: Using a 22-year video annotation database to survey marine litter in Monterey Canyon, central California, USA, *Deep Sea Research Part I: Oceanographic Research Papers*, Vol.79, pp.96–105

system in directions or on a spatial scale that were not being considered, such as vertically, or they were becoming fragmented and too small to be detected by those sampling methods.⁹⁹ Indeed, the fact is that we do not actually know what is happening to the debris in the ocean system – what is its fate, including where and on what geographical scale it can be said to be accumulating.^{100,101} Just the information that the North Pacific Subtropical Convergence Zone (STCZ), which is the location of the North Pacific ‘garbage patch’ where there is a higher concentration of debris, can move around 900km across latitudes seasonally, depending on weather patterns,¹⁰² gives an idea of the scale of factors that are influencing marine debris amounts and even prevalence of different item types, which may be affected differently by vertical and horizontal currents and wind.

A research group modelled how many surface samples would be needed to detect changes in floating plastic of between 10% and 100% to within reasonable certainty. They calculated that it would take 250 samples to detect a 50% increase in microplastic with 80% probability.¹⁰³ To give an indication of the expense of this kind of undertaking, the sampling they undertook of the North Pacific Subtropical Gyre to gather the data to support this model covered 6,000 miles of ocean, with 119 samples, and the analysis of the samples took one year for the lab and a team of volunteers. In Figure 2 a graph is shown of the number of samples needed to assess changes in the concentration of plastic in the ocean to a particular degree of certainty.

⁹⁹ Law, K.L., Morét-Ferguson, S., Maximenko, N.A., Proskurowski, G., Peacock, E.E., Hafner, J., and Reddy, C.M. (2010) Plastic Accumulation in the North Atlantic Subtropical Gyre, *Science*, Vol.329, No.5996, pp.1185–1188

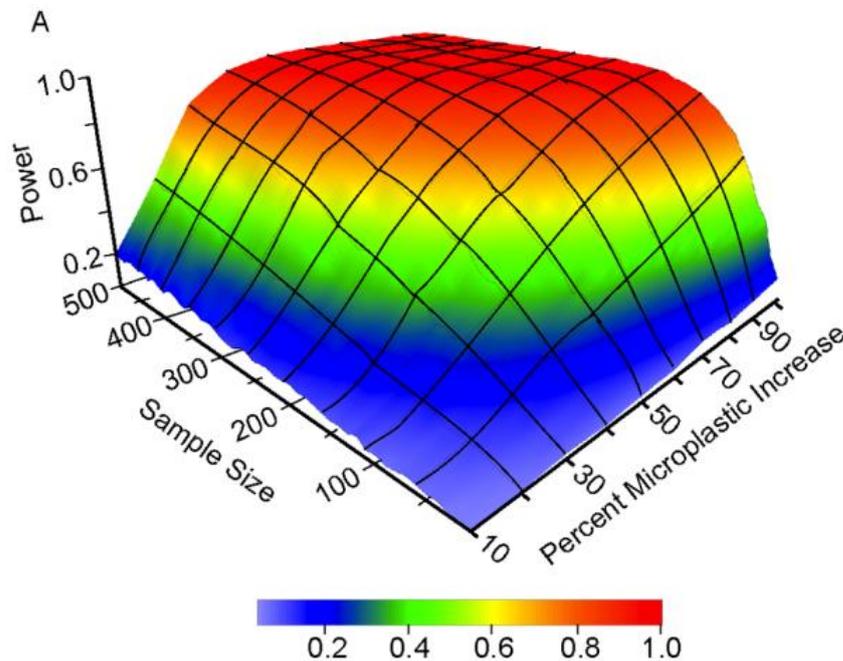
¹⁰⁰ Ryan, P.G., Moore, C.J., Franeker, J.A. van, and Moloney, C.L. (2009) Monitoring the abundance of plastic debris in the marine environment, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.1999–2012

¹⁰¹ Thompson, R.C., Olsen, Y., Mitchell, R.P., et al. (2004) Lost at Sea: Where Is All the Plastic?, *Science*, Vol.304, No.5672, pp.838–838

¹⁰² Donohue, M., and Foley, D.G. (2007) Remote Sensing Reveals Links Among the Endangered Hawaiian Monk Seal, Marine Debris, and El Niño, *Marine Mammal Science*, Vol.23, No.2, pp.468–473

¹⁰³ Goldstein, M.C., Titmus, A.J., and Ford, M. (2013) Scales of Spatial Heterogeneity of Plastic Marine Debris in the Northeast Pacific Ocean, *PLoS ONE*, Vol.8, No.11, p.e80020

Figure 2: Number of samples needed to assess changes in concentration of plastic in ocean to a given degree of certainty



Source: Goldstein, M.C., Titmus, A.J., and Ford, M. (2013) Scales of Spatial Heterogeneity of Plastic Marine Debris in the Northeast Pacific Ocean

The conclusion is that we do not have robust answers to the following questions:

- How much debris enters the marine environment each year? (Whether the total or by country or by type)
- What is the geographic distribution of marine debris?
- What is the distribution of marine debris in different marine compartments?
- What is the fate of different types of marine debris (i.e. decomposition/ fragmentation and accumulation/ distribution pattern)?

These kinds of knowledge gaps lead to problems when trying to determine the relative importance of different sources and pathways globally and regionally, which are important for devising management strategies and tactics. The old dictum states that what can't be measured can't be managed. Subsequently they lead to difficulties in setting quantitative policy targets on marine debris at any level, whether global, regional or by sector.

It may be possible to circumvent some of these issues by using 'operational' measures i.e. that take measurements closer to point sources, such as estuarine litter monitoring. Research could help to evaluate hypotheses about these unanswered questions, for example by improving knowledge about how long each type of marine debris persists (the rates of deterioration of fragmentable and biodegradable plastics in the natural environment is not very well characterized). Modelling approaches have also been used to elucidate the geographic distribution of marine debris. Surveys should also be targeted to answer specific questions; for example, those concerned with biotic interactions should concentrate on monitoring

at a smaller scale in areas where there are high levels of biological activity and debris, such as fronts or eddies. Working with existing oceanographic monitoring programs may also help overcome resource limitations.

2.3.2 Absence of Data - Prevalence

Another way of assessing marine debris is by measuring prevalence according to different parameters. This would be useful because understanding what are the most significant sources or kinds of debris can be the basis for managerial decisions on actions to prevent, reduce and control problems caused by marine litter.¹⁰⁴

The International Coastal Cleanup is a volunteer program carried out by citizens. Although it has the benefit of being standardized in some parameters and having a global reach, it is not considered fully scientific and statistically valid.¹⁰⁵ The Regional Seas areas themselves do not carry out systematic or comprehensive regional measurements and this makes it more difficult to assess the status of marine debris in the regional areas.¹⁰⁶ A summary of the data returned by the twelve Regional Seas areas that participated in the UN's Global Initiative on Marine Litter is provided by the UNEP 2009 report.¹⁰⁷ It is of note that several Regional Seas areas did not participate in the initiative, and of those that did, only six out of twelve returned data. Data was not provided, for example, by North East Pacific, Pacific, ROPME Sea Area, Western Africa and the Antarctic and Arctic, however, as covered above, there is some ICC data from countries in these areas.

Most of the data regarding sources is derived from assumptions regarding the source of particular objects. The reliability of the data depends on how robust the assumptions are about the sources of particular items of debris. There is very little data based on the monitoring of point sources themselves. Therefore there is a lack of data or a lack of specific data on a number of sources that we know exist. Examples are the informal waste sector, industrial outfall, coastal commercial enterprises, off-shore platforms, passenger vessels, ports and harbours, recreational angling, and ship-breaking yards. In broad terms we are fairly certain that the majority originates from land based activities, giving an indication of what some of the more important pathways are likely to be. The points at which waste is escaping management are likely identified correctly, but the absolute or relative quantities of waste entering the ocean via any single one, and hence their relative importance, is an unknown. Regional distinctions are also not possible on a quantitative basis. Even less is understood about the relevant importance of different pathways and vectors

¹⁰⁴ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

¹⁰⁵p19-20, Ocean Conservancy, and Sheavley (2007) *National Marine Debris Monitoring Program - Final Program Report, Data Analysis and Summary*, 2007

¹⁰⁶ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

¹⁰⁷ p204 - UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

for marine debris such as rivers, coastal erosion, or intentional dumping. These are fundamental gaps in our knowledge as regards sources, pathways and vectors of marine debris.

What *is* known about the prevalence of debris by material or item type is limited by the fact that prevalence will vary depending on the type of measure used. Different types of measure include counts of beach litter, floating (neustonic) debris, water column (pelagic) debris or seabed (benthic) debris. For the Regional Seas areas, most data are from beaches; some from open waters and very little from the sea floor. Models suggest that material from sea-based sources is slightly less likely to become beached than material from land-based sources (at 28% versus ~38%).¹⁰⁸ Accordingly it would be expected that the prevalence of item types especially will vary slightly in relation to the different profiles of the sources of debris. Although some trends are observable irrespective of the measure used (e.g. predominance of plastic litter), there may be important nuances that are being lost. One example is the disproportionate effects of fishing nets. Making up only 0.6% of beach debris globally, they appear among the most prevalent items in both entanglement and also ingestion tallies. This may reflect both the fact that their design and presentation gives them the greatest impact (see Section 3.2.3), yet also that perhaps beached debris is not actually well correlated with the amounts of this item type out at sea, which may be greater.

Regarding knowledge gaps for particular materials, the difficulty is that most regional reporting, if there is any, does not monitor by material. However there appears to be at least the consistent message from monitoring that is carried out in this regard, that plastic is the dominant material type. The picture is less clear for other material types and whether their importance is significantly different between regions. There is also not much information regarding different kinds of plastic such as polystyrene or biodegradable plastic, or composite materials such as fibreglass.

Regarding knowledge gaps for particular items, the most significant is undoubtedly microplastics. As plastic in the marine environment breaks down, much of it is destined to become microplastics – so it is, *a priori*, a major item type. There is therefore great concern that there is not enough information on its prevalence or source. One reason there is little information is that microplastics are not always scored in debris data collection efforts. There is also no official, standardized definition of a microplastic particle. Additionally there is no current method for tracing where a piece of microplastic has come from, if it is possible at all. There are suggestions that pre-processing pellets may be traceable based on some properties but these are lost during manufacturing. This leaves the rest of microplastics as unattributable by source. The relative contributions of different pathways for the emission of microplastics into the oceans, whether direct emission as plastic waste, direct emission resulting from their use in cleaning products, or from the weathering of macroplastics, are also not known.

¹⁰⁸ Lebreton, L.C.-M., Greer, S.D., and Borrero, J.C. (2012) Numerical modelling of floating debris in the world's oceans, *Marine Pollution Bulletin*, Vol.64, No.3, pp.653–661

Other examples were found of marine debris types for which little information could be found. There is a difficulty with assessing whether lack of information signifies low frequency and low impact, or just no information. What is known can be limited simply by the fact that a particular object is not listed on a coastal monitoring checklist. Some coastal monitoring methodologies do however have 'other' categories that would allow other significant items to come to light.

In conclusion, the following questions do not yet have comprehensive answers. Though there is a lot of indicative information and some detailed information for a few regions, it is far from comprehensive.

- What are the major sources of marine debris?
- What are the most important pathways and vectors for marine debris?
- What is the geographic distribution of marine debris? Of different kinds?
- What are the relative proportions of macro, micro and nanoplastic entering the marine environment (and which pose the greatest threat)?
- What are the key sources of microplastics?
- Are there any other items that may be of significance that are unmonitored?

2.3.3 Relationships between Item Parameters

A difficulty is that for a large proportion of items, there is a one-to-many relationship between an item type and item material, its source, and also the means by which it found its way into the ocean. There are also many other parameters by which a piece of debris can be scored (e.g. source: land based vs. sea based) that also do not map easily onto other types of categorization such as pathway. As an illustration, examples of items for which these relationships are more straightforward are cotton wool bud sticks and fishing nets. Cotton wool bud sticks found in the marine environment are plastic, they come from sewage (the majority of which is land-based), are purposely discarded of in toilets, and make their way into the ocean either via water treatment works, faultily connected civic water works, or combined sewage overflows. Fishing nets are with rare exception made of plastic, the vast majority (depending on the location, which will provide further clues) will come from commercial fisheries. Even so, there are multiple pathways and behaviours via which nets are lost.

These difficulties make it impossible, with current data collection efforts, to determine source and pathway, which are important for choosing management strategies, identifying stakeholders and target audiences, and devising tactics. However, a modelling approach as exemplified by Arcadis (2012) is a novel approach for circumventing this problem, and could be applied in other regions.

2.3.4 Comparability of Data

Different scoring methods influence the comparability of data between studies. Scoring methods understandably tend to use categories that are the most practicable to assign items to, and these mix item material, item type, and item source quite freely (e.g. plastic items, fishing nets, fishing gear might all be used within the same classification). This can also arise in reports as authors or researchers strive to highlight trends in prevalence. However this means that different studies use

different categories. It makes it difficult to assess regional distinctions and to look at global trends.

The Regional Seas areas use differing methodologies to carry out measurements even within the same marine compartment. Therefore it is not possible to use their data to make comparisons between the regions or to analyse trends.¹⁰⁹

It has been stated that

“Without the systematic collection of reliable data on amounts of marine litter using an internationally approved methodology, no serious assessment of the extent of the problem can be made, and consequently no proper response to the problem can be planned or implemented”¹¹⁰

However it is not necessarily the all-or-nothing situation that this quote might suggest. An adequate response may indeed be possible without the information being in as good a shape as it would be in an ideal world. A balance is probably achievable between precision and inaction, to avoid stalling progress completely. A parallel might be seen with the ‘precautionary approach’, here described in the Rio +20 declaration:

“In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall be not used as a reason for postponing cost-effective measures to prevent environmental degradation.”¹¹¹

The difference here is that irreversible damage is clear, it can be thought of as serious by various different measures, and there are many management approaches that are highly likely to be effective, irrespective of how precisely the extent of the problem is mapped out.

3.0 Impacts on Migratory Species

Any species spending all or part of its life history in a marine area is potentially affected by marine debris. There are approximately 200,000 known marine animal species of which the majority are invertebrates.¹¹² There are around 22,000 vertebrate marine species (including seabirds), within which grouping, all the marine migratory species are found.¹¹³ This includes those fish which spend part of their

¹⁰⁹ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

¹¹⁰ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

¹¹¹ United Nations (1992) *The Rio Declaration on Environment and Development*

¹¹² Appeltans, W., Ah Yong, S.T., Anderson, G., et al. (2012) The Magnitude of Global Marine Species Diversity, *Current Biology*, Vol.22, No.23, pp.2189–2202

¹¹³ WoRMS Editorial Board (2013) *World Register of Marine Species.*, <http://www.marinespecies.org at VLIZ>

lives in saltwater and part in freshwater. Further bird species, not generally classed as seabirds, but which spend time in marine environments, are also in the scope of this review, because they are also potentially affected by marine debris, and include many migratory species.

As the Convention on Migratory Species covers a defined list of migratory species considered under threat or vulnerable, it was felt useful to have a definitive list of which of the species featured are marine and so potentially affected by marine debris, and what their ranges are in the ocean basins. This was to allow the rapid evaluation of what species fall within knowledge gaps regarding impacts of marine debris within particular regions. A database was created and annotated by the Convention for this purpose. Of the approximately 370 species explicitly featuring in the appendices of the Convention,¹¹⁴ 209 are marine (as defined for the purposes of this report, i.e. spending all or part of its life history in a marine area) and so potentially affected by marine debris, highlighting the relevance of the issue for Parties to the Convention.

In order to assess knowledge gaps regarding the impacts of marine debris on migratory species, including regional distinctions, ideally it would be known in a broader sense, of the species which are marine, which are migratory, as well as their ranges in the marine environment. The largest database assembled of migratory species has information on around 4,000 species considered migratory, with around 1,000 annotated with species ranges.¹¹⁵ The alternative to using such a database is to look up each species individually as it appears during literature review and determine whether it is migratory and what its range is.¹¹⁶ Both approaches are equally limited by the fact that there is frequently not enough information available to annotate an organism as migratory or not.

Because of a lack of centralized information at the time of this review,¹¹⁷ or simply lack of the required information, knowledge gaps are instead assessed at the class level – i.e. in terms of mammals, birds, reptiles and fish.¹¹⁸ At this resolution it is not necessary to have knowledge of the entire ‘set’ of migratory marine species. Despite there not being an exhaustive database of migratory species there are certain classes or groups which have a large proportion of migratory species within them. This makes it easier to assess what information on impacts of marine debris is or is not available for migratory species belonging to different classes.

¹¹⁴ CMS (2012) Appendices I and II of the Convention on the Conservation of Migratory Species of Wild Animals (CMS)

¹¹⁵ This is the Global Register of Migratory Species (GROMS) <http://www.groms.de/>

¹¹⁶ IUCN Redlists (<http://www.iucnredlist.org/>) are another of the most comprehensive sources of information in this regard.

¹¹⁷ The GROMS database was not available for the duration of this study as it was undergoing the process of being migrated to a new online home courtesy of the University of Bonn and the Museum Koenig.

¹¹⁸ This approach was agreed in conjunction with the Secretariat

For example, of the marine mammals, there are four main groups containing migratory species – baleen whales, toothed whales (which includes dolphins and similar), seals (which are carnivores) and Sirenia species (such as manatees and dugongs, which are herbivorous). All of the approximately 14 species of baleen whales are migratory, and 12 feature in the Convention appendices. A majority of the marine dolphins are migratory, with 33 out of around 43 species appearing in the appendices. The likelihood is that only a minority of the other kinds of toothed whales are migratory, but there appears to be a general lack of information for many toothed whales in this regard. 5 out of 29 species appear in the Convention appendices. For seals, there are about 32 species, of which around 10 are commonly recognized as migratory, and 5 appear in the Convention appendices. All the four Sirenia species are considered migratory, and all of them appear in the Convention.

For reptiles, only the turtles are migratory, and all seven of the marine turtle species appear in the Convention.

There are over a thousand known species of marine sharks and rays.¹¹⁹ It was not possible to determine an overall estimate of how many are migratory, although the UN Convention on the Law of the Sea (UNCLOS) lists about 73 shark species as being ‘highly migratory’,¹²⁰ and there are 7 sharks and one ray in the Convention on Migratory Species appendices. Of the other types of fish, of which there are over 16,000 marine species, we similarly were unable to determine how many are migratory, but around 47 feature in UNCLOS and a further 14 appear in the CMS lists.

Around 850 bird species are categorized as spending part of their life history in the marine environment in the IUCN Redlists, which has completed its evaluation of all known bird species. It has been estimated that of the 10,000 or so known bird species in total 19% are migratory. If this were true for the marine birds, we would expect around 160 to be migratory. 123 birds in the Convention appendices are classed as marine in the broadest sense (in that they spend some of their time in the marine environment though they do not rely exclusively on it).

Taking these facts into consideration, the following can be concluded: any research on baleen whales, dolphins, Sirenia, and turtles as regards the impacts of marine litter is highly relevant to migratory species. Research on other toothed whales, seals, sharks/rays, fish and birds, where concerning the many non-migratory species, will be of relevance to migratory species in that within these groups, species will share many physical traits and behaviours, and therefore, susceptibilities to marine debris impacts. These groups could in principle be used to assess to what extent migratory species are impacted to a greater or lesser extent by marine debris, compared to resident species.

These considerations also make it clear that with over half of marine mammals known to be migratory, all marine turtles, and a significant proportion of birds and

¹¹⁹ WoRMS Editorial Board (2013) *World Register of Marine Species.*, <http://www.marinespecies.org> at VLIZ

¹²⁰ United Nations (1982) Annex I, United Nations Convention on the Law of the Sea

sharks (in total, at least double the number already present on the Convention appendices), the issue of marine debris is highly significant to those concerned with the conservation of migratory species.

The literature on marine debris and its impacts on different species is substantial. A detailed review was carried out in 2012 by the Scientific and Technical Advisory Panel of the Global Environment Facility on behalf of the Convention on Biological Diversity.¹²¹ They found evidence of impacts for 663 species. This provides a good idea of the number of species for which information on marine debris impacts is available. Significantly, this is a large increase from the last time such a review was carried out – more than doubling the number of species known to be impacted, which at the time was found to be 247.¹²² An evaluation of the high level numbers for different classes of organisms gives us a feel of what information there might be as regards migratory species.

The six species for which the impacts of entanglement or ingestion of marine debris were found to be greatest in the report are all migratory, and three, *Chelonia mydas* (Green Turtle), *Eubalaena glacialis* (North Atlantic Right Whale) and *Caretta caretta* (Loggerhead Turtle) appear in the CMS Appendix I and/or II. *Procellaria aequinoctialis* (White-chinned Petrel) is another Convention-listed migratory species the report singles out for concern. However the migratory *Callorhinus ursinus* (Northern Fur Seal), which is not in a CMS appendix, is considered vulnerable according to the IUCN Redlists. The report further highlights research on the migratory *Fulmarus glacialis* (Northern Fulmar), which though not endangered, has an informative time series for prevalence of ingestion of debris of different types within the population.¹²³

All known species of sea turtles, all of which are migratory, were found to be affected by entanglement or ingestion of marine debris. Half of the known marine mammal species were found to be similarly affected; and one-fifth of sea birds as defined by the report. If these proportions are assumed to be applicable to the migratory species within each class, it demonstrates how widespread the impacts of marine debris are. However the true percentages of migratory species affected may be more or less, depending on their relative susceptibility to marine debris than resident species.

¹²¹ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

¹²² Laist, D.W. (1997) *Impacts of Marine Debris: Entanglement of Marine Life in Marine Debris Including a Comprehensive List of Species with Entanglement and Ingestion Records*, *Marine Debris: Sources, Impacts and Solutions* (1997) pp.99–139

¹²³ van Franeker, J.A., Blaize, C., Danielsen, J., et al. (2011) Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea, *Environmental Pollution (Barking, Essex: 1987)*, Vol.159, No.10, pp.2609–2615

3.1 Impacts of Marine Debris on Migratory Species – Types of Impact

3.1.1 Physical - Entanglement

The way in which a species is entangled depends on the animal's body shape and behaviours. For example, seals usually become entangled around the neck or body towards the front flipper after putting their head through loops in items, a behaviour that is common in seals¹²⁴ and is perhaps exploratory and/or playful. Cetaceans and turtles may become snagged on ghost-fishing line or net around the mouth, flippers or tail (cetaceans) which then can become entangled around the whole body. Birds are more likely to become entangled by ingesting baited hooks and lines, the remainder of which becomes entangled around the body.¹²⁵ Entanglement is more likely to kill or injure than ingestion, with direct harm or death reported in 80% of reports of entanglement and in only 5% of ingestion reports.^{126,127} However there are a range of sublethal and lethal impacts for entanglement via a variety of mechanisms.

It would be a considerable omission not to address the experience of pain and suffering that an animal goes through when evaluating the severity of an impact. There have been attempts to classify injuries according to severity for whales and for marine mammals more generally on a hierarchical descriptive scale.¹²⁸ This sort of index does not exist for all species classes, and reports are not presented in such a way that allows the systematic ranking of incidents according to severity on such a scale. A broad consideration of the severity of marine debris impacts in terms of animal suffering was made which resulted in the acute impacts of drowning and starvation in the event of complete inability to feed as being characterized as the most severe, and these are impacts generally associated with entanglement. A series of chronic impacts (nominally less severe) were also associated with entanglement, which were injury, infection, amputation, exhaustion and long term starvation due to reduced ability to feed.¹²⁹

¹²⁴ Fowler, C.W. (1987) Marine debris and northern fur seals: A case study, *Marine Pollution Bulletin*, Vol.18, pp.326–335

¹²⁵ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹²⁶ Laist, D.W. (1996) Marine Debris Entanglement and Ghost Fishing: A Cryptic and Significant Type of Bycatch?, *Solving Bycatch: Proceedings of the Solving Bycatch Workshop: Considerations for Today and Tomorrow* (1996)

¹²⁷ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

¹²⁸ Andersen, M.S., Forney, K.A., Cole, T.V., et al. (2008) Differentiating Serious and Non-Serious Injury of Marine Mammals: Report of the Serious Injury Technical Workshop, *NOAA Technical Memorandum NMFS-OPR*, Vol.39

¹²⁹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

3.1.1.1 Sublethal Impacts

Tissue damage is a widespread result of entanglement. Skin lesions with ulceration can result. Necrotising myositis (death of muscle tissue) is also observed.¹³⁰ Ligatures can cause amputation of limbs, cutting into bone and muscle as the animal grows. In turtles and manatees, for example, entanglement is known to result in the loss of flippers.^{131,132} In turtles, the loss of one flipper apparently does not necessarily affect the geographical range of the affected individual, but the loss of two flippers cannot be compensated for, making it very difficult for the individual to dive and feed. Flipper stumps are vulnerable to further attack by sharks, birds and crabs. This might have consequences for the probability of secondary infection or predation.¹³³ Fins and tails of whales, sharks and dolphins can also be severed or deformed by entanglement; the implication of fin loss *per se* is uncertain but damage to the tail, especially if it affects the midline (i.e. the bilateral axis of symmetry along the spine), is considered a very serious injury.¹³⁴ In whales, massive proliferation of new bone in an attempt to wall off constricting, encircling lines has been observed.¹³⁵ Deformation of bills and missing lower bills have been observed in entangled gannets, which again may impair feeding.¹³⁶

Entanglement in trawl netting debris increases the drag on an animal as it swims through the water; it has been shown that a 400g piece of net increases the energy requirement for a California Sea Lion by about four times.¹³⁷ It is also known that in

¹³⁰ Orós, J., Torrent, A., Calabuig, P., and Dniz, S. (2005) Diseases and causes of mortality among sea turtles stranded in the Canary Islands, Spain (1998–2001), *Diseases of Aquatic Organisms*, Vol.63, No.1, pp.13–24

¹³¹ Carrington, D. (2013) 'CSI turtle' launches investigation into ghost fishing nets found in the Maldives, *Guardian* and the Maldivian Sea Turtle Conservation Program (MSTCP) http://www.seaturtle.org/tracking/?project_id=750

¹³² Beck, C.A., and Barros, N.B. (1991) The impact of debris on the Florida manatee, *Marine Pollution Bulletin*, Vol.22, No.10, pp.508–510

¹³³ Carrington, D. (2013) 'CSI turtle' launches investigation into ghost fishing nets found in the Maldives, *Guardian* and the Maldivian Sea Turtle Conservation Program (MSTCP) http://www.seaturtle.org/tracking/?project_id=750

¹³⁴ Andersen, M.S., Forney, K.A., Cole, T.V., et al. (2008) Differentiating Serious and Non-Serious Injury of Marine Mammals: Report of the Serious Injury Technical Workshop, *NOAA Technical Memorandum NMFS-OPR*, Vol.39

¹³⁵ Cassoff, R., Moore, K., McLellan, W., Barco, S., Rotstein, D., and Moore, M. (2011) Lethal entanglement in baleen whales, *Diseases of Aquatic Organisms*, Vol.96, No.3, pp.175–185

¹³⁶ Rodríguez, B., Bécares, J., Rodríguez, A., and Arcos, J.M. (2013) Incidence of entanglements with marine debris by northern gannets (*Morus bassanus*) in the non-breeding grounds, *Marine Pollution Bulletin*, Vol.75, No.1–2, pp.259–263

¹³⁷ Feldkamp, S.D. (1985) The effects of net entanglement on the drag and power output of a California sea lion, *Zalophus californianus*, *Fishery Bulletin*, Vol.83, No.4

the Northern Fur Seal, entangled lactating females spend more time at sea feeding than non-entangled females.¹³⁸

Debris may also restrict feeding, if inhibiting mouthparts or limbs necessary for foraging or other feeding behaviour, to the point of malnutrition. For example, neck entanglement in seals, where the line cuts the skin and muscles, can limit movement of the neck and the rest of the body, and can in this way impair diving ability.¹³⁹ Sharks with collars of lid parts of plastic bottles and severe tissue damage during growth were found to be emaciated.¹⁴⁰

3.1.1.2 Lethal Impacts

If a mammal, bird or reptile is prevented from resurfacing because it is entangled and trapped under the surface of the water, it will asphyxiate and drown. This can take minutes or hours. This has been observed in all these classes of organisms.^{141,142,143,144} Asphyxiation can also be caused by pulled and tightened or ingrown ligatures around the neck (several species), or occlusion of the nares (blowhole) in whales.¹⁴⁵

Chronic entanglement can cause severance of the carotid artery by ingrown ligatures (seals especially).¹⁴⁶ It can also cause haemorrhaging and debilitation due to severe damage to tissues including laceration of large blood vessels (whales).¹⁴⁷

¹³⁸ Delong, R.L., Gearin, P.J., Bengtson, J.L., and Dawson, P. (1990) Studies of the Effects of Entanglement on Individual Northern Fur Seals, *Proceedings of the Second International Conference on Marine Debris* (1990) Honolulu, Hawaii

¹³⁹ Campagna, C., Falabella, V., and Lewis, M. (2007) Entanglement of Southern Elephant Seals in Squid Fishing Gear, *Marine Mammal Science*, Vol.23, No.2, pp.414–418

¹⁴⁰ Sazima, I., Gadig, O.B., Namora, R.C., and Motta, F.S. (2002) Plastic debris collars on juvenile carcharhinid sharks (*Rhizoprionodon landi*) in southwest Atlantic, *Marine Pollution Bulletin*, Vol.44, No.10, pp.1149–1151

¹⁴¹ Scordino, J., Kajimura, H., Baba, N., and Furuta, A. (1988) Fur Seal Entanglement Studies in 1984, St Paul Island, Alaska., *Fur Seal Investigations, 1985* (1988) NOAA Tech. Memo NMFS-F/NWC-146, Wilcox, C., Hardesty, B.D., Sharples, R., Griffin, D.A., Lawson, T.J., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

¹⁴² Cassoff, R., Moore, K., McLellan, W., Barco, S., Rotstein, D., and Moore, M. (2011) Lethal entanglement in baleen whales, *Diseases of Aquatic Organisms*, Vol.96, No.3, pp.175–185

¹⁴³ Tasker, M.L., Camphuysen, C.J., Cooper, J., Garthe, S., Montevecchi, W.A., and Blaber, S.J. (2000) The impacts of fishing on marine birds, *ICES Journal of Marine Science: Journal Du Conseil*, Vol.57, No.3, pp.531–547

¹⁴⁴ Wilcox, C., Hardesty, B.D., Sharples, R., Griffin, D.A., Lawson, T.J., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

¹⁴⁵ Cassoff, R., Moore, K., McLellan, W., Barco, S., Rotstein, D., and Moore, M. (2011) Lethal entanglement in baleen whales, *Diseases of Aquatic Organisms*, Vol.96, No.3, pp.175–185

¹⁴⁶ Delong, R.L., Gearin, P.J., Bengtson, J.L., and Dawson, P. (1990) Studies of the Effects of Entanglement on Individual Northern Fur Seals, *Proceedings of the Second International Conference on Marine Debris* (1990) Honolulu, Hawaii

Entangled individuals can die from systemic infection as a consequence of open wounds.

They can also die from starvation via prevention of feeding behaviours. For example in fish, entanglement which entraps an animal will lead to starvation rather than asphyxiation. However this is generally classed as bycatch, which provides an example of the grey area between the classification of marine debris impacts and those caused by ALDFG (abandoned, lost or discarded fishing gear). Death by starvation after entanglement has also been reported in pinnipeds.¹⁴⁸

It has been conjectured that entanglement in the mouth area (common in baleen whales – one study in right whales found 77.4% of gear attachment sites were here)¹⁴⁹ may interfere with their ‘hydrostatic oral seal’ – a mechanism by which the animal can keep its mouth closed with little effort even when it is swimming. If this ability is impaired, it could compromise the animal’s ability to dive, feed and even breed – enough to cause its death.¹⁵⁰

In the case of the Northern Fur Seal, entangled lactating females spend more time at sea feeding than non-entangled females and some entangled females die at sea, pups with entangled mothers have lower survival rates than other pups.¹⁵¹

Seals under chronic stress may eventually stop producing aldosterone, a stress hormone, which results in sodium being flushed out of the body; the individual can become hyponatremic and die as a result. This has been cited as a concern for entangled pinnipeds. It is also thought that in cetaceans, a stress response, which is characterized by a number of metabolic changes and signs, can be fatal if it is severe enough.¹⁵² Given the acute and chronic stress that can be caused by entanglement, it is of concern that it might lead to fatal outcomes via this mechanism.¹⁵³

¹⁴⁷ Cassoff, R., Moore, K., McLellan, W., Barco, S., Rotstein, D., and Moore, M. (2011) Lethal entanglement in baleen whales, *Diseases of Aquatic Organisms*, Vol.96, No.3, pp.175–185

¹⁴⁸ Dau, B.K., Gilardi, K.V.K., Gulland, F.M., Higgins, A., Holcomb, J.B., Leger, J.S., and Ziccardi, M.H. (2009) Fishing Gear Related Injury In California Marine Wildlife, *Journal of Wildlife Diseases*, Vol.45, No.2, pp.355–362

¹⁴⁹ Johnson, A., Salvador, G., Kenney, J., Robbins, J., Kraus, S., Landry, S., and Clapham, P. (2005) Fishing Gear Involved in Entanglements of Right and Humpback Whales, *Marine Mammal Science*, Vol.21, No.4, pp.635–645

¹⁵⁰ Lambertsen, R.H., Rasmussen, K.J., Lancaster, W.C., and Hintz, R.J. (2005) Functional Morphology of the Mouth of the Boewhead Whale and it Implications for Conservation, *Journal of Mammalogy*, Vol.86, No.2, pp.342–352

¹⁵¹ Delong, R.L., Gearin, P.J., Bengtson, J.L., and Dawson, P. (1990) Studies of the Effects of Entanglement on Individual Northern Fur Seals, *Proceedings of the Second International Conference on Marine Debris* (1990) Honolulu, Hawaii

¹⁵² Angliss, R., and DeMaster, D.P. (1998) Differentiating Serious and Non-Serious Injury of Marine Mammals Taken Incidental to Commercial Fishing Operations: Report of the Serious Injury Workshop, *NOAA Technical Memorandum NMFS-OPR*

¹⁵³ Feldkamp, S.D. (1985) The effects of net entanglement on the drag and power output of a California sea lion, *Zalophus californianus*, *Fishery Bulletin*, Vol.83, No.4

Death can also be brought about because of a reduced ability to evade predators, or ship strike (a prominent cause of death for whales).^{154,155} Death after chronic entanglement may take months or years.¹⁵⁶

3.1.1.3 Prevalence and Regional Distinctions

Entanglement incidents have been reported in all the major classes of animals that are relevant to marine migratory species – i.e., pinnipeds, cetaceans, turtles, sharks, Sirenia, fish and birds, comprising 192 species. This corresponds to about 45% of all marine mammals (including 58% of all seals), 0.39% of all fish, 21% of all seabirds (67/312) and all sea turtles (100%).^{157,158} It has been reported that the animals most frequently affected by entanglement are pinnipeds, humpback and right whales, birds and turtles, though this is as likely to reflect reporting bias as prevalence of this type of impact within different classes.¹⁵⁹

Examples of the prevalence of entanglement in the populations of different high level species classes are shown below. It is worth noting that there are no estimates of the total numbers of individuals affected by entanglement each year, but it is thought likely that it is in the millions.¹⁶⁰ For species groups that are the best characterized in terms of entanglement (pinnipeds and baleen whales alone, for which there are fewer individuals so monitoring effort is greater in both absolute and proportional terms), figures of 57,000 - 135,000 have been estimated.¹⁶¹ The range of reported

¹⁵⁴ Beck, C.A., and Barros, N.B. (1991) The impact of debris on the Florida manatee, *Marine Pollution Bulletin*, Vol.22, No.10, pp.508–510, DeLong, R.L., Gearin, P.J., Bengtson, J.L., and Dawson, P. (1990) Studies of the Effects of Entanglement on Individual Northern Fur Seals, *Proceedings of the Second International Conference on Marine Debris* (1990) Honolulu, Hawaii

¹⁵⁵ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁵⁶ Moore, M.J., Knowlton, A., Kraus, S.D., McLellan, W.A., and Bonde, R.K. (2005) Morphometry, gross morphology and available histopathology in North Atlantic right whale (*Eubalaena glacialis*) mortalities, *Journal of Cetacean Research and Management*, Vol.6, No.3, pp.199–214

¹⁵⁷ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

¹⁵⁸ Boland, R.C., and Donohue, M.J. (2003) Marine debris accumulation in the nearshore marine habitat of the endangered Hawaiian monk seal, *Monachus schauinslandi* 1999–2001, *Marine Pollution Bulletin*, Vol.46, No.11, pp.1385–1394

¹⁵⁹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁶⁰ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁶¹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

entanglement rates is very wide within and between species, and like most estimates, based on a wide range of methodologies and recorded over varying time periods, which influences the metric considerably.¹⁶²

Baleen whales

A review of studies of entanglement in Baleen whales reported a range of population entanglement rates of from 5% to 65%; with an average of 35%. These estimates have been made for at least 7 different species, all of which are migratory (as all baleen whales are). Five of the species appear in the appendices of the Convention; they are:

- the Humpback Whale, *Megaptera novaeangliae*;
- the North Atlantic Right Whale, *Eubalaena glacialis*;
- the Fin Whale, *Balaenoptera physalus*;
- the Blue Whale, *Balaenoptera musculus*; and
- the Bryde's Whale, *Balaenoptera edeni*.

The average mortality estimate (i.e. the proportion of animals estimated to be killed by their entanglement) is 23%, with a range of 1% to 44% for different species.¹⁶³

The most commonly recorded species facing entanglement is the North Atlantic Right Whale but this is thought to be the result of the fact that monitoring effort is concentrated on the population (which numbers only about 500 individuals) which is most threatened by extinction.¹⁶⁴ Therefore it is difficult to attribute variation in impact prevalence to, for example, regional debris densities. Likewise, there is some variation in the most common items causing entanglement but it is not clear exactly what this reflects – be it surrounding debris composition or differential species vulnerability to different item types.

Toothed whales (non-baleen whales, and dolphins)

¹⁶² Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

¹⁶³ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁶⁴ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

In Hawaii 3,75% of False Killer Whales (*Pseudorca crassidens*) had major dorsal fin disfigurements thought to be caused by entanglement.¹⁶⁵ However although there are reports of entanglement for at least five species of toothed whale, there is a lack of any estimates of occurrence within species populations.¹⁶⁶ Regionally, one review stated that coastal species appear particularly at risk from the impacts of marine debris and human activities such as fisheries.¹⁶⁷ However, the lack of quantitative data does not allow regional distinctions to be made easily.

Seals

Estimates of entanglement rate for seals are around 1% of the population on average, with a range of 0.001% all the way to 7.9% for a particular population of California Sea Lions in Mexico.¹⁶⁸ These estimates have been made for at least 13 different species of seal of which about six are considered migratory, including the Harbour Seal (*Phoca vitulina*) and the Grey Seal (*Halichoerus grypus*), which feature in the Convention appendices. The entanglement rates for the migratory species span the range above, so a rough comparison does not suggest that their entanglement rates are pronouncedly different. However, estimates are so variable and the number of observations so few that the data are not sufficient to enable a proper analysis to be performed. The average mortality rates in terms of the percentage of entangled animals estimated to be killed by their entanglement is 48% and ranges from 16% to 80% depending on the study.¹⁶⁹

Sirenia

A study of manatees in Florida showed that 1.7% of the sample had signs of entanglement such as scarred, missing or entangled flippers, and 1.2% died as a direct result.¹⁷⁰ A quarter of dugongs in Australia that were recorded as being

¹⁶⁵ Neilson, J.L., Straley, J.M., Gabriele, C.M., and Hills, S. (2009) Non-lethal entanglement of humpback whales (*Megaptera novaeangliae*) in fishing gear in northern Southeast Alaska, *Journal of Biogeography*, Vol.36, No.3, pp.452–464

¹⁶⁶ Simmonds, M.P. (2012) Cetaceans and Marine Debris: The Great Unknown, *Journal of Marine Biology*, Vol.2012

¹⁶⁷ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁶⁸ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁶⁹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁷⁰ Beck, C.A., and Barros, N.B. (1991) The impact of debris on the Florida manatee, *Marine Pollution Bulletin*, Vol.22, No.10, pp.508–510

involved in entanglement incidents died as a result.¹⁷¹ Entanglements of the African manatee and the South American manatee have been reported but no prevalence was estimated.^{172,173}

Turtles

In one study in the Canary Islands, 25% of turtles necropsied were thought to have been killed via entanglement, of which 11% had suffered necrotising myositis (muscle tissue death) and 26% the amputation of one or two flippers.

Entanglement is the primary cause of mortality for turtles reported in the Gulf of Carpentaria region of Australia.¹⁷⁴

Birds

Some birds use marine debris for nesting material, which makes them vulnerable to entanglement in their breeding grounds in the North East Atlantic region.¹⁷⁵ In another study of the same species, this time in their wintering areas in the Mediterranean, 0.93% of all encountered individuals were found to be entangled.¹⁷⁶ 94% of beached birds found dead were entangled, also in the North East Atlantic region.¹⁷⁷

Fish

One study found 0.18% of sharks captured had plastic strapping bands around the body.¹⁷⁸

¹⁷¹ Ceccarelli, D.M., and C. R. Consulting (2009) Impacts of plastic debris on Australian marine wildlife, *Report by C&R Consulting to the Australian Government Department of the Environment, Water, Heritage and the Arts*

¹⁷² Silva, M.A., and Araújo, A. (2001) Distribution and current status of the West African manatee (*Trichechus senegalensis*) in Guinea-Bissau, *Marine Mammal Science*, Vol.17, No.2, pp.418–424

¹⁷³ <http://www.iucnredlist.org/details/22102/0>

¹⁷⁴ Wilcox, C., Hardesty, B.D., Sharples, R., Griffin, D.A., Lawson, T.J., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

¹⁷⁵ Votier, S.C., Archibald, K., Morgan, G., and Morgan, L. (2011) The use of plastic debris as nesting material by a colonial seabird and associated entanglement mortality, *Marine Pollution Bulletin*, Vol.62, No.1, pp.168–172

¹⁷⁶ Rodríguez, B., Bécares, J., Rodríguez, A., and Arcos, J.M. (2013) Incidence of entanglements with marine debris by northern gannets (*Morus bassanus*) in the non-breeding grounds, *Marine Pollution Bulletin*, Vol.75, No.1–2, pp.259–263

¹⁷⁷ OSPAR (2009) *Marine litter in the Northeast Atlantic Region: assessment and priorities for response*, Report for London, U.K., 2009

¹⁷⁸ Cliff, G., Dudley, S.F.J., Ryan, P.G., and Singleton, N. (2002) Large sharks and plastic debris in KwaZulu-Natal, South Africa, *Marine and Freshwater Research*, Vol.53, No.2, pp.575–581

3.1.1.4 Relationship between Debris Density and Entanglement

In order to estimate organisms' encounter rates with debris, one study profiled risk associated with "ghost-fishing" debris, based on predicted debris density and spatial overlap with the vulnerable species. The resulting model was considered to have good predictive capabilities regarding impacts when compared with real data.¹⁷⁹ Hence, for example, areas with the highest concentration of nets in Oceania and Southeast Asia such as the Gulf of Carpentaria (up to 3 tons/km) have seen an enormous range of species suffering entanglement.¹⁸⁰ It suggests entanglement is driven by the frequency with which turtles encounter debris rather than turtle foraging behaviour in general. In birds, the amount of fishing gear in nests, known to cause entanglement, was related to the fishing effort in the foraging ranges around their nests.¹⁸¹ Models of debris distribution, combined with species distribution data even at a coarse scale, would provide estimates of relative encounter rates of debris for species. This could identify global hotspots for impact, which would not necessarily be where the highest concentrations of debris are. It could also identify which species might be the most heavily impacted. This could allow the prioritization of mitigation actions.

This is contrasted however against the poor correlation between the ingestion of debris and regional debris densities (see 3.1.2.4).

3.1.2 Trophic - Ingestion

Trophic impacts can be classified as direct – i.e. impacting on the ability of migratory species to obtain adequate nutrition post-ingestion, and indirect – i.e. impacting on other members of the food chain important for the migratory species, via ecosystem effects such as on habitat and biodiversity more generally. In this section, the trophic impacts of marine debris are reviewed, restricted to those relating to direct, physical mechanisms upon ingestion, together with behavioural effects on nutrient intake where they are consequences of those physical impacts. Trophic impacts related to habitat and ecosystem level effects and toxicological mechanisms are dealt with in separate sections (3.1.4 and 3.1.3.1 respectively).

In the interest of not omitting the animal suffering component of the impacts of marine debris, it is noted that the following consequences of ingestion were considered 'acute' by one evaluation on an animal welfare scale: drowning (e.g. in the case of obstruction of the larynx by an ingested item) and internal bleeding caused by

¹⁷⁹ Wilcox, C., Hardesty, B.D., Sharples, R., Griffin, D.A., Lawson, T.J., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

¹⁸⁰ Gunn, R., Hardesty, B.D., and Butler, J. (2010) Tackling 'ghost nets': Local solutions to a global issue in northern Australia, *Ecological Management & Restoration*, Vol.11, No.2, pp.88–98

¹⁸¹ Bond, A.L., Montevercchi, W.A., Guse, N., Regular, P.M., Garthe, S., and Rail, J.-F. (2012) Prevalence and composition of fishing gear debris in the nests of northern gannets (*Morus bassanus*) are related to fishing effort, *Marine Pollution Bulletin*, Vol.64, No.5, pp.907–911

ingestion of sharp debris. The impact of ingestion considered to be 'chronic' on the same scale was starvation over long time periods due to impaction of nutrient dilution.¹⁸²

3.1.2.1 Sublethal Impacts

There have been some indications, from turtles, that ingestion of plastic and latex are correlated with lower blood glucose levels, suggesting that they may be affecting nutrient absorption or metabolism,¹⁸³ This might be a toxicological effect or it may be to do with inflammation, ulceration of the gut (this last, observed in dolphins which ingested plastic bags)¹⁸⁴ or physical obstruction, reducing absorption of nutrients by the gut via reduced surface area or cellular processes.¹⁸⁵

Ingestion of plastic and latex has also been linked to increased gas in the intestine in turtles, leading to impaired buoyancy control.¹⁸⁶

Other forms of tissue damage that are caused by ingestion of debris are oesophagitis (inflammation of the oesophagus) and oesophageal perforation, observed for example in turtles,¹⁸⁷ or ulceration of the proventriculus (birds).¹⁸⁸

One of the mechanisms by which ingestion of marine debris can harm an organism sublethally is via the displacement of equivalent volumes of food and consequent 'nutrient dilution'. The effects of the nutrient dilution effect on food intake in turtle hatchlings was evaluated and it was shown that young turtles do not compensate for the reduced volume of food taken in as a result of ingestion of debris.¹⁸⁹ Therefore the potential for impaired nutrition and sublethal consequences of this is very real, and it is possible that the consequences of this would be greater for migratory species than resident animals. For example, in migratory birds, there have been several studies showing that body condition (which includes amount of fat deposition)

¹⁸² Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁸³ Lutz, P.L. (1990) Studies on the ingestion of plastic and latex by sea turtles, *Proc. Int. Conf. Marine Debris*. (Eds. RS Shomura & ML Godfrey) NOAA-TM-154 (1990) pp.719–735

¹⁸⁴ Meirelles, A.C.O. de, and Barros, H.M.D. do R. (2011) Plastic debris ingested by a rough-toothed dolphin, *Steno bredanensis*, stranded alive in northeastern Brazil., *Biotemas*, Vol.20, No.1, pp.127–131

¹⁸⁵ Bjorndal, K.A. (1997) *Foraging Ecology and Nutrition of Sea Turtles* (1997)

¹⁸⁶ Bjorndal, K.A. (1997) *Foraging Ecology and Nutrition of Sea Turtles* (1997)

¹⁸⁷ Orós, J., Torrent, A., Calabuig, P., and Dniz, S. (2005) Diseases and causes of mortality among sea turtles stranded in the Canary Islands, Spain (1998–2001), *Diseases of Aquatic Organisms*, Vol.63, No.1, pp.13–24

¹⁸⁸ Fry, D.M., Fefer, S.I., and Sileo, L. (1987) Ingestion of plastic debris by Laysan Albatrosses and Wedge-tailed Shearwaters in the Hawaiian Islands, *Marine Pollution Bulletin*, Vol.18, pp.339–343

¹⁸⁹ McCauley, S.J., and Bjorndal, K.A. (1999) Conservation Implications of Dietary Dilution from Debris Ingestion: Sublethal Effects in Post-Hatchling Loggerhead Sea Turtles, *Conservation Biology*, Vol.13, No.4, pp.925–929

is correlated with return rates, i.e. survival, including in the migrant seabird (*Calidris canutus*), the Red Knot.^{190, 191, 192, 193, 194} Where fledgling body mass is low, this has also been shown to be correlated with reduced migration survival.¹⁹⁵ Threats to survival are magnified for birds at staging sites where birds must accumulate the extra-large reserves necessary to cross an 'ecological barrier' such as a stretch of water (therefore, highly relevant to shorebirds and waterfowl).¹⁹⁶

The plastic load ingested by Fulmars (*Fulmarus glacialis*) in the North Sea was 0.3 g on average; if this were scaled up to size it would equate to an average portion of lunch for a human adult.

It is known that some birds such as Petrels retain plastic in their stomach for months, therefore any sublethal effects of ingestion are likely to be chronic, and could escalate into an acute condition where tissue damage or occlusion of some vital internal conduit occurs at any time.¹⁹⁷ There are some indications that plastic particles are gradually eroded in the stomach, but the rate of wear is unknown and probably differs between types of plastic.¹⁹⁸ Large plastic particles tend not to be found in the faeces of seabirds, suggesting the plastic accumulates in the gut in those species that do not regurgitate indigestible stomach contents.

However there is little, and conflicting, hard evidence about what the severity of the impacts are for avian species. There is some evidence that plastic slows growth in chickens, through reduced food intake (rather than impeded assimilation).¹⁹⁹

¹⁹⁰ Morrison, R.G. (2006) Body transformations, condition, and survival in Red Knots *Calidris canutus* travelling to breed at Alert, Ellesmere Island, Canada, *ARDEA-WAGENINGEN-*, Vol.94, No.3, p.607

¹⁹¹ Benson, T.J., and Bednarz, J.C. (2010) Relationships Among Survival, Body Condition, and Habitat of Breeding Swainson's Warblers, *The Condor*, Vol.112, No.1, pp.138–148

¹⁹² Studds, C.E., and Marra, P.P. (2005) Non-breeding Habitat Occupancy and Population Processes: An Upgrade Experiment with a Migratory Bird, *Ecology*, Vol.86, No.9, pp.2380–2385

¹⁹³ Merila, J., and Svensson, E. (1997) Are Fat Reserves in Migratory Birds Affected by Condition in Early Life?, *Journal of Avian Biology*, Vol.28, No.4, p.279

¹⁹⁴ Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds?, *Journal of Ornithology*, Vol.147, No.2, pp.146–166

¹⁹⁵ Menu, S., Gauthier, G., Reed, A., and Holberton, R.L. (2005) Survival of Young Greater Snow Geese (*Chen caerulescens atlantica*) During Fall Migration, *The Auk*, Vol.122, No.2, pp.479–496

¹⁹⁶ Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds?, *Journal of Ornithology*, Vol.147, No.2, pp.146–166

¹⁹⁷ Spear, L.B., Ainley, D.G., and Ribic, C.A. (1995) Incidence of plastic in seabirds from the tropical pacific, 1984–1991: Relation with distribution of species, sex, age, season, year and body weight, *Marine Environmental Research*, Vol.40, No.2, pp.123–146, Ryan, P., and Jackson, S. (1987) The lifespan of ingested plastic particles in seabirds and their effect on digestive efficiency, *Marine Pollution Bulletin*, Vol.18, No.5, pp.217–219

¹⁹⁸ Ryan, P., and Jackson, S. (1987) The lifespan of ingested plastic particles in seabirds and their effect on digestive efficiency, *Marine Pollution Bulletin*, Vol.18, No.5, pp.217–219

¹⁹⁹ Ryan, P.G. (1988) Effects of ingested plastic on seabird feeding: Evidence from chickens, *Marine Pollution Bulletin*, Vol.19, No.3, pp.125–128

However White-chinned Petrels (*Procellaria aequinoctialis*) showed no change in assimilation efficiency but also no mass loss when fed large quantities of plastic particles.²⁰⁰

Evidence from the field is mixed: one paper concluded, from a small sample of the migratory Red Phalarope (*Phalaropus fulicarius*), that there was a negative correlation between amount of plastic and fat deposition, though this wasn't actually statistically significant.²⁰¹ A study of albatross chicks on Midway Atoll showed that Laysan Albatross (*Diomedea immutabilis*) chicks had significantly lower fledgling weights if they had high volumes of proventricular plastic.²⁰² In another approach, one study found that chicks found dead had significantly higher weights of plastic than chicks that had been struck by cars and necropsied, suggesting that the plastic was associated with poorer survival.²⁰³ No effect was observed for Black-footed Albatross (*Diomedea nigripes*) chicks. Another concluded that no influence of ingested plastic on weight was detectable in White-faced Storm Petrels.²⁰⁴ Another stated the same for the Short-tailed Shearwater (*Puffinus tenuirostris*).²⁰⁵ Even in species that ingested the greatest amount of plastic in another study (Northern Fulmars (*Fulmarus glacialis*), Red Phalaropes (*Falaropus fulicaria*) and Greater Shearwaters (*Puffinus gravis*)), no evidence that seabird health was affected was found.²⁰⁶

It has been proposed that whether plastic ingestion has effects on feeding and growth via food displacement is a function of digestive tract morphology and regurgitation habit, which varies between species. In some species, the gizzard and the proventriculus are quite separate chambers joined by a small conduit. Plastic is mostly retained in the gizzard which is not however used for food storage (the role of the proventriculus) – this may be why procellariiformes (petrels, shearwaters and albatrosses), who have this morphology, do not seem to lose weight as the amount of plastic ingested increases (and these species accumulate plastic to a great extent because they cannot regurgitate it like other species). Other species (sphenisciforms, pelecaniforms and charadriiforms) have a single sac-like stomach, where plastic

²⁰⁰ Ryan, P., and Jackson, S. (1987) The lifespan of ingested plastic particles in seabirds and their effect on digestive efficiency, *Marine Pollution Bulletin*, Vol.18, No.5, pp.217–219

²⁰¹ Connors, P.G., and Smith, K.G. (1982) Oceanic plastic particle pollution: suspected effect on fat deposition in red phalaropes, *Marine Pollution Bulletin*, Vol.13, No.1, pp.18–20

²⁰² Sievert, P.R., and Sileo, L. (1993) The effects of ingested plastic on growth and survival of albatross chicks, *The Status, Ecology and Conservation of Marine Birds of the North Pacific* (1993)

²⁰³ Auman, H.J., Ludwig, J.P., Giesy, J.P., and Colborn, T. (1997) Plastic ingestion by Laysan albatross chicks on Sand Island, Midway Atoll, in 1994 and 1995, *Albatross Biology and Conservation*, pp.239–244

²⁰⁴ Furness, R.W. (1985) Ingestion of plastic particles by seabirds at Gough Island, South Atlantic Ocean, *Environmental Pollution Series A, Ecological and Biological*, Vol.38, No.3, pp.261–272

²⁰⁵ Vlietstra, L.S., and Parga, J.A. (2002) Long-term changes in the type, but not amount, of ingested plastic particles in short-tailed shearwaters in the southeastern Bering Sea, *Marine Pollution Bulletin*, Vol.44, No.9, pp.945–955

²⁰⁶ Moser, M.L., and Lee, D.S. (1992) A Fourteen-Year Survey of Plastic Ingestion by Western North Atlantic Seabirds, *Colonial Waterbirds*, Vol.15, No.1, p.83

would be displacing food. However most of these species regurgitate indigestible items regularly, with the exception of some auks and phalaropes, and this might also mitigate any body mass effects of the plastic. Albatrosses and Giant Petrels have intermediate stomach morphology, and atypically for the procellariiformes, do exhibit regurgitation; nevertheless they do accumulate large amounts of plastic in their digestive system showing the complex relationship between plastic accumulation, bird morphology and behaviour.²⁰⁷

Fish are known to ingest pieces of plastic. In the laboratory, some fish have been observed to ingest but reject or pass the pellets; other observations reveal that plastic can be retained in fish guts for prolonged periods of time and may become encysted or ingrown into the gut lining. Ingestion in fish has been hypothesised, as for other species, to result in displacement of food, and large pieces that cannot be expelled from the fish has been suggested to cause ulceration but there is not experimental evidence to support this.²⁰⁸ It has also been suggested that ingested plastic may influence the buoyancy of fish, and be especially detrimental to those that migrate vertically.²⁰⁹

3.1.2.2 Lethal Impacts

Ingestion of marine debris by turtles has been demonstrated to result in death in one of two ways. One is by impaction, where a blockage of the digestive tract causes paralysis of the gut, in which case, death will result from starvation.²¹⁰ In the other scenario, debris can puncture the gut lining, causing peritonitis or septicaemia.²¹¹ In one study, of turtles found stranded and the fatality attributed to ingestion, impaction was found to have led to more fatalities (83%) than perforation (17%).²¹² Ingestion of debris was suspected to be the cause of death in two stranded Sperm Whales, one of which was emaciated, while the other had a ruptured stomach, both suspected to be caused by intestinal impaction.²¹³ Intestinal impaction and starvation has also been observed in birds including the migratory and endangered Laysan Albatross, though

²⁰⁷ Ryan, P.G. (1988) Effects of ingested plastic on seabird feeding: Evidence from chickens, *Marine Pollution Bulletin*, Vol.19, No.3, pp.125–128

²⁰⁸ Hoss, D.E., and Settle, L.R. (1990) Ingestion of plastics by teleost fishes, *Proceedings of the Second International Conference on Marine Debris. NOAA Technical Memorandum. NOAA-TM-NMFS-SWFSC-154. Miami, FL (1990) pp.693–709*

²⁰⁹ Carson, H.S. (2013) The incidence of plastic ingestion by fishes: From the prey's perspective, *Marine Pollution Bulletin*

²¹⁰ Lutz, P.L. (1990) Studies on the ingestion of plastic and latex by sea turtles, *Proc. Int. Conf. Marine Debris.*(Eds. RS Shomura & ML Godfrey) NOAA-TM-154 (1990) pp.719–735

²¹¹ Beck, C.A., and Barros, N.B. (1991) The impact of debris on the Florida manatee, *Marine Pollution Bulletin*, Vol.22, No.10, pp.508–510

²¹² Townsend, K.A. (2011) Impact of ingested marine debris on sea turtles of eastern Australia: Life history stage susceptibility, pathological implications and plastic bag preference., *Technical Proceedings of the 5th International Marine Debris Conference (2011) pp.180–183*

²¹³ Jacobsen, J.K., Massey, L., and Gulland, F. (2010) Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*), *Marine Pollution Bulletin*, Vol.60, No.5, pp.765–767

such observations are as yet rare.^{214,215} Intussusception of the intestine (a potentially fatal condition where the one portion of the intestine slides into another) was also identified as caused by ingestion of monofilament line in a manatee.²¹⁶

Ingestion has also been shown to result in larynx strangulation in dolphins, where ingestion of netting is followed by the netting becoming wrapped around the larynx (which in dolphins connects the breathing tube to the breathing hole) of the animal inside its throat. This progressively cuts into the larynx, causing oedema, tissue damage and thickening of the tissue, which in itself can present as a chronic condition, although at some point, asphyxiation can occur if the stricture becomes too tight or the tissue gives way and occludes the wind pipe. At present this is linked to dolphins learning to depredate small commercial fisheries for fish and biting off small pieces of netting. However in principle, it could apply to free-floating debris.²¹⁷

3.1.2.3 Prevalence and Regional Distinctions

Ingestion is thought to be more widespread than entanglement.²¹⁸ At present however there are only marginally more marine species for which ingestion incidents have been recorded than entanglement, at 196 versus 192. This includes mammals (26% of all marine mammal species), turtles (86%), birds (38% [199/312]) and fish (0.24%).²¹⁹ It has been reported that the animals most frequently affected by ingestion are birds and turtles.²²⁰

Examples of the prevalence of ingestion in the populations of different species follow. There are no estimates of the total numbers of individuals affected by ingestion each year, but it is thought likely that it is in the millions.²²¹

²¹⁴ Fry, D.M., Fefer, S.I., and Sileo, L. (1987) Ingestion of plastic debris by Laysan Albatrosses and Wedge-tailed Shearwaters in the Hawaiian Islands, *Marine Pollution Bulletin*, Vol.18, pp.339–343

²¹⁵ Pierce, K.E., Harris, R.J., Larned, L.S., and Pokras, M.A. (2004) Obstruction and starvation associated with plastic ingestion in a northern gannet *Morus bassanus* and a greater shearwater *Puffinus gravis*, *Marine Ornithology*, Vol.32, pp.187–189

²¹⁶ Beck, C.A., and Barros, N.B. (1991) The impact of debris on the Florida manatee, *Marine Pollution Bulletin*, Vol.22, No.10, pp.508–510

²¹⁷ Gomerčić, M., Galov, A., Gomerčić, T., et al. (2009) Bottlenose dolphin (*Tursiops truncatus*) depredation resulting in larynx strangulation with gill-net parts, *Marine Mammal Science*, Vol.25, No.2, pp.392–401

²¹⁸ Secchi, E.R., and Zarzur, S. (1999) Plastic debris ingested by a Blainville's beaked whale, *Mesoplodon densirostris*, washed ashore in Brazil

²¹⁹ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

²²⁰ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

²²¹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

Baleen whales

Filter-feeding Baleen whales are known to ingest debris during feeding, though there are no statistics on prevalence, as it is not systematically documented; and reports are few. Examples are the Bowhead Whale, *Balaena mysticetus*, the Minke Whale, *Balaenoptera acutorostrata* and Bryde's Whale, *Balaenoptera edeni*. It is therefore impossible to make any regional distinctions for the impacts of the ingestion of marine debris within the range of these species.

Toothed whales (non-baleen whales, and dolphins)

Toothed whales are liable to ingest debris during play, exploration or feeding. One study found 31% of beached La Plata Dolphins (*Pontoporia blainvillei*) had ingested plastic debris.²²² In Bottlenose Dolphins (*Tursiops truncatus*) in the Adriatic, 10% of stranded individuals died from constriction of the larynx post net ingestion,²²³ Fatalities have also been reported in sperm whales (*Physeter macrocephalus*) and the Tucuxi (*Sotalia fluviatilis*);^{224,225} each of these species are migratory and endangered. In Baird's Beaked Whale (*Berardius bairdii*), debris ingestion was found in 15-27% of individuals, at different locations in the Pacific coastal waters of Japan.²²⁶ There are many other reports of ingestion, for at least 26 different species of toothed whale in total.²²⁷ However, because as a rule only isolated incidents are reported, it is not possible to make well supported regional distinctions about prevalence of this impact for these animals.

Seals

There are few quantitative studies of debris ingestion in seals; the first study on earless seals, in the North Sea, found plastic in the stomach of 11% of the individuals

²²² Bastida et al., 2000 in Marsh, H., Arnold, P., Freeman, M., et al. (2003) Strategies for Conserving Marine Mammals, *Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues* (2003)

²²³ Gomerčić, M., Galov, A., Gomerčić, T., et al. (2009) Bottlenose dolphin (*Tursiops truncatus*) depredation resulting in larynx strangulation with gill-net parts, *Marine Mammal Science*, Vol.25, No.2, pp.392–401

²²⁴ Jacobsen, J.K., Massey, L., and Gulland, F. (2010) Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*), *Marine Pollution Bulletin*, Vol.60, No.5, pp.765–767

²²⁵ Geise, L., and Gomes, N. (1992) Ocorrência de Plástico no estômago de um golfinho, *Sotalia guianensis* (Cetacea, Delphinidae), *Proceedings of the Third. Reunión de Trabajo de Especialistas de Mamíferos. Acuáticos de América Del Sur*

²²⁶ Simmonds, M.P. (2012) Cetaceans and Marine Debris: The Great Unknown, *Journal of Marine Biology*, Vol.2012

²²⁷ Baird, R., and Hooker, S. (2000) Ingestion of Plastic and Unusual Prey by a Juvenile Harbour Porpoise, *Marine Pollution Bulletin*, Vol.40, No.8, pp.719–720

sampled, albeit in very small quantities.²²⁸ This was <10% of the prevalence as measured by faecal samples, demonstrating how prevalence varies according to methodology. Plastic has also been found in the faeces of fur seals.²²⁹

Sirenia

A study of West Indian manatees in Florida showed that 14% of the sample of stranded manatees had ingested debris and 0.9% died as direct result.²³⁰ There are no reports of ingestion in the other three species of Sirenia.

Turtles

It has been suggested that sea turtle anatomy predisposes them to ingesting larger quantities of marine debris and that this is why all sea turtle species, all of which are migratory, have been found to experience this impact.²³¹ Sea turtles have downward facing, keratinized papillae in their oesophagus, the presumed function of which is to trap food while excess water is expelled prior to swallowing. This mechanism may prevent regurgitation of plastics and increases the probability that they remain within the digestive tract.

A global review on turtles and ingestion found that the probability of ingesting debris had increased for some species (green and leatherback turtles) over time. Turtles in nearly all regions studied ingest debris, with the exception of the Persian Gulf. Across all the studies, an average 30% of deceased turtles sampled had ingested debris. Depending on the study reviewed, death was attributed to marine debris for 9% of those individuals on average, and overall mortality owing to marine debris calculated at between 2% and 17%.²³² There were regions where the proportion of individuals ingesting debris was higher than others, but there was a high degree of variability over time and within regions. There is not a clear correlation between ingestion rates and local debris densities (see Section 3.1.2.4).

²²⁸ Bravo Rebolledo, E.L., Van Franeker, J.A., Jansen, O.E., and Brasseur, S.M.J.M. (2013) Plastic ingestion by harbour seals (*Phoca vitulina*) in The Netherlands, *Marine Pollution Bulletin*, Vol.67, No.1–2, pp.200–202

²²⁹ Eriksson, C., and Burton, H. (2003) Origins and Biological Accumulation of Small Plastic Particles in Fur Seals from Macquarie Island, *AMBIO: A Journal of the Human Environment*, Vol.32, No.6, pp.380–384

²³⁰ Beck, C.A., and Barros, N.B. (1991) The impact of debris on the Florida manatee, *Marine Pollution Bulletin*, Vol.22, No.10, pp.508–510

²³¹ Müller, C., Townsend, K., and Matschullat, J. (2012) Experimental degradation of polymer shopping bags (standard and degradable plastic, and biodegradable) in the gastrointestinal fluids of sea turtles, *Science of The Total Environment*, Vol.416, pp.464–467

²³² Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

Birds

95% of Northern Fulmars (*Fulmarus glacialis*) whose bodies were washed ashore were found to have plastic debris in their digestive system.²³³ OSPAR set an 'Ecological Quality Objective' of plastic ingested not exceeding 0.1g in 90% of the population; 55% of all examined birds exceeded this limit.²³⁴ The endangered, migratory Balearic Shearwater (*Puffinus mauretanicus*) had an ingestion occurrence of 70% of individuals, in the western Mediterranean.²³⁵ In a study of Laysan Albatrosses (*Phoebastria immutabilis*), also endangered and migratory, 97% of chicks had ingested plastic,²³⁶ while in another study, 7% of chicks that had ingested plastic had ulcerative lesions or impactions in the proventriculus.²³⁷

Fish

Many species of fish have been found to have ingested plastic. This includes migratory species, such as the Atlantic Cod (*Gadus morhua*), Blackfin Tuna (*Thunnus albacares*), Yellowfin Tuna (*Thunnus atlanticus*), many species of shark, many of which are migratory, and the anadromous Striped Bass (*Morone saxatilis*).^{238,239}

One study found 0.38% of sharks captured had ingested plastic debris.²⁴⁰ In the English Channel, 21% of flounder (*Platychthyes flesus*) individuals and 25% of the fish *Liparis liparis* had ingested polystyrene spherules, though those levels subsequently

²³³ van Franeker, J.A., Blaize, C., Danielsen, J., et al. (2011) Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea, *Environmental Pollution (Barking, Essex: 1987)*, Vol.159, No.10, pp.2609–2615

²³⁴ OSPAR (2010) *Quality Status Report 2010*, 2010, http://qsr2010.ospar.org/en/media/chapter_pdf/QSR_complete_EN.pdf

²³⁵ Codina-García, M., Militão, T., Moreno, J., and González-Solís, J. (2013) Plastic debris in Mediterranean seabirds, *Marine Pollution Bulletin*

²³⁶ Auman, H.J., Ludwig, J.P., Giesy, J.P., and Colborn, T. (1997) Plastic ingestion by Laysan albatross chicks on Sand Island, Midway Atoll, in 1994 and 1995, *Albatross Biology and Conservation*, pp.239–244

²³⁷ Fry, D.M., Fefer, S.I., and Sileo, L. (1987) Ingestion of plastic debris by Laysan Albatrosses and Wedge-tailed Shearwaters in the Hawaiian Islands, *Marine Pollution Bulletin*, Vol.18, pp.339–343

²³⁸ U. S. Fish and Wildlife Service Southern New England-New York Bight Coastal Ecosystems Program(1996) *Regionally Significant Habitats and Habitat Complexes of the New York Bight Watershed*, http://library.fws.gov/pubs5/web_link/text/int_fish.htm

²³⁹ Laist, D.W. (1997) Impacts of Marine Debris: Entanglement of Marine Life in Marine Debris Including a Comprehensive List of Species with Entanglement and Ingestion Records, *Marine Debris: Sources, Impacts and Solutions* (1997) pp.99–139

²⁴⁰ Cliff, G., Dudley, S.F.J., Ryan, P.G., and Singleton, N. (2002) Large sharks and plastic debris in KwaZulu-Natal, South Africa, *Marine and Freshwater Research*, Vol.53, No.2, pp.575–581

declined.²⁴¹ Another, off the west coast of the USA, found that 8 out of 14 fish species examined had ingested such material, and up to 33% of the individuals within a species.²⁴² In the North Sea, five out of seven species had ingested debris, and overall 2.6% of individuals, though in one species (cod from the English Channel) it was 33%.²⁴³ In the central North Pacific, one study found that 19% of individuals had ingested plastic on average, with a range of <1% to 58% of individuals.²⁴⁴ In one Mediterranean study, plastic was found in 5 out of 26 species of deep sea fish. The highest prevalence within species was 3.2%.²⁴⁵

3.1.2.4 Relationship between Debris Density, Quantity of Debris Ingested and Cause of Death

In turtles, the probability of ingestion was not closely related to modelled debris densities where the turtles were sampled.²⁴⁶ This was thought to reflect the fact that most turtles migrate long distances during their post hatching pelagic phase and during breeding migrations, so they are highly likely to encounter ocean-borne debris at some life stage. Furthermore, it is important to highlight, especially in the context of marine debris ingestion potentially being used as an environmental quality indicator (for the North-East Atlantic region (OSPAR) - the EcoQO or 'Ecological Quality Objective'),²⁴⁷ that the amount of debris ingested is not necessarily linearly correlated with the potential to cause fatality. For example, in one turtle study in Florida, of 24 stranded turtles that had ingested marine debris, just two of the deaths could be clearly attributed to marine debris. However, the weight and volume of debris in these specimens was small and was within the range of that ingested by other individuals.²⁴⁸ Therefore these parameters do not predict the mortality caused by debris ingestion well and instead it is proposed that the chance orientation of a piece

²⁴¹ Kartar, S., Abou-Seedo, F., and Sainsbury, M. (1976) Polystyrene spherules in the Severn Estuary—a progress report, *Marine Pollution Bulletin*, Vol.7, No.3, p.52

²⁴² Carpenter, E.J., Anderson, S.J., Harvey, G.R., Miklas, H.P., and Peck, B.B. (1972) Polystyrene spherules in coastal waters, *Science (New York, N.Y.)*, Vol.178, No.4062, pp.749–750

²⁴³ Foekema, E.M., De Grijter, C., Mergia, M.T., van Franeker, J.A., Murk, A.J., and Koelmans, A.A. (2013) Plastic in North Sea Fish, *Environmental Science & Technology*, p.130711150255009

²⁴⁴ Choy, C.A., and Drazen, J.C. (2013) Plastic for dinner? Observations of frequent debris ingestion by pelagic predatory fishes from the central North Pacific, *Marine Ecology Progress Series*, Vol.485, pp.155–163

²⁴⁵ Anastasopoulou, A., Mytilineou, C., Smith, C.J., and Papadopoulou, K.N. (2013) Plastic debris ingested by deep-water fish of the Ionian Sea (Eastern Mediterranean), *Deep Sea Research Part I: Oceanographic Research Papers*, Vol.74, pp.11–13

²⁴⁶ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

²⁴⁷ van Franeker, J.A., Heubeck, M., Fairclough, K., et al. (2005) 'Save the North Sea' Fulmar Study 2002–2004: A Regional Pilot Project for the Fulmar-Litter-EcoQO in the OSPAR Area, 2005, <http://www.vliz.be/imisdocs/publications/72498.pdf>

²⁴⁸ Bjorndal, K.A., Bolten, A.B., and Lagueux, C.J. (1994) Ingestion of marine debris by juvenile sea turtles in coastal Florida habitats, *Marine Pollution Bulletin*, Vol.28, No.3, pp.154–158

of debris as it transits the digestive tract will determine whether it becomes lodged in the tract and causes an obstruction and death. The majority of debris appears to be excreted through defecation.²⁴⁹

Therefore as a consequence of these non-linear relationships between debris density, probability of ingestion and probability of acute, severe impacts, it has been stated that anthropogenic debris must be managed at a global level; and that targeted approaches according to 'hotspots' are not going to be as effective as a global approach, for ingestion, at least.²⁵⁰

On the other hand for some species and areas, there does seem to be a correlation between local spatial distributions of debris and the prevalence of ingestion. Some studies suggest that the amounts of plastic in the intestines of birds reflects regional differences in the abundance of marine debris.²⁵¹ For example, Northern Fulmars in the North Sea, which is highly contaminated, have very high rates of plastic ingestion (95% of individuals), whereas in birds of the same species in Arctic Canada, the figure is only 36%.²⁵² Therefore using species-level impacts as a way of monitoring environmental quality may be robust, but only for certain species and certain areas.

3.1.3 Physiological

3.1.3.1 Toxicological Impacts via Ingestion

Plastics contain a wide range of additives such as plasticizers (to make them pliable), flame retardants and colorants. They also accumulate chemicals from sea water.²⁵³ The chemicals of concern are persistent, bio-accumulative and toxic substances (PBTs), which tend to be hydrophobic, fat-soluble, organic molecules that accordingly have a tendency to associate with plastic surfaces as opposed to remaining dissolved in the water of the ocean. Microplastics, because of their very large surface area to volume ratio, are especially significant in this regard, as the greater the surface area the greater the surface for molecule exchange, whether via off-gassing or adsorption and desorption.²⁵⁴ There is evidence that desorption is enhanced under physiological

²⁴⁹ Tourinho, P.S., Ivar do Sul, J.A., and Fillmann, G. (2010) Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil?, *Marine Pollution Bulletin*, Vol.60, No.3, pp.396–401

²⁵⁰ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

²⁵¹ van Franeker, J.A., Blaize, C., Danielsen, J., et al. (2011) Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea, *Environmental Pollution (Barking, Essex: 1987)*, Vol.159, No.10, pp.2609–2615

²⁵² Mallory, M.L., Robertson, G.J., and Moenting, A. (2006) Marine plastic debris in northern fulmars from Davis Strait, Nunavut, Canada, *Marine Pollution Bulletin*, Vol.52, No.7, pp.813–815

²⁵³ Lee, H., Shim, W.J., and Kwon, J.-H. (2013) Sorption capacity of plastic debris for hydrophobic organic chemicals, *Science of The Total Environment*

²⁵⁴ Mato, Y., Isobe, T., Takada, H., Kanehiro, H., Ohtake, C., and Kaminuma, T. (2001) Plastic Resin Pellets as a Transport Medium for Toxic Chemicals in the Marine Environment, *Environmental Science & Technology*, Vol.35, No.2, pp.318–324

conditions, i.e. post-ingestion.²⁵⁵ Therefore even small amounts of ingested material may be having an impact beyond its physical mass, which may not be large, sharp or obstructive enough to pose any welfare problems for the animal by physical means.

Plasticizers such as phthalates (e.g. DEHP - bis(2-ethylhexyl) phthalate), BPA (bisphenol A) and PCBs (polychlorinated biphenyls), incorporated into plastics at production can leach into the environment or into tissue.²⁵⁶ Because these molecules are similar in structure to hormones, they can interfere with hormonal signalling pathways.²⁵⁷ They have effects at very low levels, distinguishing them from classic dose-response curves used in toxicology.²⁵⁸ Other toxins adsorbed onto microplastics can also be transferred into the tissues of animals upon ingestion.²⁵⁹ There is growing evidence as to whether and how these chemicals can affect wildlife, an overview of which is given below, yet more research is needed to discover whether these translate into population level effects.

The plasticizer polychlorinated biphenyl (PCB) has been shown to accumulate in (migratory) seabirds such as the Great Shearwater (*Puffinus gravis*), and this was positively correlated with the birds' ingestion of plastic particles.²⁶⁰ The concentration of certain PCBs in fatty tissue was also found to be correlated with the amount of ingested plastic in the Short-tailed Shearwater (*Puffinus tenuirostris*).²⁶¹

PCBs have been shown to lead to reduced reproductive success in birds via increased embryo mortality and reduced hatching rates, altered reproductive behaviour such as nest attentiveness²⁶² and song,²⁶³ egg shell thinning, lowered steroid hormone levels

²⁵⁵ Bakir, A., Rowland, S.J., and Thompson, R.C. (2014) Enhanced desorption of persistent organic pollutants from microplastics under simulated physiological conditions, *Environmental Pollution*, Vol.185, pp.16–23

²⁵⁶ Oehlmann, J., Schulte-Oehlmann, U., Kloas, W., et al. (2009) A critical analysis of the biological impacts of plasticizers on wildlife, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.2047–2062

²⁵⁷ Talsness, C.E., Andrade, A.J.M., Kuriyama, S.N., Taylor, J.A., and Saal, F.S. vom (2009) Components of plastic: experimental studies in animals and relevance for human health, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.2079–2096

²⁵⁸ Vandenberg, L.N., Maffini, M.V., Sonnenschein, C., Rubin, B.S., and Soto, A.M. (2009) Bisphenol-A and the Great Divide: A Review of Controversies in the Field of Endocrine Disruption, *Endocrine Reviews*, Vol.30, No.1, pp.75–95

²⁵⁹ Teuten, E.L., Saquing, J.M., Knappe, D.R.U., et al. (2009) Transport and release of chemicals from plastics to the environment and to wildlife, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.2027–2045

²⁶⁰ Ryan, P.G., Connell, A.D., and Gardner, B.D. (1988) Plastic ingestion and PCBs in seabirds: Is there a relationship?, *Marine Pollution Bulletin*, Vol.19, No.4, pp.174–176

²⁶¹ Yamashita, R., Takada, H., Fukuwaka, M., and Watanuki, Y. (2011) Physical and chemical effects of ingested plastic debris on short-tailed shearwaters, *Puffinus tenuirostris*, in the North Pacific Ocean, *Marine Pollution Bulletin*, Vol.62, No.12, pp.2845–2849

²⁶² Peakall, D.B., and Peakall, M.L. (1973) Effect of a Polychlorinated Biphenyl on the Reproduction of Artificially and Naturally Incubated Dove Eggs, *The Journal of Applied Ecology*, Vol.10, No.3, p.863

causing delayed ovulation,²⁶⁴ plus increased risk of cardiomyopathy with presumed increase in mortality,²⁶⁵ and impaired immune function.²⁶⁶ Impaired hatching has been shown to be correlated with PCB concentration in wild populations of the migratory Double-crested Cormorant (*Phalacrocorax auritis*) from the Great Lakes in North America; although the bird is estuarine rather than marine, it eats fish and is at risk of ingestion of plastic debris directly or indirectly.²⁶⁷

In Baltic Grey and Ringed Seals (*Halichoerus grypus* and *Phoca hispida*), high body burdens of PCBs are linked to reproductive effects resulting in population declines.

Seabirds have also been shown to accumulate PBDEs (a family of flame-retardant chemicals) in proportion to the quantity of plastic ingested.²⁶⁸

The toxicological implications of absorption of chemicals by fish through plastic pellet ingestion has been only recently directly demonstrated, with fish ingesting pellets that had been immersed in the water in San Diego Bay, California, for three months, inducing hepatic stress in fish, compared with the ingestion of clean plastic pellets. In the two month duration of the feeding experiment, the fish accumulated some of the chemicals to which they had been exposed (one each of several PAHs and PCBs and all but one PBDE measured). The effects observed included glycogen depletion, attributed to the direct effect of the chemicals on carbohydrate metabolism and the energy cost of detoxification, and cellular changes that can lead to fatty liver degeneration and have already been observed in rats exposed to PCBs.²⁶⁹

²⁶³ Ottinger, M.A., Lavoie, E., Abdelnabi, M., Quinn, M.J., Marcell, A., and Dean, K. (2009) An Overview of Dioxin-Like Compounds, PCB, and Pesticide Exposures Associated with Sexual Differentiation of Neuroendocrine Systems, Fluctuating Asymmetry, and Behavioral Effects in Birds, *Journal of Environmental Science and Health, Part C*, Vol.27, No.4, pp.286–300

²⁶⁴ Hoffman, D.J., Rice, C.P., and Kubiak, T.J. (1996) *PCBs and dioxins in birds*, 1996, <http://pubs.er.usgs.gov/publication/5210754>

²⁶⁵ Carro, T., Dean, K., and Ottinger, M.A. (2013) Effects of an environmentally relevant polychlorinated biphenyl (PCB) mixture on embryonic survival and cardiac development in the domestic chicken, *Environmental Toxicology and Chemistry*, Vol.32, No.6, pp.1325–1331

²⁶⁶ Grasman, K.A., and Fox, G.A. (2001) Associations between altered immune function and organochlorine contamination in young Caspian terns (*Sterna caspia*) from Lake Huron, 1997-1999, *Ecotoxicology (London, England)*, Vol.10, No.2, pp.101–114

²⁶⁷ Tillitt, D.E., Ankley, G.T., Giesy, J.P., et al. (1992) Polychlorinated biphenyl residues and egg mortality in double-crested cormorants from the great lakes, *Environmental Toxicology and Chemistry*, Vol.11, No.9, pp.1281–1288

²⁶⁸ Tanaka, K., Takada, H., Yamashita, R., Mizukawa, K., Fukuwaka, M., and Watanuki, Y. (2013) Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics, *Marine Pollution Bulletin*, Vol.69, No.1–2, pp.219–222

²⁶⁹ Rochman, C.M., Hoh, E., Kurobe, T., and Teh, S.J. (2013) Ingested plastic transfers hazardous chemicals to fish and induces hepatic stress, *Scientific Reports*, Vol.3

Phthalate plasticizers such as DEHP have been associated with intersex conditions in fish.²⁷⁰ The breakdown product of DEHP, MEHP was detected in the blubber of stranded Fin Whales (the migratory *Balaenoptera physalus*) in the Mediterranean; microplastic and phthalates were also detected in ocean water samples in the surrounding coastal areas. The upregulation of the oestrogen receptor alpha gene in Mediterranean fin whales compared with individuals from the Sea of Cortez was attributed to corresponding differences in the concentrations of organic pollutants in the whale blubber and ultimately to differences in environmental pollution in the surrounding areas.²⁷¹ In birds, in vitro exposure to environmentally relevant concentrations of MEHP can negatively affect spermatogenesis.²⁷²

In turtles, the ingestion of plastic and latex is correlated with lower blood glucose levels, suggesting that they may be affecting nutrient absorption or metabolism.²⁷³ It is not known whether this is a toxicological effect or to do with other trophic effects, however this is consistent with results from fish where effects of chemicals on carbohydrate metabolism were attributed to the energy cost of detoxification.

Bisphenol A is an oestrogen agonist and an androgen antagonist. It affects reproduction in the fish and different invertebrates assayed, in concentration and species dependent ways. In fish it has been shown to affect spermatogenesis, ovulation and sex steroid levels at environmentally relevant concentrations. These changes can affect growth, bone and brain development, cellular division, and cause masculinization or feminization. One study demonstrated delayed sexual development in male chickens at environmentally relevant doses. Many detrimental effects on reproduction and development have been demonstrated in experimental rodents at high levels of BPA. There has been little research into the effects of long term, low level, chronic exposure on marine species, whether fish, turtles, birds or mammals.^{274, 275}

²⁷⁰ Oehlmann, J., Schulte-Oehlmann, U., Kloas, W., et al. (2009) A critical analysis of the biological impacts of plasticizers on wildlife, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.2047–2062

²⁷¹ Fossi, M.C., Panti, C., Guerranti, C., Coppola, D., Giannetti, M., Marsili, L., and Minutoli, R. (2012) Are baleen whales exposed to the threat of microplastics? A case study of the Mediterranean fin whale (*Balaenoptera physalus*), *Marine Pollution Bulletin*, Vol.64, No.11, pp.2374–2379

²⁷² Guibert, E., Prieur, B., Cariou, R., et al. (2013) Effects of mono-(2-ethylhexyl) phthalate (MEHP) on chicken germ cells cultured in vitro, *Environmental Science and Pollution Research*, Vol.20, No.5, pp.2771–2783

²⁷³ Lutz, P.L. (1990) Studies on the ingestion of plastic and latex by sea turtles, *Proc. Int. Conf. Marine Debris*.(Eds. RS Shomura & ML Godfrey) NOAA-TM-154 (1990) pp.719–735

²⁷⁴ Oehlmann, J., Schulte-Oehlmann, U., Kloas, W., et al. (2009) A critical analysis of the biological impacts of plasticizers on wildlife, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.2047–2062

²⁷⁵ Flint, S., Markle, T., Thompson, S., and Wallace, E. (2012) Bisphenol A exposure, effects, and policy: A wildlife perspective, *Journal of Environmental Management*, Vol.104, pp.19–34

There is at least one monitoring program that is mapping the traces of organic pollutants on plastic pellets from worldwide samples so as to produce maps of microplastic associated pollutants.²⁷⁶

3.1.3.2 Immunity and Disease

One possible pathway via which organisms may be impacted by marine litter is via effects on the immune system. There are indications that chemicals associated with plastics can compromise immune function in birds.²⁷⁷ In Baltic grey and ringed seals (*Halichoerus grypus* and *Phoca hispida*), high body burdens of PCBs are linked to impairment of immune function and mass mortalities due to morbillivirus infection.²⁷⁸

Marine debris puts animals at risk of long term, open wounds. These can be external like those caused by some kind of constricting ligature, which are often infected.²⁷⁹ Stumps left by fins lost through entanglement of turtles were noticed to be scarred, and it was thought that they had been further attacked by sharks, crabs or birds attracted by blood, necrotizing tissue, and possibly the prospect of food to be scavenged or an easy prey.²⁸⁰ Open wounds can also be internal, like ulceration caused by ingestion, or a fish hook embedded in the jaw. These open wounds are potential initiation points for secondary infection. It has been suggested that uncontrolled infection can lead to microbes entering the blood stream and causing secondary infections in the lungs, heart, brain or other internal organs.²⁸¹ Infection in the jaw and resulting abscess can result in loss of teeth.²⁸² Peritonitis following intestinal perforation or rupture is an example of an acute infection that would follow immediately on from the occurrence of the internal injury, and is usually fatal.^{283,284}

²⁷⁶ <http://www.pelletwatch.org/>

²⁷⁷ Grasman, K.A., and Fox, G.A. (2001) Associations between altered immune function and organochlorine contamination in young Caspian terns (*Sterna caspia*) from Lake Huron, 1997-1999, *Ecotoxicology (London, England)*, Vol.10, No.2, pp.101-114

²⁷⁸ Vos, J.G., Dybing, E., Greim, H.A., et al. (2008) *Health Effects of Endocrine-Disrupting Chemicals on Wildlife, with Special Reference to the European Situation*, accessed 13 December 2013, <http://informahealthcare.com/doi/abs/10.1080/10408440091159176%20>

²⁷⁹ Raum-Suryan, K.L., Jemison, L.A., and Pitcher, K.W. (2009) Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions, *Marine Pollution Bulletin*, Vol.58, No.10, pp.1487-1495

²⁸⁰ Carrington, D. (2013) 'CSI turtle' launches investigation into ghost fishing nets found in the Maldives, *Guardian*

²⁸¹ Raum-Suryan, K.L., Jemison, L.A., and Pitcher, K.W. (2009) Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions, *Marine Pollution Bulletin*, Vol.58, No.10, pp.1487-1495

²⁸² Raum-Suryan, K.L., Jemison, L.A., and Pitcher, K.W. (2009) Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions, *Marine Pollution Bulletin*, Vol.58, No.10, pp.1487-1495

²⁸³ Beck, C.A., and Barros, N.B. (1991) The impact of debris on the Florida manatee, *Marine Pollution Bulletin*, Vol.22, No.10, pp.508-510

Stress hormones such as glucocorticoids are known to be released as a response to tissue damage – the example cited refers to cetaceans but it perhaps this mechanism applies to other animals. This suppresses lymphocyte production (part of the immune response) and may compromise the animal's ability to fight secondary infections or other disease.²⁸⁵

An example from turtles suggests that stranded turtles have high rates of parasite related death and makes the point that death from parasitism is an indicator of general poor health levels, as natural selection dictates that a successful parasite tends not to kill its host.²⁸⁶ This is one example of how different factors in combination can affect mortality in the population. Small cetaceans that have been entangled in fishing gear were also thought to have above average parasite loads.²⁸⁷ It has also been noted that large cetaceans who had suffered entanglement appeared more likely to display cutaneous white fungal infection (around 50%) compared to only a small fraction of the population at large.²⁸⁸

3.1.3.3 Temperature Dependent Sex Determination in Reptiles

An empirical approach that reconstructed sediment cores with different concentrations of microplastics in them found that the fragments altered the permeability of the sediment and this caused it to warm more slowly. As 95% of plastic fragments found on a heavily polluted Hawaiian beach occur in the top 15cm of sediment, it was deemed possible that this could affect species with temperature-dependent sex determination such as turtles, and alter the balance of males and females in the population.²⁸⁹

3.1.3.4 Migration Speed and Timing

There are strong indications that alterations to the timing of migration, such as delays which lead to late arrival at stopover or breeding sites, can have considerable effects

²⁸⁴ Jacobsen, J.K., Massey, L., and Gulland, F. (2010) Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*), *Marine Pollution Bulletin*, Vol.60, No.5, pp.765–767

²⁸⁵ Angliss, R., and DeMaster, D.P. (1998) Differentiating Serious and Non-Serious Injury of Marine Mammals Taken Incidental to Commercial Fishing Operations: Report of the Serious Injury Workshop, *NOAA Technical Memorandum NMFS-OPR*

²⁸⁶ Townsend, K.A. (2011) Impact of ingested marine debris on sea turtles of eastern Australia: Life history stage susceptibility, pathological implications and plastic bag preference., *Technical Proceedings of the 5th International Marine Debris Conference (2011)* pp.180–183

²⁸⁷ Angliss, R., and DeMaster, D.P. (1998) Differentiating Serious and Non-Serious Injury of Marine Mammals Taken Incidental to Commercial Fishing Operations: Report of the Serious Injury Workshop, *NOAA Technical Memorandum NMFS-OPR*

²⁸⁸ Angliss, R., and DeMaster, D.P. (1998) Differentiating Serious and Non-Serious Injury of Marine Mammals Taken Incidental to Commercial Fishing Operations: Report of the Serious Injury Workshop, *NOAA Technical Memorandum NMFS-OPR*

²⁸⁹ Carson, H.S., Colbert, S.L., Kaylor, M.J., and McDermid, K.J. (2011) Small plastic debris changes water movement and heat transfer through beach sediments, *Marine Pollution Bulletin*, Vol.62, No.8, pp.1708–1713

on reproductive fitness.²⁹⁰ There are examples of migratory birds stopping over longer where food resources are poor in the stopping-over area, so that they attain sufficient weight, leading to subsequent delays resuming migration. There may also be severe competition for food resources at stop-over sites. At breeding sites, late arrivals may find resources already depleted by earlier arrivals, which can range from food and mates to territory. Birds with the best body condition arrive earlier and so have their pick of nesting and feeding sites; they start breeding sooner and have larger clutch sizes.^{291,292} It is possible that individuals whose nutrition is negatively affected by marine debris, may be induced to spend longer at stopover sites, and/or compete less successfully for food at those sites (in the case of suppressed appetite). This could result in a generally poorer body condition, or later arrival at breeding sites, or both, and the affected individuals might suffer smaller clutch sizes as a result; however there is no direct evidence of this occurring as yet.

A further risk that could be incurred by individuals staying longer at stop-over sites is predation; for example, the Western Sandpiper (*Calidris mauri*), a shorebird, has been found to be making its stays at stopover sites shorter, apparently in response to the recovery of peregrine falcon populations after the reduction in the use of DDT, as a means of limiting their exposure to the predator. A factor leading them to extend their stay could conversely put them more at risk.²⁹³

There are even examples of birds apparently unable to accumulate sufficient body reserves in time to migrate at an appropriate date, in which case, they may remain in wintering areas or stop-over sites, where one assumes their ability to reproduce is severely compromised, or in breeding areas, where they may die as winter approaches.²⁹⁴ The risk of this may be greater in birds that have consumed marine debris.

Another behavioural trait relevant to the marine debris issue is that lean pre-migratory birds take greater risks than fatter ones, spending less time scanning for predators, feeding for longer each day, more actively and in more dangerous places, and that this is how they speed their rate of feeding and weight gain.²⁹⁵ This type of behaviour might be evident in a bird undernourished because of debris ingestion

²⁹⁰ Faaborg, J., Holmes, R.T., Anders, A.D., et al. (2010) Recent advances in understanding migration systems of New World land birds, *Ecological Monographs*, Vol.80, No.1, pp.3–48

²⁹¹ Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds?, *Journal of Ornithology*, Vol.147, No.2, pp.146–166

²⁹² Smith, R.J., and Moore, F.R. (2005) Arrival timing and seasonal reproductive performance in a long-distance migratory landbird, *Behavioral Ecology and Sociobiology*, Vol.57, No.3, pp.231–239

²⁹³ Ydenberg, R.C., Butler, R.W., Lank, D.B., Smith, B.D., and Ireland, J. (2004) Western sandpipers have altered migration tactics as peregrine falcon populations have recovered, *Proceedings of the Royal Society of London. Series B: Biological Sciences*, Vol.271, No.1545, pp.1263–1269

²⁹⁴ Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds?, *Journal of Ornithology*, Vol.147, No.2, pp.146–166

²⁹⁵ Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds?, *Journal of Ornithology*, Vol.147, No.2, pp.146–166

Although the timing of migration to coincide with types of vegetation or food resources and/or avoidance of certain predators²⁹⁶ is felt to be of concern for the conservation of some migratory species in the context of climate change,²⁹⁷ there is little direct evidence to demonstrate where this has occurred at present. Arguably such scenarios could be extended to any factor that could prevent a migratory species tracking some resource peaks such as delays that might be caused by marine debris impacts. However a marine debris impact affecting this type of migratory delay has not yet been demonstrated.

3.1.3.5 Feeding Behaviour

There is evidence from sharks, seals, turtles and whales, that entanglement can physically inhibit feeding behaviours and lead to starvation. See section 3.1.1.1 for details.

3.1.3.6 Obstacles to Migration

Litter on beaches has been shown to adversely affect the ability of turtle hatchlings to reach the Mediterranean Sea with two of three turtles having contact with litter on their way to reach the water²⁹⁸

3.1.4 Other Ecosystem or Habitat-related Impacts

One of the least well characterized impacts of marine debris is via ecosystem level effects.

For example, coral reefs, seagrass beds and the bottom-dwelling species associated with them are vulnerable to the impacts of marine debris in the following ways.²⁹⁹ Netting snags itself on coral and can tear it apart. Debris can smother benthic habitats. It has been suggested that the accumulation of debris on the sea floor might inhibit gas exchange between water within the sediment and the overlying water, resulting in decreased oxygen in the benthos that could alter the composition of life on the sea floor.³⁰⁰ Benthic debris coverage can be considerable. In a highly polluted bay in the Antarctic 15% of the surface area was covered by debris in parts.³⁰¹ An

²⁹⁶ Skov, C., Chapman, B.B., Baktoft, H., et al. (2013) Migration confers survival benefits against avian predators for partially migratory freshwater fish, *Biology Letters*, Vol.9, No.2, p.20121178

²⁹⁷ Faaborg, J., Holmes, R.T., Anders, A.D., et al. (2010) Recent advances in understanding migration systems of New World land birds, *Ecological Monographs*, Vol.80, No.1, pp.3–48

²⁹⁸ Triessnig, P., Roetzer, A., and Stachowitsch, M. (2012) Beach Condition and Marine Debris: New Hurdles for Sea Turtle Hatchling Survival, *Chelonian Conservation and Biology*, Vol.11, No.1, pp.68–77

²⁹⁹ Ocean Conservancy, and Sheavley (2007) *National Marine Debris Monitoring Program - Final Program Report, Data Analysis and Summary*, 2007

³⁰⁰ Goldberg, E.D. (1997) Plasticizing the Seafloor: An Overview, *Environmental Technology*, Vol.18, No.2, pp.195–201

³⁰¹ Lenihan, H.S., Oliver, J.S., Oakden, J.M., and Stephenson, M.D. (1990) Intense and localized benthic marine pollution around McMurdo Station, Antarctica, *Marine Pollution Bulletin*, Vol.21, No.9, pp.422–430

Indonesian study showed that there were fewer diatoms in the sediments underneath marine debris but more small invertebrates.³⁰² Additional hard substrate on the sea-floor attracts colonies of sessile marine organisms, and will affect the biodiversity.³⁰³ Any alteration to these habitats will have knock on effects on species that rely on them, or species in higher trophic levels which feed on those species. For example, herbivorous turtles graze on sea-grass 'pastures'. Smothering or abrasion of these benthic habitats might degrade an important habitat for them, and additionally leave the turtles more vulnerable to ingestion of debris.^{304,305}

In another example, the level of marine debris cover and coral cover was found to be negatively correlated, with debris abundance associated with decreasing species diversity, in the South Pacific.³⁰⁶

An emerging issue is the effect of ingestion of microplastics on invertebrates such as annelids, echinoderms, molluscs and crustaceans that are part of the food chain for marine vertebrates.³⁰⁷ One concern is that plastics and their impacts will accumulate up the food chain exponentially. Much remains to be elucidated about this type of effect. For example, birds were shown to accumulate flame-retardants that are not present in their food diet, in direct proportion to the amount of plastic ingested, but not other chemicals that were expected to be found in the fish in their diet.³⁰⁸

Another concern is that microplastics might affect the productivity of these important prey items, and this would have implications for the species that feed on them. For example, blue mussels reduce their filter feeding activity upon ingestion of

³⁰² Unepetty, P., and Evans, S.M. (1997) The impact of plastic debris on the biota of tidal flats in Ambon Bay (eastern Indonesia), *Marine Environmental Research*, Vol.44, No.3, pp.233–242

³⁰³ Harms, J. (1990) Marine plastic litter as an artificial hard bottom fouling ground, *Helgoländer Meeresuntersuchungen*, Vol.44, No.3-4, pp.503–506

³⁰⁴ Kiessling, I. (2003) *Finding Solutions: Derelict Fishing Gear and Other Marine Debris In*, Report for the National Oceans Office and the Department of the Environment and Heritage, 2003, <http://www.environment.gov.au/system/files/resources/e4f285b6-6181-4c73-a510-8bc0ac0e2c0b/files/marine-debris-report.pdf>

³⁰⁵ Gunn, R., Hardesty, B.D., and Butler, J. (2010) Tackling 'ghost nets': Local solutions to a global issue in northern Australia, *Ecological Management & Restoration*, Vol.11, No.2, pp.88–98

³⁰⁶ Richards, Z.T., and Beger, M. (2011) A quantification of the standing stock of macro-debris in Majuro lagoon and its effect on hard coral communities, *Marine Pollution Bulletin*, Vol.62, No.8, pp.1693–1701

³⁰⁷ Ivar do Sul, J.A., and Costa, M.F. (2014) The present and future of microplastic pollution in the marine environment, *Environmental Pollution*

³⁰⁸ Tanaka, K., Takada, H., Yamashita, R., Mizukawa, K., Fukuwaka, M., and Watanuki, Y. (2013) Accumulation of plastic-derived chemicals in tissues of seabirds ingesting marine plastics, *Marine Pollution Bulletin*, Vol.69, No.1–2, pp.219–222

microplastics.³⁰⁹ Microplastic concentration in sediment, reduced lugworm feeding and weight loss was shown to be positively correlated in a laboratory experiment.³¹⁰

Another scenario is the introduction of alien species which are known to significantly impact marine ecosystems.³¹¹ One study predicted that global marine species diversity might decrease by as much as 58% if worldwide biotic mixing occurs.³¹² Floating debris provides a platform upon which invasive species can raft, increasing the probability of 'biotic mixing'. 270 species have been reported rafting so far. This is considered an underestimate by the authors of the report. The size of this impact is not fully apparent, as whether a species is considered invasive or what particular impact it might have is not evaluated or stated.³¹³

Floating plastic may also change population structure in a subtly different way. For example, it was recently demonstrated that for the Sea Skater (*Halobates sericeus*), an insect that lives on the surface of the sea, increased density of microplastic in the ocean positively correlated with the density of Sea Skater eggs. Normally, because the species needs hard surfaces upon which to lay its eggs, the availability of such surfaces limits the number of eggs that are laid.³¹⁴ This shows how increasing microplastic levels might lead to changes in population density, the extension of the range of certain species or the introduction of new ones,⁸⁵ different species have been found using marine debris as a habitat so far.³¹⁵ Invertebrates are an important link in the marine food chain, and anything that significantly affects their population and distribution may represent a very significant change in the population structure of an ecosystem.

³⁰⁹ Wegner, A., Besseling, E., Foekema, E.M., Kamermans, P., and Koelmans, A.A. (2012) Effects of nanoplastyrene on the feeding behavior of the blue mussel (*Mytilus edulis* L.), *Environmental Toxicology and Chemistry / SETAC*, Vol.31, No.11, pp.2490–2497

³¹⁰ Besseling, E., Wegner, A., Foekema, E.M., van den Heuvel-Greve, M.J., and Koelmans, A.A. (2013) Effects of microplastic on fitness and PCB bioaccumulation by the lugworm *Arenicola marina* (L.), *Environmental Science & Technology*, Vol.47, No.1, pp.593–600

³¹¹ Hansen, G.J.A., Vander Zanden, M.J., Blum, M.J., et al. (2013) Commonly Rare and Rarely Common: Comparing Population Abundance of Invasive and Native Aquatic Species, *PLoS ONE*, Vol.8, No.10, Sala, O.E., Chapin, F.S., 3rd, Armesto, J.J., et al. (2000) Global biodiversity scenarios for the year 2100, *Science (New York, N.Y.)*, Vol.287, No.5459, pp.1770–1774

³¹² Mckinney, M.L. (1998) On predicting biotic homogenization: species-area patterns in marine biota, *Global Ecology & Biogeography Letters*, Vol.7, No.3, pp.297–301

³¹³ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

³¹⁴ Goldstein, M.C., Rosenberg, M., and Cheng, L. (2012) Increased oceanic microplastic debris enhances oviposition in an endemic pelagic insect, *Biology Letters*, p.rsbl20120298

³¹⁵ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

3.1.5 Knowledge Gaps

Filling in knowledge gaps is necessary to help focus management priorities. In some circumstances, focussing initiatives on particular species, stakeholders or regions may be a highly effective use of limited resources. However there will be limitations, whether because of economic, technological, or practical feasibility, to what it is possible to know, consequent limitations for the comprehensiveness of any dataset, and difficulties in making analyses of trends through the integration of multiple datasets. The argument can be made that a great deal of time and momentum would be needlessly lost awaiting information that answers *all* the unanswered questions that remain about marine debris and its impacts, a goal which is only ever going to be attainable in part. Many initiatives have been proposed on the basis of qualitative information or hypotheses with a narrow evidence base. It is unlikely that all of the actions deemed highly likely to be effective at present would change radically with more knowledge, save better focussing and some exceptions. Some researchers have stated that studies of debris need to move on from documenting occurrence and invest more effort in estimating the lethal and sublethal impacts at the population level, as they could represent a significant proportion of affected individuals not yet accounted for.³¹⁶ Others remind that a balance must be achieved between avoiding delay and guiding action with a reasonable amount of evidence:

“Sometimes it is justified to act before all information we would like is available – but needs to be proportionate and adaptive, as some proposed ‘solutions’ may make the marine litter situation worse” ³¹⁷

3.1.5.1 Quantitative Information on Prevalence

It is not known, with any accuracy, which species are the most affected by marine debris. The quantitative information available is unequally distributed across species groups and impacts. Most quantitative data comes from studies of seals and entanglement.^{318,319} There is a moderate amount, relatively speaking, of information regarding baleen whales and entanglement also. There are a number of quantitative studies regarding birds and entanglement but poor global coverage. This is also true for turtles and entanglement. Toothed whales are lacking almost any quantitative data on entanglement. There is a single large scale quantitative study on manatees,

³¹⁶ Bjorndal, K.A. (1997) Foraging Ecology and Nutrition of Sea Turtles (1997)

³¹⁷ Kershaw, P.J. (2013) *Marine Litter - where are we?*, Global Conference on Land - Ocean Connections, Jamaica

³¹⁸ Marsh, H., Arnold, P., Freeman, M., et al. (2003) Strategies for Conserving Marine Mammals, *Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues* (2003)

³¹⁹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

entanglement and ingestion. As bycatch and entanglement in debris is not distinguished for fish, no quantitative data has been considered.

There is a considerable amount of quantitative information on birds and ingestion, and also on turtles and ingestion, albeit with incomplete regional coverage. There is a moderate amount of information on fish and ingestion but with little global coverage. There is very little information however on seals and ingestion. Data regarding baleen whales and ingestion are almost entirely represented by occasional incidents.

It is difficult to assess to what extent the number and geographical distribution of reported animal-debris interactions represents occurrence of impacts as opposed to focus of monitoring effort, however several reviews conclude it is a result of the latter.

Of the quantitative information available, there are few population level estimates of impact. There are several reasons why it is difficult to determine the significance of marine debris impacts at population levels. At the most basic level, it is often made impossible by the fact that impact monitoring is often not accompanied by estimates of total population as it would be too resource intensive to produce them.

Another reason that it is not known, with any accuracy, which species are the most affected by marine debris is that observed incidences of any impact underestimate actual figures. (For example, entangled species may die at sea prior to detection.)³²⁰ For seals, studies have shown that the probability of sighting entangled animals on land is reduced because entangled seals spend more time at sea and have lower survival rates.³²¹ One study on whales estimated that only 3 to 10% of entanglements were witnessed and reported.³²² Of all the killer whale mortality documented in British Columbia, only 6% of cases result in the finding of carcasses.³²³ Total debris-related mortality will therefore be underestimated.³²⁴

Furthermore, accurate data related to ingestion is unavailable because there is currently no reliable method for assessing debris ingestion in live populations.³²⁵ For ingestion, most data is based only on examination of carcasses and attempts to

³²⁰ Marsh, H., Arnold, P., Freeman, M., et al. (2003) Strategies for Conserving Marine Mammals, *Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues* (2003)

³²¹ Fowler, C.W. (1987) Marine debris and northern fur seals: A case study, *Marine Pollution Bulletin*, Vol.18, pp.326–335, Delong, R.L., Gearin, P.J., Bengtson, J.L., and Dawson, P. (1990) Studies of the Effects of Entanglement on Individual Northern Fur Seals, *Proceedings of the Second International Conference on Marine Debris* (1990) Honolulu, Hawaii

³²² Cole, T.V., Hartley, D., and Garron, M. (2006) Mortality and Serious Injury Determinations for Baleen Whale Stocks along the Eastern Seaboard of the United States, 2000-2004

³²³ Williams, R., Ashe, E., and O'Hara, P.D. (2011) Marine mammals and debris in coastal waters of British Columbia, Canada, *Marine Pollution Bulletin*, Vol.62, No.6, pp.1303–1316

³²⁴ Marsh, H., Arnold, P., Freeman, M., et al. (2003) Strategies for Conserving Marine Mammals, *Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues* (2003)

³²⁵ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

establish prevalence at the population level are rarely made. The sample population, which in that case consists solely of stranded, deceased individuals, is likely to be unrepresentative of the total population, and in addition will miss out the majority of affected individuals, whether affected fatally or sublethally (for example birds that die from ingestion though obstruction of the intestinal tract and starvation will mostly sink in the water or be scavenged,³²⁶ and this is also thought to be the case for baleen and toothed whales, especially the deep-sea diving ones).³²⁷ This makes the extrapolation of prevalence to the population as a whole untenable. Some studies have tried to make the sample population more representative by collecting birds that have died via other means (e.g. accidentally caught in longline fishing,³²⁸ or those hit by vehicles).³²⁹ In both cases, accidentally killed birds had lower quantities of ingested plastic than those found dead, further suggesting that plastic ingestion is contributing to mortality, however occurrence was not necessarily lower. Nevertheless, this form of sampling may still be biased against an unknown number of deceased individuals lost or scavenged at sea, and so still not as reliable for making population wide estimates as desired.

It has been suggested that relative to entanglement, ingestion is generally likely to be underreported, simply because of the fact that entanglement and its consequences are more easily observed.³³⁰

On the other hand, techniques to obtain representative live sample populations and assess them for ingestion are also known to lead to underestimates, for some species at least, but is likely to be true of other animals too.³³¹ For example, when lavage (gastric irrigation) and faecal analysis were compared in the same population of turtles, faecal analysis revealed 10 times more individuals having ingested debris than lavage at 19% vs. 1.9%. Necropsy revealed a proportion of 29%.³³² It is also very difficult to establish exact cause of death, with only a clinical history plus a necropsy

³²⁶ Pierce, K.E., Harris, R.J., Larned, L.S., and Pokras, M.A. (2004) Obstruction and starvation associated with plastic ingestion in a northern gannet *Morus bassanus* and a greater shearwater *Puffinus gravis*, *Marine Ornithology*, Vol.32, pp.187–189

³²⁷ Simmonds, M.P. (2012) Cetaceans and Marine Debris: The Great Unknown, *Journal of Marine Biology*, Vol.2012

³²⁸ Codina-García, M., Militão, T., Moreno, J., and González-Solís, J. (2013) Plastic debris in Mediterranean seabirds, *Marine Pollution Bulletin*

³²⁹ Auman, H.J., Ludwig, J.P., Giesy, J.P., and Colborn, T. (1997) Plastic ingestion by Laysan albatross chicks on Sand Island, Midway Atoll, in 1994 and 1995, *Albatross Biology and Conservation*, pp.239–244

³³⁰ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

³³¹ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

³³² Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

able to do so with a reasonable success rate, which is not feasible for most observational studies on wild populations.³³³

It is clear that the data available is likely to underestimate the population wide prevalence of the impacts of marine debris.

3.1.5.2 Difficulty Establishing Extent of Sublethal Impacts

One turtle study pointed out that sublethal impacts of ingestion are relatively rarely reported upon, even though sublethal effects such as partial obstruction of the digestive tract and reduction of feeding stimulus are more likely to be the major threats in the long term.³³⁴ There have been some studies making progress around the state of knowledge about the exact nature and severity of such impacts. Some are experimental ^{335,336} and some are field studies – yet a great deal more specific research is needed to unequivocally establish mechanisms and extent of harm, and this has been stated by a variety of researchers.^{337,338} It is challenging to establish causation versus correlation in the few studies where plastic ingestion has been correlated with poorer body condition and year on year survival, and empirical approaches are needed. ³³⁹

3.1.5.3 Interaction between Factors

There is not currently a great deal of research on interactions between impacts of marine debris and other threats, as large and comprehensive datasets would be needed to tease out the likely subtle influence of multiple factors on a population. If marine debris impairs the health of an organism, it may make them more vulnerable to other threats. One example is effects of debris on the immune system via toxicological effects of chemicals associated with plastic, or stress from entanglement, and parasite load (Section 3.1.3.2).

³³³ Pierce, K.E., Harris, R.J., Larned, L.S., and Pokras, M.A. (2004) Obstruction and starvation associated with plastic ingestion in a northern gannet *Morus bassanus* and a greater shearwater *Puffinus gravis*, *Marine Ornithology*, Vol.32, pp.187–189

³³⁴ Tourinho, P.S., Ivar do Sul, J.A., and Fillmann, G. (2010) Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil?, *Marine Pollution Bulletin*, Vol.60, No.3, pp.396–401

³³⁵ McCauley, S.J., and Bjorndal, K.A. (1999) Conservation Implications of Dietary Dilution from Debris Ingestion: Sublethal Effects in Post-Hatchling Loggerhead Sea Turtles, *Conservation Biology*, Vol.13, No.4, pp.925–929

³³⁶ Ryan, P.G. (1988) Effects of ingested plastic on seabird feeding: Evidence from chickens, *Marine Pollution Bulletin*, Vol.19, No.3, pp.125–128

³³⁷ Vlietstra, L.S., and Parga, J.A. (2002) Long-term changes in the type, but not amount, of ingested plastic particles in short-tailed shearwaters in the southeastern Bering Sea, *Marine Pollution Bulletin*, Vol.44, No.9, pp.945–955

³³⁸ Bjorndal, K.A. (1997) Foraging Ecology and Nutrition of Sea Turtles (1997)

³³⁹ Ryan, P.G. (1987) The effects of ingested plastic on seabirds: Correlations between plastic load and body condition, *Environmental Pollution*, Vol.46, No.2, pp.119–125

3.1.5.4 Migratory vs. Resident Species

As is often stated, migratory species are particularly vulnerable because of the fact that they rely on a whole series of habitats throughout their ranges, and if any one of these is impacted, it will constitute a threat to the population as a whole. Because multiple locations are involved, there is a greater likelihood that one or more *will* be affected.^{340,341} And these threats come from multiple sources – not just marine debris but many other human activities such as hunting, egg removal, feral animals, fishing practices and physical barriers as well as larger scale environmental changes which are also predominantly anthropogenic.^{342,343} For a migratory species in any one range state, their survival depends on their continued viability in a whole series of locations in their global distribution.

However, there are no studies systematically examining whether and how migratory species are more vulnerable to marine debris than resident species.

Within research on species which happen to be migratory, several points have, however, been noted.

One is that more research is needed to properly establish the causal chain between plastic ingestion, trophic effects and/or behavioural effects, and impacts on fitness or survival, for migrant individuals. It is thought that en route conditions can limit migrant populations; but it is recognized that linking migration habitat quality indicators to fitness or population consequences presents a major challenge, and there are very few studies that have attempted to do this.^{344,345} This can equally apply to marine debris.

Many observations relate to the geospatial distribution of animals, debris, and the en route habits of particular migrants.

Some migratory species feed constantly, as they migrate across areas that are generally ecologically hospitable to them (most marine migratory species). Some species pick their way forward in stages upon modest fat resources (some bird species). While others still make their way nonstop across ecological barriers (particular bird species especially).

³⁴⁰ GRID-Arendal (2011) *Living planet: connected planet: preventing the end of the world's wildlife migrations through ecological networks*, Report for UNEP, 2011

³⁴¹ Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds?, *Journal of Ornithology*, Vol.147, No.2, pp.146–166

³⁴² GRID-Arendal (2011) *Living planet: connected planet: preventing the end of the world's wildlife migrations through ecological networks*, Report for UNEP, 2011

³⁴³ National Research Council of the United States of America (1990) *Decline of the Sea Turtles: Causes and Prevention*,

³⁴⁴ Faaborg, J., Holmes, R.T., Anders, A.D., et al. (2010) Recent advances in understanding migration systems of New World land birds, *Ecological Monographs*, Vol.80, No.1, pp.3–48

³⁴⁵ Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds?, *Journal of Ornithology*, Vol.147, No.2, pp.146–166

Species that feed constantly are expected to ingest litter all through their range. Items that they ingest will reflect the debris composition across the range that they are able to travel across in the time it takes for debris to transit their digestive systems. For example, petrels retain debris in their stomachs for months, and so this is held to reflect the composition of debris found all over the Pacific Ocean, where they range.³⁴⁶ Similarly, the debris found in the stomachs of turtles, which migrate over distances of thousands of miles, is not well correlated with the location in which the turtle is found.³⁴⁷ This highlights one way in which migratory species are more vulnerable than sedentary populations: as they travel, they are less likely to be able to avoid areas where debris accumulates than resident populations, which may have proportions residing in less polluted areas. This is true for entanglement as well as ingestion; however there are some indications that entanglement risk can be more localized.

However there are also migratory species that travel large distances in very few days such as the Bar-tailed Godwit (*Limosa lapponica*),³⁴⁸ or the endangered Pink-footed Shearwater (*Puffinus creatopus*).³⁴⁹ They will therefore cover considerable distances without being at risk of encountering marine debris; this will affect the relationship between impact risk and distribution of marine debris for these species. Breeding and non-breeding distributions may be very large for these birds and so, as a population, they will perhaps benefit in the way that resident species might from parts of their population being able to avoid areas most impacted by marine debris.

However it has been suggested that habitat degradation would have the most severe effect on migrants in the places where the habitat is the last possible feeding place before an ecological barrier, or the first feeding place after such a barrier.³⁵⁰ For shorebirds, like the Golden Plover (*Pluvialis dominica*), or the Turnstone, (*Arenarius interpres*), many of these 'staging sites' will be coastal areas,³⁵¹ and so a prime location for these birds to encounter marine debris.

Birdlife International has assessed these and other important locations (which they term 'Important Bird Areas' (IBAs)) for 300 waterbird species.³⁵² It would be informative to compare the IBAs with distributions of debris for entanglement and

³⁴⁶ Ryan, P.G. (2008) Seabirds indicate changes in the composition of plastic litter in the Atlantic and south-western Indian Oceans, *Marine Pollution Bulletin*, Vol.56, No.8, pp.1406–1409

³⁴⁷ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

³⁴⁸ <http://www.birdlife.org/datazone/speciesfactsheet.php?id=3005>

³⁴⁹ Hodum, P., and Hyrenbach, D. (2006) Conservation Implications of Migration Routes of Pink-footed Shearwaters

³⁵⁰ Newton, I. (2006) Can conditions experienced during migration limit the population levels of birds?, *Journal of Ornithology*, Vol.147, No.2, pp.146–166

³⁵¹ Alerstam, T.(1993) *Bird Migration*, Cambridge University Press

³⁵² Birdlife International (2008) *A network of critical sites for migratory waterbirds is being identified across Africa and Eurasia. Presented as part of the BirdLife State of the world's birds website.*, accessed 26 November 2013, <http://www.birdlife.org/datazone/sowb/casestudy/101>

ingestion risk.³⁵³ The few studies that have attempted to do this for any migratory species tend to use proxies to estimate marine debris in some way, such as shipping routes for example,³⁵⁴ and even fewer have used detailed species distributions and records of impacts.³⁵⁵ None have been found that utilize migratory path data. This comes as no surprise as it would require considerable research effort; with plenty of the necessary data about migration routes, feeding locations and marine debris distribution perhaps never collected on an adequate spatial resolution or even at all. To integrate this spatial information, probably in very different formats and resolutions, would also represent a challenge.

The anadromous Striped Bass (*Morone saxatilis*) is known to ingest debris. Anadromous species spawn in fresh water but live most of their lives in marine environments; there is concern that this life-history trait, which brings the fish into close contact with areas of concentrated human activity, can increase their risk of exposure to anthropogenic threats.³⁵⁶

3.1.5.5 Differential Vulnerability to Marine Debris at Different Life History Stages and other Trends

Several studies have shown that in seals, juveniles are the age class most susceptible to entanglement^{357,358} and it has been suggested that this is because of their playful behaviour, inexperience and the comparatively small size of their heads, which enable them to fit through a wide range of mesh sizes³⁵⁹ Additionally, some studies have shown that juvenile males are very significantly more likely to become entangled than juvenile females; so much so that this was thought to mitigate any population level effects of entanglement as the number of males is not the limiting factor on breeding in this polygynous species.³⁶⁰ In turtles, it is also the younger life stages that appear to be more affected; in Australian waters and amongst stranded

³⁵³ <http://maps.birdlife.org/marineIBAs/default.html>

³⁵⁴ Pompa, S., Ehrlich, P.R., and Ceballos, G. (2011) Global distribution and conservation of marine mammals, *Proceedings of the National Academy of Sciences*, p.201101525

³⁵⁵ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a-n/a

³⁵⁶ U. S. Fish and Wildlife Service Southern New England-New York Bight Coastal Ecosystems Program(1996) *Regionally Significant Habitats and Habitat Complexes of the New York Bight Watershed*, http://library.fws.gov/pubs5/web_link/text/int_fish.htm

³⁵⁷ Pemberton, D., Brothers, N., and Kirkwood, R. (1992) Entanglement of Australian fur seals in man-made debris in Tasmanian waters, *Wildlife Research*, Vol.19, No.2, pp.151-159

³⁵⁸ Arnould, J.P.Y., and Croxall, J.P. (1995) Trends in entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at South Georgia, *Marine Pollution Bulletin*, Vol.30, No.11, pp.707-712

³⁵⁹ Marsh, H., Arnold, P., Freeman, M., et al. (2003) Strategies for Conserving Marine Mammals, *Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues* (2003)

³⁶⁰ Arnould, J.P.Y., and Croxall, J.P. (1995) Trends in entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at South Georgia, *Marine Pollution Bulletin*, Vol.30, No.11, pp.707-712

individuals, young, pelagic feeders had ingested debris at a disproportionate rate (55%) relative to 25% for older, benthic feeding turtles.³⁶¹ It was suggested that a range of factors may play a role in the probability of the turtles dying due to ingested marine debris, such as size of animal, feeding strategy, location during life stage (such as open versus coastal areas), and length of time spent in the open ocean. For example, the young pelagic individuals may be spending time in convergence zones where marine debris tends to accumulate.³⁶²

Maximal debris ingestion was found in recently weaned dolphins by one study, suggesting juveniles might also be more vulnerable in this group of animals too, correlated with changes in feeding behaviour during development.³⁶³ Younger whales are more vulnerable to entanglement as they can become entangled in ropes of lower breaking strength than adults.³⁶⁴ It is also noted that calves have the lowest annual scarring rate of all ages – it is thought that this reflects higher mortality owing to softer and growing tissues being more susceptible to debris becoming embedded and resulting in constriction, wounding and infection.³⁶⁵

Young birds often have a higher load of plastic in their digestive tracts compared with adults, which is thought to either be because of transfer from parents to offspring during feeding or because of lack of discrimination during feeding by naïve juveniles.³⁶⁶ The Northern Gannet (*Morus bassanus*), which is migratory, has been found to use nets as nesting material, either found *in situ* or actively gathered by the birds, with ensuing grave entanglement and mortality risk predominantly for nestlings

³⁶¹ Townsend, K.A. (2011) Impact of ingested marine debris on sea turtles of eastern Australia: Life history stage susceptibility, pathological implications and plastic bag preference., *Technical Proceedings of the 5th International Marine Debris Conference* (2011) pp.180–183

³⁶² Carr, A. (1987) Impact of nondegradable marine debris on the ecology and survival outlook of sea turtles, *Marine Pollution Bulletin*, No.18, p.352

³⁶³ Denuncio, P., Bastida, R., Dassis, M., Giardino, G., Gerpe, M., and Rodríguez, D. (2011) Plastic ingestion in Franciscana dolphins, *Pontoporia blainvillei* (Gervais and d'Orbigny, 1844), from Argentina, *Marine Pollution Bulletin*, Vol.62, No.8, pp.1836–1841

³⁶⁴ Werner, T. (2011) Preliminary Report of the Dynamics of Large Whale Entanglements in Fishing Gear Workshop (2011)

³⁶⁵ Neilson, J.L., Straley, J.M., Gabriele, C.M., and Hills, S. (2009) Non-lethal entanglement of humpback whales (*Megaptera novaeangliae*) in fishing gear in northern Southeast Alaska, *Journal of Biogeography*, Vol.36, No.3, pp.452–464

³⁶⁶ Ryan, P.G. (1988) Effects of ingested plastic on seabird feeding: Evidence from chickens, *Marine Pollution Bulletin*, Vol.19, No.3, pp.125–128, Mallory, M.L., Robertson, G.J., and Moenting, A. (2006) Marine plastic debris in northern fulmars from Davis Strait, Nunavut, Canada, *Marine Pollution Bulletin*, Vol.52, No.7, pp.813–815

but also adults.³⁶⁷ Young gannets at sea were also found to be overwhelmingly the ones affected by entanglement.³⁶⁸

The implication of this is that prioritizing breeding areas where there are high concentrations of juveniles may be one way of concentrating effort against marine debris to its greatest effect; at least for clean-up initiatives. However removal strategies are not always demonstrably successful; there have been regular efforts to disentangle Hawaiian monk seals and remove derelict fishing gear from their pupping beaches, but there has been no apparent decline in the number of entanglements or the amounts of material removed.³⁶⁹ But perhaps more data is needed to make a firm conclusion, as for example, background levels of debris were not simultaneously monitored. Despite the acknowledged paucity of data, it is still suggested that removal of debris from breeding areas and adjacent waters may be particularly beneficial.³⁷⁰ Mapping breeding areas of importance to migratory species, akin to Birdlife's 'Important Bird Area' mapping would be a good start if such an approach was desired.

In a survey of plastic ingestion among 36 seabird species in the southern hemisphere, incidence of ingested plastic was directly related to foraging technique. Foraging techniques were categorized as dipping/pattering. A greater number of species that feed by dipping /pattering ingested plastic compared to species classified as surface-seizing, pursuit diving, plunge diving and piracy; and the incidence within these species was also greater. This is thought to be linked to the fact that most plastic debris is found floating on the surface of the water. Incidence was inversely related to the frequency of regurgitation of indigestible stomach contents. Birds that periodically regurgitate include albatrosses, giant petrels, cormorants, skuas and gulls. They tended to have lower incidence of plastic ingestion than birds that do not regurgitate habitually, such as penguins and other types of petrels.^{371,372} Additionally, omnivores were more likely to have ingested plastic than those eating crustaceans, cephalopods or fish alone, perhaps because

³⁶⁷ Votier, S.C., Archibald, K., Morgan, G., and Morgan, L. (2011) The use of plastic debris as nesting material by a colonial seabird and associated entanglement mortality, *Marine Pollution Bulletin*, Vol.62, No.1, pp.168-172

³⁶⁸ Rodríguez, B., Bécarea, J., Rodríguez, A., and Arcos, J.M. (2013) Incidence of entanglements with marine debris by northern gannets (*Morus bassanus*) in the non-breeding grounds, *Marine Pollution Bulletin*, Vol.75, No.1-2, pp.259-263

³⁶⁹ Henderson, J.R. (2001) A Pre- and Post-MARPOL Annex V Summary of Hawaiian Monk Seal Entanglements and Marine Debris Accumulation in the Northwestern Hawaiian Islands, 1982-1998, *Marine Pollution Bulletin*, Vol.42, No.7, pp.584-589

³⁷⁰ Marsh, H., Arnold, P., Freeman, M., et al. (2003) Strategies for Conserving Marine Mammals, *Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues* (2003)

³⁷¹ Tourinho, P.S., Ivar do Sul, J.A., and Fillmann, G. (2010) Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil?, *Marine Pollution Bulletin*, Vol.60, No.3, pp.396-401

³⁷² Ryan, P.G. (1987) The incidence and characteristics of plastic particles ingested by seabirds, *Marine Environmental Research*, Vol.23, No.3, pp.175-206

they are less discriminating feeders. A greater proportion of smaller bird species ingested plastic, with a lower degree of colour selectivity. It was suggested that this might be due to more specific prey-identification in large birds that feed on squid or larger fish, whereas it might be more difficult for small species which eat smaller planktonic organisms to distinguish them from small pieces of debris.

Procellariiformes (petrels, shearwaters and albatrosses), of which a large proportion are migratory and many are endangered, exhibit the largest plastic loads because they frequently forage at, or near the surface of the sea, taking a wide range of prey types, and seldom regurgitate indigestible stomach contents.³⁷³ Charadriiformes (gulls, terns, curlews and others), of which there are also many migratory and endangered species, generally have lower incidence of plastic ingestion because of their different behaviours.³⁷⁴ However there are exceptions to all these observed trends, with some albatross and the giant petrel, which despite the fact that they, atypically for the procellariiformes, do exhibit regurgitation, still accumulate large quantities of plastic. Some studies have found a low incidence of ingestion in penguins, despite the fact that they seldom regurgitate indigestible items.³⁷⁵ It has been suggested that the entanglement risk for gannets is related to their plunge-diving fishing behaviour.³⁷⁶

For turtles, different species have been shown to have different susceptibility to different marine debris impacts. Carnivorous species (such as the Loggerhead or Kemp's Ridley turtles) are less likely to ingest debris than herbivorous, omnivorous or gelatinivorous species (such as Green or Leatherback turtles). This could be for a variety of reasons, such as soft plastic having a closer resemblance to gelatinous organisms as compared to any kind of debris and carnivore prey; or because herbivores are less selective or feed in areas that accumulate debris. It was suggested that other species-specific differences in prevalence might be due to different species having different size diameter digestive tracts within similar age classes; those with smaller diameter tracts may find it more difficult to pass ingested materials.³⁷⁷ In an entanglement study more Hawksbill and Olive Ridley turtles were affected than Green or Flatback turtles. However whether this was disproportionate

³⁷³ Ryan, P.G. (1987) The incidence and characteristics of plastic particles ingested by seabirds, *Marine Environmental Research*, Vol.23, No.3, pp.175–206

³⁷⁴ Tourinho, P.S., Ivar do Sul, J.A., and Fillmann, G. (2010) Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil?, *Marine Pollution Bulletin*, Vol.60, No.3, pp.396–401

³⁷⁵ Tourinho, P.S., Ivar do Sul, J.A., and Fillmann, G. (2010) Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil?, *Marine Pollution Bulletin*, Vol.60, No.3, pp.396–401

³⁷⁶ Rodríguez, B., Bécares, J., Rodríguez, A., and Arcos, J.M. (2013) Incidence of entanglements with marine debris by northern gannets (*Morus bassanus*) in the non-breeding grounds, *Marine Pollution Bulletin*, Vol.75, No.1–2, pp.259–263

³⁷⁷ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

compared to the local population composition was not tested because the sample sizes were considered to be too small to do so.³⁷⁸

It has been proposed that animals whose feeding behaviour includes bottom feeding, such as the sperm whale, accounts for the tendency of this species to ingest a variety of non-food items, such as sand, rocks, coconuts or other debris, so this and species with similar behaviour, may be at greater risk from marine debris, at least that on the sea-floor.³⁷⁹ Beluga and Grey whales are also benthic feeders, and may also run similarly elevated risk. Sperm whales and other toothed whales have also been singled out as at greater risk because of their 'suction feeding' behaviour, while the northern right whale (*Eubalaena glacialis*) has been singled out as being at particular risk from entanglement because it is a 'ram feeder' and so likely to encounter various forms of marine debris with their mouths open.³⁸⁰

In a study of pelagic predatory fish, the species with the highest rates of ingestion were thought to live and feed primarily in the subsurface part of the water column. This was deemed surprising as most of the plastic found was buoyant in samples of seawater mimicking all depths.³⁸¹

3.1.5.6 Regional Distinctions

Regarding whether there can be considered 'hotspots' for particular impacts the report commissioned for the Convention on Biological Diversity states that it is likely that there is an underreporting in some regions. More reports are from North America, Europe and Australasia, while few reports of impacts exist from Asia, Africa, the Arctic and Antarctic. It was felt that this reflected frequency of reporting rather than a reflection of quantities of debris and therefore decreased frequency of impacts.³⁸² Survey efforts were also felt to determine the distribution of records of impacts within regions, such as Australian waters. For example, it was noted that seabird records tend to be concentrated around large urban centres, especially where zoos or wildlife rescue organizations receive dead and injured birds and maintain records, and on

³⁷⁸ Wilcox, C., Hardesty, B.D., Sharples, R., Griffin, D.A., Lawson, T.J., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

³⁷⁹ de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., and Cañadas, A. (2013) As main meal for sperm whales: Plastics debris, *Marine Pollution Bulletin*, Vol.69, No.1–2, pp.206–214

³⁸⁰ Simmonds, M.P. (2012) Cetaceans and Marine Debris: The Great Unknown, *Journal of Marine Biology*, Vol.2012

³⁸¹ Choy, C.A., and Drazen, J.C. (2013) Plastic for dinner? Observations of frequent debris ingestion by pelagic predatory fishes from the central North Pacific, *Marine Ecology Progress Series*, Vol.485, pp.155–163

³⁸² STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

offshore islands where plastic ingestion by particular seabird species has been studied.³⁸³

There are areas where turtles occur in large numbers such as Southeast Asia, Western and Northern Australia, South America, Africa, and in the high seas at subtropical latitudes, where the effects of debris are considered under-researched.³⁸⁴ There is reasonably good coverage of reports of ingestion across these regions, but this is not the case for reports of entanglement. However there are enough reports of impacts all in all to understand that debris is a significant issue for sea turtles.

However, another review states that even though research and reporting effort is not uniformly distributed, with no reporting at all in some regions, it is felt that in some regions, the elevated number of reports does reflect areas where there is a higher risk of impacts, and that it may be helpful to target resources in those areas. For entanglement, the review concluded that the Eastern coast of the USA, the Northern Pacific and Sea of Japan were risk areas for whales, the Western coast of the USA was a risk area for fur seals, sea lions and humpback whales, the Eastern Coast of Australia and the Southern African a hotspot for fur seals, the North Sea a risk area for grey seals, Minke Whales and gannets, and the Northern Coast of Australia a hotspot for turtle entanglement.³⁸⁵ Each of these areas includes range states of migratory species and will arguably pose a risk for whatever species passes through or spends time there.

The same review concluded that for ingestion, the distribution of reports for birds reflected that the risk of ingestion is global for them. Studies on turtle species were considered to be rather more sporadic geographically, yet it was held to be a reasonable assumption that a species will ingest plastic waste wherever both it and the waste are present.

One example was found where a hotspot approach could be an effective way of targeting resources. In the Gulf of Carpentaria, spatial distribution of nets and turtle impacts were found to correlate. Furthermore, monitoring revealed that most nets enter the Gulf from a prevalent direction, the northwest, cross to the northernmost part of the eastern shore and continue to travel along it in a clockwise direction. Hence monitoring or even interception of nets was hypothesised to be possible by covering a relatively small area north of the Gulf, before it enters the bay, and encounters high-density turtle areas.³⁸⁶

³⁸³ Ceccarelli, D.M., and C. R. Consulting (2009) Impacts of plastic debris on Australian marine wildlife, Report by C&R Consulting to the Australian Government Department of the Environment, Water, Heritage and the Arts

³⁸⁴ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

³⁸⁵ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

³⁸⁶ Wilcox, C., Hardesty, B.D., Sharples, R., Griffin, D.A., Lawson, T.J., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

3.1.5.7 Incomparability of Data

Although there are examples of many different types of impact on different high level classes of animal, in different regions, this does not really constitute a comprehensive body of data regarding where debris occurs, where it is from, what species it interacts with and what the direct impacts are of those interactions.³⁸⁷ In addition, of the data that does exist, several reports state that globally, there is a lack of standardized reporting methods on debris effects on wildlife, including debris type and size, species and life history stage of animals affected.³⁸⁸

For example, different types of prevalence statistics tend to be reported for different animals. The type of statistic likely to be reported is influenced by the population size and therefore ease of monitoring/estimation of that population size, and the nature of the impact, as assessed above. Therefore we see a range of different statistics, such as:

- percentage of deceased individuals suffering a particular impact;
- percentage of deceased individuals which died as a result of that impact;
- % of the population suffering an impact in a year;
- % of the population at any one time point that are suffering from an impact;
- mortality over one year as a proportion of either the affected individuals or the population; and
- cohort mortality (i.e. % of individuals in the population or of a particular age that die over a lifetime from that impact).

Prevalence is also estimated inter-species with statistics such as the proportion of all animals found entangled belonging to a particular species or higher taxon.

This means that there is not a globally consistent and comparable dataset that comprehensively covers even the most well studied impacts such as entanglement or ingestion, for any high level class of species. This makes it difficult to compare the prevalence of different types of impact.

3.2 Scale of Impacts of Marine Debris on Migratory Species – Ranking by Debris Type

There are many different ways that impacts can be ranked, which are all worth consideration. Impacts can be categorized according to:

- whether they are lethal or sublethal;
- whether they are acute or chronic;

³⁸⁷ Derraik, J.G. (2002) The pollution of the marine environment by plastic debris: a review, *Marine Pollution Bulletin*, Vol.44, No.9, pp.842–852, Wilcox, C., Hardesty, B.D., Sharples, R., Griffin, D.A., Lawson, T.J., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

³⁸⁸ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

- the degree of suffering caused to the animal;
- how widespread they are in the population; and
- how many species they affect and their geographical distribution.

However, recording efforts are not at sufficient scale, detail or comparability between species and impact type to produce rankings that take into account all these aspects.

Considering the ranking of impacts by debris item material or type for different species, the simplest method is by prevalence of item causing impact on a group of individuals. Even this can be expressed in a variety of ways, such as the number of animals found to have ingested that item expressed as a proportion of animals that have ingested debris or as a proportion of the population as a whole; or by the proportion of total items ingested by an individual or across a population. There is not enough data to produce a comprehensive ranking of impact by marine debris type according to the main species classes relevant to migratory species, however there are some clear trends.

3.2.1 By Material Type

The report commissioned by the Convention on Biological Diversity found that around 80% of the species impacts were associated with plastic debris, while paper, glass and metal together accounted for less than 2%. For ingestion, many items are unidentifiable fragments so the main feature of note is that plastic is always the prevalent material, across all taxa and all regions, and that generally the items have the characteristic of being of swallowable size (of course increasing in size for whales). 90% of the items ingested by turtles from the Australian coast were plastic.³⁸⁹ Two South American studies found that 60-71% of stranded turtles had ingested plastic.^{390, 391} 94% by weight of foreign material ingested by a sperm whale was plastic (around 18 kg of material).³⁹² A further illustration is given as 95% of Northern Fulmars (*Fulmarus glacialis*) whose bodies were washed ashore were found to have plastic debris in their digestive system.³⁹³ It has been noted in several studies

³⁸⁹ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2012) To eat or not to eat? Debris selectivity by marine turtles, *PLoS One*, Vol.7, No.7, p.e40884

³⁹⁰ Tourinho, P.S., Ivar do Sul, J.A., and Fillmann, G. (2010) Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil?, *Marine Pollution Bulletin*, Vol.60, No.3, pp.396–401

³⁹¹ Ivar do Sul, J.A., and Costa, M.F. (2007) Marine debris review for Latin America and the Wider Caribbean Region: From the 1970s until now, and where do we go from here?, *Marine Pollution Bulletin*, Vol.54, No.8, pp.1087–1104

³⁹² de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., and Cañadas, A. (2013) As main meal for sperm whales: Plastics debris, *Marine Pollution Bulletin*, Vol.69, No.1–2, pp.206–214, van Franeker, J.A., Blaize, C., Danielsen, J., et al. (2011) Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea, *Environmental Pollution (Barking, Essex: 1987)*, Vol.159, No.10, pp.2609–2615

³⁹³ van Franeker, J.A., Blaize, C., Danielsen, J., et al. (2011) Monitoring plastic ingestion by the northern fulmar *Fulmarus glacialis* in the North Sea, *Environmental Pollution (Barking, Essex: 1987)*, Vol.159, No.10, pp.2609–2615

that higher proportions of seabirds appear to ingest plastic than other taxa, regularly in the range of 90-100% of individuals. Although it has been suggested that this reflects the fact that plastic is the most prevalent in the oceans, it does not explain inter-species differences.

3.2.2 By Item Type

The report commissioned by the Convention on Biological Diversity found that the most prevalent item types within the plastics category were rope and netting (24%), fragments (20%), packaging (17%), other fishing debris (16%) and microplastics (11%).³⁹⁴

In another recent review, across all species, net fragments, rope and line, monofilament line, packing bands, plastic rings and can yokes were the debris most frequently associated with entanglement.³⁹⁵

In the US, beach clean-up data estimated that 32% of beach litter had the potential to entangle animals. Of the nine items which contributed to this total, the five most numerous were: plastic bags with seams of less than one metre (9%); balloons (8%); rope (6%); fishing line (3%); and fishing nets (1.4%).³⁹⁶ By comparing these percentages with the prevalence of these items in entanglement incidents, an indication is given of whether items causing entanglement are disproportionately affecting individuals and species; with prevalence of net and fishing gear in entanglement reports over 90% in some cases (see below), the conclusion is that they are massively overrepresented.

Regarding ingestion, the most common items recorded are small plastic fragments of swallowable size, with plastic bags of particular concern for turtles and whales, and larger items of plastic waste including netting also of concern for baleen whales.³⁹⁷

Regarding the relative importance of different impacts, although entanglement appears to result in more acute consequences than ingestion,^{398,399} its prevalence is

³⁹⁴ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

³⁹⁵ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

³⁹⁶ Ocean Conservancy, and Sheavley (2007) *National Marine Debris Monitoring Program - Final Program Report, Data Analysis and Summary*, 2007

³⁹⁷ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

³⁹⁸ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

³⁹⁹ Laist, D.W. (1996) *Marine Debris Entanglement and Ghost Fishing: A Cryptic and Significant Type of Bycatch?*, *Solving Bycatch: Proceedings of the Solving Bycatch Workshop: Considerations for Today and Tomorrow* (1996)

considered to be less than, for example, ingestion.⁴⁰⁰ Therefore items more likely to result in entanglement, such as fishing equipment or packing bands would top the list in terms of impact for the individual but not necessarily at the population level. However too little population level data exists for this to be stated conclusively.

3.2.3 Plastic: Rope, Line and Netting

Rope and netting are the most prevalent item type causing impacts when all species and impacts are considered together. The prevalence however varies between taxonomic grouping. For example, fish were the most disproportionately affected by rope and netting in terms of number of species, with around half of the species recorded impacted by this item type. For marine mammals the comparable figure was a third, while for birds and turtles this proportion was markedly less.⁴⁰¹

It is a fair assumption that rope and netting are more likely to be associated with entanglement than other types of debris, as they are specifically designed for capturing wildlife, and it is known that the prevalence of fishing items an animal encounters can be well correlated with entanglement rates.⁴⁰² For turtles, the numbers of species suffering entanglement versus ingestion were more or less equal while for mammals and fish more species had been recorded as being involved with entanglement rather than having ingested material. For birds, many fewer species had been recorded as having suffered entanglement (67 species) versus ingestion (199 species). This may reflect the fact that birds spend less time in the water and may be less likely to come into contact with the kind of debris that causes entanglement, or that other behaviours make them more circumspect about the possibility of entanglement. On the other hand there is little information available, for example, on the incidence of seabird entanglements caused by adrift plastic debris both because of difficulty detecting it before animals die and carcasses are lost, and because of biases in sampling and reporting.⁴⁰³ Bird research is more resource intensive at sea where bird population densities will be so much lower than on the coast, while concurrently this is exactly where a considerable proportion of bird entanglement incidents might occur.

Fishing line was however noted as one of the most common items ingested by seabirds around the Australian coast, according to a recent review, and also by fish in the North Pacific, so these items are not exclusively associated with

⁴⁰⁰ Secchi, E.R., and Zarzur, S. (1999) Plastic debris ingested by a Blainville's beaked whale, *Mesoplodon densirostris*, washed ashore in Brazil

⁴⁰¹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

⁴⁰² Wilcox, C., Hardesty, B.D., Sharples, R., Griffin, D.A., Lawson, T.J., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

⁴⁰³ Rodríguez, B., Bécares, J., Rodríguez, A., and Arcos, J.M. (2013) Incidence of entanglements with marine debris by northern gannets (*Morus bassanus*) in the non-breeding grounds, *Marine Pollution Bulletin*, Vol.75, No.1–2, pp.259–263

entanglement.^{404,405} One study on fish ingestion stated that 19% of the items were fishing gear.⁴⁰⁶ For Steller Sea Lions, (*Eumetopias jubatus*) in the North Pacific, many had ingested fishing equipment such as salmon fishery flashers/lures, longline gear, hooks and lines, spinners/spoons and bait hooks.⁴⁰⁷

For seals, on average 38% of entanglement cases were attributed to net and 28% to fishing line. It appears that studies vary a great deal as to what the predominant impact causing debris item type is.⁴⁰⁸ This may reflect local composition of debris but this has never been tested.

For baleen whales, net was also the most prevalent item in which individuals were entangled at 50% on average, closely followed by 'fishing pot gear', at 42%.⁴⁰⁹ In a study on Right Whales and Humpback Whales, 81% of entanglements involved vertical or horizontal lines such as buoy lines or groundlines from pots.⁴¹⁰

Of the few recorded incidents of debris ingestion in toothed whales, two Sperm Whales had 134 different types of net pieces in their stomachs ranging from 10cm² to 16m² in size, although fishing line also featured heavily.⁴¹¹ 18% by weight of the indigestible stomach contents of another was rope (thought to be derived from the greenhouse industry).⁴¹²

⁴⁰⁴ Ceccarelli, D.M., and C. R. Consulting (2009) Impacts of plastic debris on Australian marine wildlife, Report by C&R Consulting to the Australian Government Department of the Environment, Water, Heritage and the Arts

⁴⁰⁵ Choy, C.A., and Drazen, J.C. (2013) Plastic for dinner? Observations of frequent debris ingestion by pelagic predatory fishes from the central North Pacific, *Marine Ecology Progress Series*, Vol.485, pp.155–163

⁴⁰⁶ Anastasopoulou, A., Mytilineou, C., Smith, C.J., and Papadopoulou, K.N. (2013) Plastic debris ingested by deep-water fish of the Ionian Sea (Eastern Mediterranean), *Deep Sea Research Part I: Oceanographic Research Papers*, Vol.74, pp.11–13

⁴⁰⁷ Raum-Suryan, K.L., Jemison, L.A., and Pitcher, K.W. (2009) Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions, *Marine Pollution Bulletin*, Vol.58, No.10, pp.1487–1495

⁴⁰⁸ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

⁴⁰⁹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

⁴¹⁰ Johnson, A., Salvador, G., Kenney, J., Robbins, J., Kraus, S., Landry, S., and Clapham, P. (2005) Fishing Gear Involved in Entanglements of Right and Humpback Whales, *Marine Mammal Science*, Vol.21, No.4, pp.635–645

⁴¹¹ Jacobsen, J.K., Massey, L., and Gulland, F. (2010) Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*), *Marine Pollution Bulletin*, Vol.60, No.5, pp.765–767

⁴¹² de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., and Cañadas, A. (2013) As main meal for sperm whales: Plastics debris, *Marine Pollution Bulletin*, Vol.69, No.1–2, pp.206–214

Of stranded bottlenose dolphins from the Adriatic Sea, 10% had been affected by larynx strangulation post ingestion of fragments of gill net. In another dolphin study, 45% of the items recovered from stomachs were classified as fishing related debris, including net, rope and line.⁴¹³

For Sirenia species, manatees and dugongs predominantly become entangled in net, line and rope.⁴¹⁴

For turtles, one study attributed 25% of deaths in stranded turtles to entanglement in netting, of which 26% were contributed to by amputation of one or two flippers.

Turtles also ingest rope – in the Adriatic Sea, 42% of ingested items were rope.⁴¹⁵

In birds, it was reported that 48% of beached birds were entangled in line or rope, 39% in nets and 7% with line and hooks. In another study in California, 11.3-16.1% of entanglement cases, including birds, were owing to fishing related debris.⁴¹⁶ A study into entanglement in debris that was collected by one species for nesting material showed that about 83% of the inorganic nesting material was synthetic fibre rope, and 15% was netting.⁴¹⁷

3.2.4 Plastic: Bags and Film

In turtles, there is some evidence that the species target particular types of plastic for ingestion. In one Australian study, 55% of inorganic items recovered from stranded turtle digestive tracts were flexible plastics such as bags and film, which is far higher than the fraction of such items making up marine debris in the area at around 15%.⁴¹⁸ Similarly, in the Adriatic, 68% of debris ingested by turtles was soft plastic.⁴¹⁹ Balloons were also singled out as an item disproportionately ingested by turtles off

⁴¹³ Bastida *et al.*, 2000 in Marsh, H., Arnold, P., Freeman, M., *et al.* (2003) Strategies for Conserving Marine Mammals, *Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues* (2003)

⁴¹⁴ Beck, C.A., and Barros, N.B. (1991) The impact of debris on the Florida manatee, *Marine Pollution Bulletin*, Vol.22, No.10, pp.508–510, Ceccarelli, D.M., and C. R. Consulting (2009) Impacts of plastic debris on Australian marine wildlife, *Report by C&R Consulting to the Australian Government Department of the Environment, Water, Heritage and the Arts*

⁴¹⁵ Lazar, B., and Gračan, R. (2011) Ingestion of marine debris by loggerhead sea turtles, *Caretta caretta*, in the Adriatic Sea, *Marine Pollution Bulletin*, Vol.62, No.1, pp.43–47

⁴¹⁶ OSPAR (2009) *Marine litter in the Northeast Atlantic Region: assessment and priorities for response*, Report for London, U.K., 2009

⁴¹⁷ Votier, S.C., Archibald, K., Morgan, G., and Morgan, L. (2011) The use of plastic debris as nesting material by a colonial seabird and associated entanglement mortality, *Marine Pollution Bulletin*, Vol.62, No.1, pp.168–172

⁴¹⁸ Townsend, K.A. (2011) Impact of ingested marine debris on sea turtles of eastern Australia: Life history stage susceptibility, pathological implications and plastic bag preference., *Technical Proceedings of the 5th International Marine Debris Conference* (2011) pp.180–183

⁴¹⁹ Lazar, B., and Gračan, R. (2011) Ingestion of marine debris by loggerhead sea turtles, *Caretta caretta*, in the Adriatic Sea, *Marine Pollution Bulletin*, Vol.62, No.1, pp.43–47

the Australian coast, found in 30% of turtles which ingested debris.⁴²⁰ Several studies found that black, white and clear bags are prevalent in turtle guts (hypothesized to be similar to jellyfish prey). However, the authors did not compare this prevalence statistically with the colour distribution of plastic film in the environment, so it could not be proved that turtles, who are able to discriminate colour, were selectively feeding on different colours of plastic.⁴²¹ However one study did successfully show that pelagic, younger turtles, were less selective in terms of items and colours ingested, while older, benthic feeders, were statistically more likely to ingest flexible, clear plastic, when compared with surrounding debris composition.⁴²²

The few reports of death in the toothed Pygmy Sperm Whale (*Kogia breviceps*) by ingestion of debris involved plastic bags, and plastic bags made up 2% of the items recovered from a Sperm Whale (*Physeter macrocephalus*), also suffering the fatal consequences of ingestion.⁴²³ In another Sperm Whale incident, plastic sheeting from the greenhouse industry was implicated, and made up 43% of the stomach remains by weight.⁴²⁴ A review of ingestion reports from toothed whales pre-1990 states that plastic bags and sheeting were the predominant items ingested (62.5%).⁴²⁵ One study on fish ingestion stated that 22% of the items were small pieces of plastic bag.⁴²⁶

Small fragments of plastic film were also the predominant item ingested by the migratory Glaucous-Winged Gull *Larus glaucescens*, found in 67% of the individuals who had ingested plastic.⁴²⁷

3.2.5 Plastic: Miscellaneous Items

There are many other item types that have been indicated as being involved in a significant proportion of debris related impacts. For example, packing bands feature very frequently in entanglement reports. In one study, they caused more than 50% of

⁴²⁰ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2012) To eat or not to eat? Debris selectivity by marine turtles, *PloS One*, Vol.7, No.7, p.e40884

⁴²¹ Bugoni, L., Krause, L., and Virgínia Petry, M. (2001) Marine debris and human impacts on sea turtles in southern Brazil, *Marine Pollution Bulletin*, Vol.42, No.12, pp.1330–1334

⁴²² Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2012) To eat or not to eat? Debris selectivity by marine turtles, *PloS One*, Vol.7, No.7, p.e40884

⁴²³ Jacobsen, J.K., Massey, L., and Gulland, F. (2010) Fatal ingestion of floating net debris by two sperm whales (*Physeter macrocephalus*), *Marine Pollution Bulletin*, Vol.60, No.5, pp.765–767

⁴²⁴ de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., and Cañadas, A. (2013) As main meal for sperm whales: Plastics debris, *Marine Pollution Bulletin*, Vol.69, No.1–2, pp.206–214

⁴²⁵ Simmonds, M.P. (2012) Cetaceans and Marine Debris: The Great Unknown, *Journal of Marine Biology*, Vol.2012

⁴²⁶ Anastasopoulou, A., Mytilineou, C., Smith, C.J., and Papadopoulou, K.N. (2013) Plastic debris ingested by deep-water fish of the Ionian Sea (Eastern Mediterranean), *Deep Sea Research Part I: Oceanographic Research Papers*, Vol.74, pp.11–13

⁴²⁷ Lindborg, V.A., Ledbetter, J.F., Walat, J.M., and Moffett, C. (2012) Plastic consumption and diet of Glaucous-winged Gulls (*Larus glaucescens*), *Marine Pollution Bulletin*, Vol.64, No.11, pp.2351–2356

neck entanglements for Steller Sea Lions in Alaska, and other studies reported similar rates for this item type.⁴²⁸ Rubber packing bands have also been identified in one case as being a significant cause of entanglement (30% of cases) in a similar population.⁴²⁹ This draws attention to the rather obvious fact that it is the shape of some materials (i.e. that they are looped) that is of particular relevance to the impact that they have. Hence education campaigns promoting simple procedures such as cutting entangling loops of material should help prevent entanglement.⁴³⁰

Styrofoam (15%) was a major group within items ingested by turtles in the Adriatic Sea⁴³¹ and also off the Australian coast (12% of turtles ingesting debris having ingested that item).⁴³²

13% by weight of the items ingested by a sperm whale were classified as ‘small plastics’ (less than 4 cm), and several miscellaneous household items were also found too.⁴³³ In one dolphin study, 45% of items ingested were classed as general ‘plastic packaging’ and a further 16% as small pieces of plastic.⁴³⁴ One study on fish ingestion stated 56% of the items were small pieces of plastic.⁴³⁵

Seabirds have been shown to exhibit a preference for darker, more conspicuously-coloured debris, and a comparison between ingested plastic and surrounding debris suggests they are mistaking the plastic for prey. Ingested consumer plastic tends to be larger than the average mass of particles found at sea and they also display some colour selectivity – for example, it has been suggested that Albatrosses prefer red particles because they resemble the colouration of some crustaceans.⁴³⁶ Gannets

⁴²⁸ NOAA (2013) *Pinniped Entanglement in Marine Debris*, accessed 14 November 2013, <http://alaskafisheries.noaa.gov/protectedresources/entanglement/pinnipeds.htm>

⁴²⁹ Raum-Suryan, K.L., Jemison, L.A., and Pitcher, K.W. (2009) Entanglement of Steller sea lions (*Eumetopias jubatus*) in marine debris: Identifying causes and finding solutions, *Marine Pollution Bulletin*, Vol.58, No.10, pp.1487–1495

⁴³⁰ Waluda, C.M., and Staniland, I.J. (2013) Entanglement of Antarctic fur seals at Bird Island, South Georgia, *Marine Pollution Bulletin*

⁴³¹ Lazar, B., and Gračan, R. (2011) Ingestion of marine debris by loggerhead sea turtles, *Caretta caretta*, in the Adriatic Sea, *Marine Pollution Bulletin*, Vol.62, No.1, pp.43–47

⁴³² Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2012) To eat or not to eat? Debris selectivity by marine turtles, *PLoS One*, Vol.7, No.7, p.e40884

⁴³³ de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., and Cañadas, A. (2013) As main meal for sperm whales: Plastics debris, *Marine Pollution Bulletin*, Vol.69, No.1–2, pp.206–214

⁴³⁴ Bastida et al., 2000 in Marsh, H., Arnold, P., Freeman, M., et al. (2003) Strategies for Conserving Marine Mammals, *Marine Mammals: Fisheries, Tourism and Management Issues: Fisheries, Tourism and Management Issues* (2003)

⁴³⁵ Anastasopoulou, A., Mytilineou, C., Smith, C.J., and Papadopoulou, K.N. (2013) Plastic debris ingested by deep-water fish of the Ionian Sea (Eastern Mediterranean), *Deep Sea Research Part I: Oceanographic Research Papers*, Vol.74, pp.11–13

⁴³⁶ Derraik, J.G. (2002) The pollution of the marine environment by plastic debris: a review, *Marine Pollution Bulletin*, Vol.44, No.9, pp.842–852, Gregory, M.R. (2009) Environmental implications of plastic debris in marine settings—entanglement, ingestion, smothering, hangers-on, hitch-hiking and

also were entangled most frequently in red items (however this was not compared against baseline ambient colour composition of debris).⁴³⁷ However the fact that they ingested plastic at all was taken to mean that the birds are relatively non-selective, opportunistic foragers.⁴³⁸

There are even reports that fish feed selectively for debris that is white, plastic and spherical.⁴³⁹ Others suggest that blue and yellow items are attacked more frequently as evidenced by bite marks. Fish also attack bottle shaped items disproportionately relative to their abundance in the environment.⁴⁴⁰

Although plastic beads were the prevalent item ingested by birds decades ago, 'user plastics' are now the prevalent item.⁴⁴¹

3.2.6 Plastic: Microplastics

The impacts of microplastics are currently hypothesised to be via one of two main mechanisms: firstly, via their physical mass which could have impacts post ingestion, and secondly, via toxicological means, either through chemicals that derive from the plastic directly, or which the small plastic particles accumulate (see Section 3.1.3.1). These chemicals are associated with all marine debris made of plastic, however the large surface area of microplastics plus their potential ease of ingestion by the widest range of organisms aggravates the impact. One review calculates that 10% of all marine debris encounters are with microplastics.⁴⁴² Many items that would fall within the definition of microplastic tend to be counted together with other miscellaneous plastic fragments, therefore it is not possible to obtain prevalence information by this item type for different species groups or regions. There is increasing evidence that microplastics are also ingested by marine invertebrates such as amphipods, lugworms, barnacles, mussels, lobster and squid.⁴⁴³ This is of concern because they are eaten by species higher up the food chain, and may provide a further vector for

alien invasions, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.2013–2025

⁴³⁷ Rodríguez, B., Bécas, J., Rodríguez, A., and Arcos, J.M. (2013) Incidence of entanglements with marine debris by northern gannets (*Morus bassanus*) in the non-breeding grounds, *Marine Pollution Bulletin*, Vol.75, No.1–2, pp.259–263

⁴³⁸ Ryan, P.G. (1987) The incidence and characteristics of plastic particles ingested by seabirds, *Marine Environmental Research*, Vol.23, No.3, pp.175–206

⁴³⁹ Carpenter, E.J., Anderson, S.J., Harvey, G.R., Miklas, H.P., and Peck, B.B. (1972) Polystyrene spherules in coastal waters, *Science (New York, N.Y.)*, Vol.178, No.4062, pp.749–750

⁴⁴⁰ Carson, H.S. (2013) The incidence of plastic ingestion by fishes: From the prey's perspective, *Marine Pollution Bulletin*

⁴⁴¹ Ryan, P.G. (2008) Seabirds indicate changes in the composition of plastic litter in the Atlantic and south-western Indian Oceans, *Marine Pollution Bulletin*, Vol.56, No.8, pp.1406–1409

⁴⁴² STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

⁴⁴³ Ivar do Sul, J.A., and Costa, M.F. (2014) The present and future of microplastic pollution in the marine environment, *Environmental Pollution*

microplastics and their impacts, or alternatively a mechanism for ecosystem level effects, for instance if the growth and productivity of these invertebrates were significantly affected.

3.2.7 Other Materials: Fishing Hooks

26% of stranded turtles in one Canary Island study had suffered inflammation or perforation of the oesophagus through the ingestion of fishing hooks.⁴⁴⁴ Seals are also known to ingest debris such as fish hooks.⁴⁴⁵ Albatrosses are regularly found with hooks embedded in their mouthparts or intestines with the accompanying risk of oesophageal damage.⁴⁴⁶ Fishing hooks have also been ingested by Sperm Whales.⁴⁴⁷ With this item type there is again the issue of what counts as bycatch and what counts as ingestion of marine debris, as these incidents might well result from scavenging behaviour.

3.2.8 Knowledge Gaps

3.2.8.1 Ranking of Item Type by Impact – Data Integration

Scoring of debris items by material or type is not consistent enough between studies in terms of categories (which may include a mixture of categories defined by material, type or source), to compare prevalence for a given category across impacts and species groups. Environmental debris levels are usually not measured so as rule it is not possible to determine if risk is owing to nature of item (demonstrated by its over-representation in debris encounters) or its prevalence in the environment. A few items are very obviously overrepresented for particular types of species and impacts. For an overview of impact risk globally for different species, a comprehensive database of geographical regions, background debris composition, linked to data on item type prevalence in debris encounters would be needed. Yet there is a distinct lack of global coverage for both variables; it is not known, with any accuracy, which species are the most affected by marine debris. In addition, lack of consistency in data scoring, would make it difficult to integrate even the available data.

⁴⁴⁴ Orós, J., Torrent, A., Calabuig, P., and Dniz, S. (2005) Diseases and causes of mortality among sea turtles stranded in the Canary Islands, Spain (1998–2001), *Diseases of Aquatic Organisms*, Vol.63, No.1, pp.13–24

⁴⁴⁵ Osinga, N., and 't Hart, P. (2006) Fish-Hook Ingestion in Seals (<l>Phoca vitulina</l> and <l>Halichoerus grypus</l>): The Scale of the Problem and a Non-Invasive Method for Removing Fish-Hooks, *Aquatic Mammals*, Vol.32, No.3, pp.261–264

⁴⁴⁶ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

⁴⁴⁷ de Stephanis, R., Giménez, J., Carpinelli, E., Gutierrez-Exposito, C., and Cañadas, A. (2013) As main meal for sperm whales: Plastics debris, *Marine Pollution Bulletin*, Vol.69, No.1–2, pp.206–214

3.2.8.2 Difficulty Including Animal Welfare Considerations

The factoring in of animal suffering to the weighting of impacts in a ranking is also not currently possible. Reporting of debris encounters does not include a consideration of measures of animal welfare. As addressed in Section 3.1, very few measures of the kind exist and have only been developed for whales.

3.2.8.3 Scoring Bias

It is likely that large, conspicuous and easily identified items are more likely to be identified and reported, like rope and netting. Therefore fragments of plastic and microplastics are likely to be underreported. ⁴⁴⁸

3.2.8.4 Microplastics

The impacts of microplastics are not yet fully understood. It is known that they are ingested by many types of organism, but a full picture is not yet known. What happens to microplastics after they have been ingested by marine invertebrates has also barely been demonstrated. The bioavailability of associated contaminants is undetermined. Geographical variation in adsorbed pollutants and the role of microplastics as a vector is only just beginning to be addressed. The mechanisms by which damage may occur are in the process of being established but are incomplete for many species and potential impacts. Whether and how microplastics or their impacts accumulate in successive levels of the food chain has not been demonstrated. Harm has not been established at population levels and ultimately ecosystem levels, and it will be difficult because much of it will be sublethal, subtle and extremely complex to unravel the influence of different factors (see above).

3.2.8.5 Effects of Colour, Shape, Plastic Type on Impacts Prevalence

A moderate number of studies have been carried out demonstrating statistically significant effects of colour, shape and plastic type on the likelihood of ingestion or composition of adsorbed chemicals. It would be useful to have a more comprehensive understanding of this aspect of marine debris impacts in case the information could be utilized in focussing management strategies.

4.0 Management of Debris in Marine Ecosystems

4.1 Current Management Strategies

In this section, current management measures and strategies for waste already present in marine systems (e.g. removal strategies and monitoring) are reviewed and current knowledge gaps identified. As regards monitoring, knowledge gaps have however been thoroughly addressed in Section 2.3.

⁴⁴⁸ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

4.1.1 Monitoring

Monitoring is an important part of any management strategy. Without monitoring no strategy can be evaluated; and the relative success of different tactics cannot be determined. Monitoring is also necessary for the setting of targets.

The following main questions have been defined regarding the monitoring of marine debris:⁴⁴⁹

- What is the abundance, distribution and composition of debris, and are these attributes changing over time?
- What are the main sources of debris, and are they changing over time?
- What are the impacts of debris (environmental and economic) and are they changing over time?

Distribution refers to the different marine compartments of the coast, the surface of the sea, the water column, the sea floor and even the sediment under the sea floor.

Methods of marine debris monitoring can be divided into three approaches; beach surveys, at-sea surveys and estimates of the amounts entering the sea.⁴⁵⁰

4.1.1.1 Beach Surveys

Beach surveys are widely viewed as the simplest to implement and the most cost effective. However, because they are influenced by many factors (i.e. inputs and outputs such as beach dynamics and contamination by beach users) that are not related to overall marine debris abundance, they do not necessarily provide a good indicator of changes in overall marine debris abundance.

There are many different ways to approach beach litter sampling. Different parameters can be recorded such as litter count, or weight and items categorized by material, function or assumed source. Different studies have different lower limits for debris size and beach width also tends to vary between studies, with some standardizing the breadth of the area sampled and others not. Buried litter is usually not sampled, though it may be a considerable proportion of beach litter (40% of total in one study).⁴⁵¹

Some beaches will better indicate specific sources of debris than others, for example, remote beaches track litter from ships and long-distance drift litter better than urban beaches, which track urban input. Finally, some studies report standing stock of litter, while others observe the rate of accumulation following removal of existing debris.

⁴⁴⁹ Ryan, P.G., Moore, C.J., Franeker, J.A. van, and Moloney, C.L. (2009) Monitoring the abundance of plastic debris in the marine environment, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.1999–2012

⁴⁵⁰ Rees, G., and Pond, K. (1995) Marine litter monitoring programmes—A review of methods with special reference to national surveys, *Marine Pollution Bulletin*, Vol.30, No.2, pp.103–108

⁴⁵¹ Kusui, T., and Noda, M. (2003) International survey on the distribution of stranded and buried litter on beaches along the Sea of Japan, *Marine Pollution Bulletin*, Vol.47, No.1–6, pp.175–179

The latter is considered a better indicator of at-sea debris than the former. Because of these many different parameters, global guidelines on marine debris monitoring have been developed by the Intergovernmental Oceanographic Commission in conjunction with UNEP. These are yet to be implemented by the Regional Seas areas, although there has been, and continues to be, considerable work towards standardizing monitoring approaches within the EU, the USA and Australia.

Beach surveys generally neglect micro-debris as floatation systems needed to separate out low-density debris are costly compared to visual counts. For the same reason, accumulation studies are not really possible as they would require clean-up prior to subsequent monitoring. Additionally, some of the fragments will derive from the disintegration of debris *in situ*; and hence are unlikely to provide a stable indication of micro-debris abundance at sea, as so many new particles will be derived from closer sources. The sampling of micro-debris is in its early stages. Identification of polymer type is possible via infrared spectroscopy (a technology also used to sort plastics for recycling).

4.1.1.2 At-sea Surveys

At-sea surveys probably reflect overall debris abundance better than beach surveys. However, sampling has to be much more intensive in order to detect change because of the geospatial scale involved and the complexity introduced by ocean circulation. It is therefore more expensive and logistically challenging. At-sea surveys can also only assess stock and not accumulation, therefore changes detected are likely to be reflecting a shift in the balance between many different inputs and losses, rather than differences owing to mitigation measures. From-deck observation sampling suffers from the fact that litter detectability goes down the farther from the transect it is, though this can be modelled and taken into account. Trawl surveys can be used to sample floating litter or litter in the water column, depending on nets used. Aerial surveys are most suitable for recording spatial distribution of larger items.

Seabed surveys are conducted with divers, submersibles and remote-operated vehicles. It is possible to obtain both accumulation and stock data in this marine compartment.

Another approach to monitoring is to look at impacts directly. Entanglement data or ingestion data can be used for this purpose and trends are visible in this type of data. Entanglement data does suffer from not always being expressed as a proportion of the population, because of a lack of population estimates, and can wrongly be conflated with within-species prevalence. Ingestion data similarly suffers as the sample population is often restricted to deceased, stranded individuals as opposed a sample from the population at large. An alternative way of sampling which might broaden the sample population base is to examine the pellets regurgitated by predators of seabirds who expel the bones, feathers and other indigestible remains of birds they eat.⁴⁵²

⁴⁵² Ryan, P.G. (2008) Seabirds indicate changes in the composition of plastic litter in the Atlantic and south-western Indian Oceans, *Marine Pollution Bulletin*, Vol.56, No.8, pp.1406–1409

It has been noted that there are correlations between certain interventions and downward trends in impact data.⁴⁵³ In one example, the halving of entanglement observations in Antarctic Fur Seals (*Arctocephalus gazella*) post MARPOL Annex V implementation was accompanied by a doubling in population size; therefore this 'correlation' could actually have been showing that the abundance of the litter in the sea did not change.⁴⁵⁴ A further longer term study of the same population did however calculate a change in entanglement incidence from 0.4% in 1988/1989 to 0.016% between 1994 and 2013, on average.⁴⁵⁵ This shows the importance of attempting to estimate prevalence at the population level. There are other studies that have failed to show a correlation between interventions and impact rates.⁴⁵⁶

It has been argued that entanglement is in fact quite rare within the population as a whole and so the number of observations obtained might not be enough for adequate statistical power unless constant surveillance is being undertaken. In contrast, ingestion is much more widespread, given that up to 100% of sampled individuals of certain species may be found to have ingested debris. It is felt to reflect spatial heterogeneity of debris, incidence being greatest for, for example, the Northern Fulmar (*Fulmarus glacialis*) in more highly contaminated areas of the North Sea, as compared to Arctic populations. Although some Fulmar subpopulations do migrate, most of the population is considered relatively sedentary in the North Atlantic. This can be contrasted with birds such as petrels, which range widely over, for example, the Pacific Ocean. They retain plastic in their stomachs for months, and so their ingested plastic reflects changes in the composition of plastic over much of the Pacific Ocean.⁴⁵⁷ Whether this statement is always true for migratory and non-migratory species still needs to be comprehensively answered, and only data collection will resolve it. The conclusion is that it is important to choose the indicator species carefully.

It is considered that the composition of ingested plastic in birds accurately reflected the decrease of plastic manufacturing pellets over the last 20 years and its displacement in most populations, by fragments from consumer generated plastic debris, i.e. it is held to reflect ambient debris composition. However, the relationship between overall plastic loads and environmental plastic abundance is also not yet totally clear, as the total amount of plastic over the same period did not change

⁴⁵³ Ryan, P.G., Moore, C.J., Franeker, J.A. van, and Moloney, C.L. (2009) Monitoring the abundance of plastic debris in the marine environment, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.1999–2012

⁴⁵⁴ Arnould, J.P.Y., and Croxall, J.P. (1995) Trends in entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at South Georgia, *Marine Pollution Bulletin*, Vol.30, No.11, pp.707–712

⁴⁵⁵ Waluda, C.M., and Staniland, I.J. (2013) Entanglement of Antarctic fur seals at Bird Island, South Georgia, *Marine Pollution Bulletin*

⁴⁵⁶ Ryan, P.G., Moore, C.J., Franeker, J.A. van, and Moloney, C.L. (2009) Monitoring the abundance of plastic debris in the marine environment, *Philosophical Transactions of the Royal Society B: Biological Sciences*, Vol.364, No.1526, pp.1999–2012

⁴⁵⁷ Ryan, P.G. (2008) Seabirds indicate changes in the composition of plastic litter in the Atlantic and south-western Indian Oceans, *Marine Pollution Bulletin*, Vol.56, No.8, pp.1406–1409

significantly, in some studies at least.⁴⁵⁸ There is some suggestion that at some density of environmental debris, plastic loads stabilise at a maxima and no longer track the levels in the environment.⁴⁵⁹

Nevertheless, the need to take action means that targets are being proposed for this measure of marine debris, despite these uncertainties, for areas where the spatial distribution of debris and plastic ingestions appears to be better related. For the North-East Atlantic region (OSPAR) - the EcoQO or 'Ecological Quality Objective' is proposed at <10% of fulmars having more than 0.1g of plastic in their stomachs).⁴⁶⁰ Three other European Member States have proposed turtles, lobsters and cetaceans as potential indicator species.⁴⁶¹ Other indicator species suggested, to cover the Mediterranean part of Europe, as the Northern Fulmar does not range so far south, include various species of migratory Shearwater (Cory's Shearwater (*Calonectris diomedea*), Yelkouan Shearwater (*Puffinus yelkouan*), and the Balearic Shearwater (*Puffinus mauretanicus*), which is also a Convention listed species).⁴⁶²

4.1.1.3 At-source Input Modelling

The last approach for monitoring marine debris is at-source input monitoring. This is considered to be the most indicative of changes related to management initiatives. In theory it is possible to monitor ship-based sources by obtaining records from port waste reception facilities and from independent fishery observers' examination of garbage log books. However no attempt has been made to estimate the amount of waste disposed of by vessels at sea since the implementation of MARPOL Annex V. Sampling of land based sources can occur in rivers or storm drains, though there is much temporal heterogeneity owing to weather events and the washing away of accumulated debris that must be taken into account when deciding on sampling frequency. A variety of techniques can be used such as manta trawling, use of hand nets, weighted nets, stream bed nets or scooping of sediments, and both active or passive sampling methods can be used.

As has been covered in Section 2.0, global monitoring efforts are currently focused on beach litter. There is very little coverage of any other marine compartment and there is not standardization. This means that it is difficult to compare the nature of the

⁴⁵⁸ Ryan, P.G. (2008) Seabirds indicate changes in the composition of plastic litter in the Atlantic and south-western Indian Oceans, *Marine Pollution Bulletin*, Vol.56, No.8, pp.1406–1409

⁴⁵⁹ Vlietstra, L.S., and Parga, J.A. (2002) Long-term changes in the type, but not amount, of ingested plastic particles in short-tailed shearwaters in the southeastern Bering Sea, *Marine Pollution Bulletin*, Vol.44, No.9, pp.945–955

⁴⁶⁰ van Franeker, J.A., Heubeck, M., Fairclough, K., et al. (2005) 'Save the North Sea' Fulmar Study 2002–2004: A Regional Pilot Project for the Fulmar-Litter-EcoQO in the OSPAR Area, 2005, <http://www.vliz.be/imisdocs/publications/72498.pdf>

⁴⁶¹ InterSus, University of Trier, Milieu, UBA, and COM (2013) Issue Paper to the 'International Conference on Prevention and Management of Marine Litter in European Seas'

⁴⁶² Codina-García, M., Militão, T., Moreno, J., and González-Solís, J. (2013) Plastic debris in Mediterranean seabirds, *Marine Pollution Bulletin*

problem from region to region. There is also the possibility that important item types may be neglected. Attribution of litter to source is not very robust and hence does not allow very detailed appraisal of the importance of different sources.

4.1.2 Removal

There are a range of different strategies employed throughout the world in an attempt to remove litter from marine ecosystems. Each management initiative may vary depending on the type of operation, who is responsible or involved in the scheme, and the type of litter that is targeted. A number of different types of strategies (as outlined in Table 6) are set out in the following sections, with examples of practical operation.

Table 6: Debris Removal Strategies

Type of Management Strategy	Description	Example Strategies
Removal of litter at sea during regular fishing activity	Trawlers retain on board the marine litter caught in their nets and deposit in ports	<ul style="list-style-type: none"> ➤ KIMO Fishing for Litter ➤ S Korea Marine Debris Buyback Program
Targeted removal of marine litter at sea during special purpose trips	Payments are made for conducting special trips to collect litter (this is restricted to floating litter)	<ul style="list-style-type: none"> ➤ Waste Free Oceans (WFO) ➤ S Korea Clean Up Deposited Marine Litter Program
Targeted retrieval of derelict fishing gear (DFG) at sea during special purpose trips	Payments are made for conducting special trips to collect DFG	<ul style="list-style-type: none"> ➤ Norway DFG retrieval program ➤ WWF Poland, Lithuanian Fund for Nature removal campaign
Coastal Beach Clean Ups	Voluntary or paid for efforts to collect debris from coastline	<ul style="list-style-type: none"> ➤ International Coastal Clean-up ➤ S Korea Coastal Cleanup Program

We review a selection of these types of initiatives, focussing on how the model works, its efficacy in terms of litter removal, its efficacy in terms of their ability to raise awareness and promote behaviour change in industry, its efficacy in terms of reducing the impacts of marine debris, and cost effectiveness.

4.1.2.1 Removal of Litter During Regular Fishing Activity

KIMO (Local Authorities International Environmental Organisation) is an association of coastal local authorities whose goal is to eliminate pollution from Northern Seas. KIMO's Fishing for Litter initiatives now operate in 6 countries around the North and

Baltic seas, involving more than 40 ports and 400 vessels. The programs have removed more than 3500 tonnes of litter from the sea since the first project began in the Netherlands in 2000. However KIMO's own estimate of 20,000 tonnes of litter dumped into the North Sea alone every year shows that the primary achievement of the project is likely to be awareness raising and hopefully change in waste management practices in the fishing industry.⁴⁶³

As far as costs are concerned, it is conducted on a voluntary basis, with funding covering the costs of co-ordinators, reporting, bags for collecting the debris, and the cost of the waste disposal. The Fishing for Litter Scheme (Scotland) funding for 2005-2008 was £199,218.75, and 117 tonnes of litter was removed. The cost was borne jointly by the Scottish Executive, Scottish Natural Heritage, the Crown Estate, Shetland Enterprise and Western Islands and Aberdeenshire Councils.⁴⁶⁴ In 2009-2011, 242 tonnes was collected at a similar cost.⁴⁶⁵ Regarding the type of debris collected, the Scotland Fishing for Litter scheme reports that the prevalence of heavy metal objects is greater than in coastal clear-ups, reflecting the propensity of these items to sink. There is anecdotal evidence that in areas that are regularly trawled, this type of debris is starting to be encountered less often.

South Korea has been running a marine debris buy-back program as part of their national marine debris strategy, where fishermen were paid a small fee for collecting and depositing the debris and used fishing gear they encountered while fishing. A report stated this was collecting 6,000 tonnes per annum at a cost of around \$4,000 annually,⁴⁶⁶ and the tonnage does however include some fishermen's daily waste and used fishing gear too. (This turns it partly into a waste prevention program though). A study estimated the tonnage of discarded fishing traps and gill-nets in the coastal waters of South Korea as 11,436 t of traps and 38,535 t of gill-nets per year.⁴⁶⁷

In the US Fishing for Energy program, fishermen bring back fishing gear debris they encounter on their trips and it is sent to an energy recovering facility. Participation is voluntary. One thousand tonnes of gear has been collected since 2008, and \$2,000,000 has been invested in the program.⁴⁶⁸ Early on in the project's

⁴⁶³ KIMO website, accessed June 2013. <http://www.kimointernational.org/FishingforLitter.aspx>

⁴⁶⁴ Ibid.

⁴⁶⁵ KIMO (2011) *Final Report. Fishing for Litter Scotland 2008-2011*, 2011, <http://www.kimointernational.org/WebData/Files/FFL%20Scotland/FFL%20Scotland%20Report%20FINAL.pdf>

⁴⁶⁶ Morishige, C. (2010) *Marine Debris Prevention Projects and Activities in the Republic of Korea and United States: A compilation of project summary reports*. NOAA Technical Memorandum NOS-OR&R-36, Report for National Oceanic and Atmospheric Administration, 2010, <http://permanent.access.gpo.gov/gpo2954/koreawkshop.pdf>

⁴⁶⁷ Kim, S.-G., Lee, W.-I., and Yuseok, M. (2014) The estimation of derelict fishing gear in the coastal waters of South Korea: Trap and gill-net fisheries, *Marine Policy*, Vol.46, pp.119-122

⁴⁶⁸ Fishing for Energy (2013) *Fishing for Energy Factsheet 2013*

implementation, eight media events and 30 news stories in print, radio, TV news and the web generated 2 million media impressions.⁴⁶⁹

4.1.2.2 Targeted Removal of Marine Debris During Special Purpose Trips

Waste Free Oceans (WFO)/Ecover's 'Message in Our Bottle Campaign' involves Waste Free Oceans working with fishermen to fish for plastic. It addresses floating marine debris and doesn't deal with debris in the water column or on the seabed. Ecover will recycle the plastic into bottles. Ecover has stated that the aim of the 'Message in Our Bottle' project is to create a closed loop packaging material,⁴⁷⁰ however the likely expense of obtaining plastic recycle via this means as opposed to using separately collected plastic bottles via conventional waste collection routes suggests that this is largely a public awareness exercise. However, if material is to be recovered from the ocean, it may as well be recycled. As Ecover will incur costs of the project, it may represent a novel funding model, but the overall cost is unclear at present.

South Korea also runs a clean-up project for that involves special trips to collect marine debris. This proved more expensive than fishing for litter type schemes, as capital is needed for vessels and other equipment. The scheme collected around 4,000 tonnes of marine debris per year and cost around \$8,000 annually.⁴⁷¹

4.1.2.3 Targeted Retrieval of Derelict Fishing Gear (DFG) During Special Purpose Trips

There are a number of examples of such projects:

- Fishermen participating in a joint project led by WWF Poland collected 22 tonnes of DFG in 2012.⁴⁷² An estimated 5,500-10,000 gillnets are lost each year in the Baltic. If the average weight of a gill-net is 480kg,⁴⁷³ this is 2,640 – 4,800t.

⁴⁶⁹ Morishige, C. (2010) *Marine Debris Prevention Projects and Activities in the Republic of Korea and United States: A compilation of project summary reports*. NOAA Technical Memorandum NOS-OR&R-36, Report for National Oceanic and Atmospheric Administration, 2010, <http://permanent.access.gpo.gov/gpo2954/koreawkshop.pdf>

⁴⁷⁰ Guardian website, accessed June 2013
<http://www.guardian.co.uk/environment/2013/mar/07/ecover-sea-plastic-bottles-recycling>

⁴⁷¹ Morishige, C. (2010) *Marine Debris Prevention Projects and Activities in the Republic of Korea and United States: A compilation of project summary reports*. NOAA Technical Memorandum NOS-OR&R-36, Report for National Oceanic and Atmospheric Administration, 2010, <http://permanent.access.gpo.gov/gpo2954/koreawkshop.pdf>

⁴⁷² <http://www.balticsea2020.org/english/press-room/261-135-kilometres-of-dangerous-fishing-nets-collected-in-the-baltic-sea>

⁴⁷³ Kim, S.-G., Lee, W.-I., and Yuseok, M. (2014) The estimation of derelict fishing gear in the coastal waters of South Korea: Trap and gill-net fisheries, *Marine Policy*, Vol.46, pp.119–122

- Norway carries out annual efforts to remove derelict fishing gear, with one vessel spending 5 weeks covering 1000 nautical miles of ocean, removing an average of 450 nets per year.⁴⁷⁴
- Interface's Aquafil/Net-Works™ Program. In the pilot phase in the Philippines, one tonne of fishing nets was collected by a community based supply chain who sold the recovered nylon based material to Interface to be reprocessed into carpet tiles.⁴⁷⁵ The economics of this project are affected by the relatively low income of the local communities involved and that many nets can be collected on the coast rather than at-sea. However detailed information regarding costs is not available.
- The Northwest Straits Initiative has removed 4,605 gillnets from Puget Sound (a marine estuarine system in Washington State).⁴⁷⁶ They have been awarded \$3.5m to finish removing the remaining shallow nets (estimated to be around 900 in number). Unknown numbers of derelict deepwater nets are in the area.

4.1.2.4 Coastal Beach Clean-ups

Two such examples are given below:

- International Coastal Clean-up. The ICC cleared about 4,200 tonnes of beach litter worldwide in 2012 with the help of around 600,000 volunteers.⁴⁷⁷ It has a budget of about \$2,200,000 annually.⁴⁷⁸
- The South Korean Coastal Clean-up program removed 27,401 tonnes of marine debris in 2007. One citizen based effort with 46,150 volunteers removed 2,218 t of debris with a budget of \$1,600,000.⁴⁷⁹

4.1.2.5 Efficacy of Removal Strategies in Terms of Amount of Debris Removed

Evaluating removal strategies in this way is made difficult by the lack of information on the amount of debris entering the oceans and thus what proportion is being addressed by current initiatives. Better data would help. Also the relevant information

⁴⁷⁴ Volckaert, A., and Van Breusegem, W. (2013) *MARELITT - Overview of project objectives and activities*

⁴⁷⁵ Interface (2013) *Press Release 7th January 2013. Interface, Inc. and the Zoological Society of London pilot in the Philippines hailed a success*

⁴⁷⁶ <http://www.derelictgear.org/>

⁴⁷⁷ Ocean Conservancy (2012) *The Ocean Trash Index - Results of the International Coastal Cleanup (ICC), 2012*, <http://www.oceanconservancy.org/our-work/marine-debris/2012-icc-data-pdf.pdf>

⁴⁷⁸ The Ocean Conservancy (2012) *The Ocean Conservancy Annual Report 2012*, 2012, <http://www.oceanconservancy.org/assets/financial-pdfs/2012-annual-report-1.pdf>

⁴⁷⁹ Morishige, C. (2010) *Marine Debris Prevention Projects and Activities in the Republic of Korea and United States: A compilation of project summary reports*. NOAA Technical Memorandum NOS-OR&R-36, Report for National Oceanic and Atmospheric Administration, 2010, <http://permanent.access.gpo.gov/gpo2954/koreaworkshop.pdf>

is often in different units, and a more thorough assessment of the available data would help in this regard. This constitutes a knowledge gap.

Where there is a little indicative data, no matter how rough the estimates are, it is clear that removal efforts so far are only tackling a small percentage of debris entering the sea. For example, the Fishing for Litter scheme in the North Sea is only tackling about 2% of the quantity of marine debris entering the North Sea every year. The WWF Poland led initiative retrieved perhaps 0.2-0.8% of the quantity of nets entering the Baltic every year. This means that removal initiatives are not reducing the stock of marine debris in the ocean. This is true of all the types of removal strategy assessed. If removal strategies of all types were implemented by every nation, they might be enough to bring the rate of increase of the stock of marine debris down significantly, but whether they would succeed in counterbalancing it entirely is less likely, and whether they would decrease overall levels of marine debris is less likely still. Unless the flow of debris into the oceans can be staunched, the impact that removal strategies have on marine debris levels globally is likely to remain small.

It has been asserted that given the difficulties of retrieving debris from the sea (systematic at-sea collection being considered unfeasible because of the scale of the endeavour and the impossibility of separating meso- and microplastic from plankton at scale and speed) beach clean-up is an effective method of ocean clean up.⁴⁸⁰ This invokes the theory that the gyres, which are often talked of as indefinite accumulators of plastic, actually releases a considerable proportion (50%) of their debris every cycle, and that this eventually ends up on the coasts, where it can be more cost-effectively removed. Another, simple 'model' of debris movement (which has been said to be based on little more than anecdotes) holds that 70% of marine debris sinks, 15% ends up on the coast and 15% floats in the sea (so, half of floating debris ends up beached and half remains floating).⁴⁸¹ A more sophisticated mathematical model produced the result that material from sea-based sources is slightly less likely to become beached than material from land-based sources (at 28% versus ~38%).⁴⁸² This collection of information roughly corroborates the other. However it highlights that the movement and fate of debris in the ocean is not well characterized, yet it is important for judging what removal strategies are actually achieving, and for making informed policy decisions. This is an information gap.

In conclusion, the removal of litter from ocean at present scales is not having a big impact globally. Beach clean-up may be a way of addressing floating marine debris globally, but research is needed to assess this more effectively.

⁴⁸⁰ <http://inhabitat.com/the-fallacy-of-cleaning-the-gyres-of-plastic-with-a-floating-ocean-cleanup-array/>

⁴⁸¹ OSPAR, UNEP, and KIMO (2007) *OSPAR Pilot Project on Monitoring Marine Beach Litter: Preventing a Sea of Plastic*, 2007, http://qsr2010.ospar.org/media/assessments/p00306_Litter_Report.pdf

⁴⁸² Lebreton, L.C.-M., Greer, S.D., and Borrero, J.C. (2012) Numerical modelling of floating debris in the world's oceans, *Marine Pollution Bulletin*, Vol.64, No.3, pp.653–661

4.1.2.6 Efficacy in Terms of Reducing the Impacts of Marine Debris

There has been little consideration, in the implementation of these programs, to measuring whether there are at least local changes in the impacts of marine debris.

The Fishing for Litter scheme in Scotland reports anecdotally that in areas that are regularly trawled, heavy, metal debris is starting to be encountered less often. This might reduce snagging, which in turn, might reduce the rate of net loss.

In Puget Sound, benthic habitat was considered to be substantially restored within a year of the removal of derelict fishing gear.⁴⁸³ The relative abundance of algae, invertebrates and fish between newly cleared areas and the control areas which had not been abraded by nets changed from 41% less to 6% less after a year.

Even though there have not been attempts to estimate or measure the impacts of the removal of derelict fishing gear in terms of ghost fishing where this is carried out, efforts have been made to quantify the fishing capacity of ghost nets over time. Many studies show that capacity does decrease as nets become weighed down and/or become more visible because of the accumulation of detritus and marine organisms growing on the nets, but the extent varies widely from study to study.⁴⁸⁴ Generally in Europe, ghost fishing is estimated to account for <1% of the weight of landed catch, with some exceptions for different types of fishing (such as deep water nets for shark and monkfish, where net loss and ghost fishing is thought to be high), though no estimates exist for this.⁴⁸⁵ Their contribution as stressors on some populations of over exploited species could be significant, and it is not really clear what the population level effects on endangered migratory species might be, for example (see Section 3.1.1.3). Perhaps work could be undertaken to relate available information to specific removal programs and span this knowledge gap in this way. Improving knowledge regarding the wider environmental implications of derelict fishing gear would also be useful.

Routine efforts to disentangle Hawaiian Monk Seal pups and to remove derelict fishing gear and other potentially entangling debris has not led to a reduction in the amount of debris removed or the number of entanglements.⁴⁸⁶ The amount of debris accumulating year on year did not change. Removal on this scale was not reducing impacts relative to preceding years.

In conclusion, it is possible that marine debris removal has significant local benefits, but there is very little data in this regard. It would be useful to have better monitoring

⁴⁸³ June, J., and Antonelis, K. (2009) *Marine Habitat Recovery after Derelict Fishing Net Removal*, Report for Northwest Straits Initiative, 2009, http://depts.washington.edu/uwconf/psgb/proceedings/papers/7d_june.pdf

⁴⁸⁴ UNEP, and FAO (2009) *Abandoned, Lost or Otherwise Discarded Fishing Gear*, 2009

⁴⁸⁵ Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

⁴⁸⁶ Henderson, J.R. (2001) A Pre- and Post-MARPOL Annex V Summary of Hawaiian Monk Seal Entanglements and Marine Debris Accumulation in the Northwestern Hawaiian Islands, 1982–1998, *Marine Pollution Bulletin*, Vol.42, No.7, pp.584–589

in conjunction with the removal programs so that the benefits in different regions and of particular programs can clearly be assessed.

4.1.2.7 Efficacy in Terms of Awareness Raising and Promotion of Behaviour Change

This aspect of removal programs is rarely monitored, but data would be extremely informative as this may be the biggest contribution that removal programs are currently making. The Fishing for Energy programs have good media penetration (2 million media impressions for the campaign) and are the only example where such an output has been measured. For other such removal programs the awareness raising and behaviour change impacts are a key knowledge gap.

The general impression is that fishing for litter schemes are received with enthusiasm by fishermen, even where, as is mostly the case, they are voluntary. It would be useful to assess to what extent the presumed increase in awareness of fisherman of the amount and nature of marine debris they are recovering would lead to behaviour change in terms of waste management and prevention of marine debris from at-sea sources. Sometimes the schemes, in providing a cost-effective means of disposal of derelict gear (such as the Fishing for Energy program), and even an incentive for their collection (such as the Aquafil project) may also prevent abandonment of gear.

4.1.2.8 Cost Effectiveness

There are widely varying costs estimated for removal schemes, possibly in large part because the estimates are not made on a comparable basis and will not include the same components of cost.⁴⁸⁷ Judging the cost-effectiveness also requires reliable quantification of debris removed, and the local stock and flow of debris, which as addressed above, is generally lacking.

Relatively speaking, the impression is that debris collection that is carried out in the regular course of fishing or by volunteer programs is probably cheapest, as it will require least equipment and resources to carry out. Collection of floating debris is likely to be next cheapest, but will vary (on a per tonne basis at least) a great deal depending on the density of the debris and other factors. Removing DFG can require geolocation and specialist equipment as well as the financing of special trips, meaning this is likely to be the most expensive approach (on a per tonne basis, but not necessarily on a 'per impact on migratory species' basis). Some retrieval schemes are carried out with the involvement of divers, which can also contribute to the expense.

One cost-benefit analysis of ghost fishing in the EU estimated that the cost of net retrieval per fleet (€46,500) would outweigh the benefits (€22,664) for the fishery of reducing ghost fishing by more than a factor of two. Benefits per vessel of the retrieval programme would be limited to just over €500 per vessel.⁴⁸⁸ However this

⁴⁸⁷ UNEP, and FAO (2009) *Abandoned, Lost or Otherwise Discarded Fishing Gear*, 2009

⁴⁸⁸ Brown, J., and Macfadyen, G. (2007) Ghost fishing in European waters: Impacts and management responses, *Marine Policy*, Vol.31, No.4, pp.488–504

study only takes into account economic value of the catch of commercially exploited fish and not wider environmental benefits, which, the study conceded, are difficult to quantify. To do so, considerable financial resources would have to be deployed on additional studies. The study suggested that although such quantification may itself not be cost-effective, these other types of costs and benefits should also be considered as part of the decision-making process about whether to engage in retrieval programmes or other management measures.

Other studies have found a more favourable cost:benefit ratio. In Puget Sound, for one gillnet, a loss of \$19,656 of Dungeness crab to the commercial fishery was estimated, compared to \$1358 in costs to remove a given gillnet, yielding a cost:benefit ratio of 1:14.5.⁴⁸⁹

Various removal strategies attempt to create an economic incentive for marine litter to be collected (e.g. collected plastics can be sold to a plastics reprocessor or sent for energy recovery), or even converted to transport fuel. The Fishing to Energy project found however that distance transported to processors could be cost prohibitive, limiting participation to where reprocessing can be undertaken close to collection points.⁴⁹⁰ For other schemes, recycling has proved difficult. Scotland's Fishing for Litter project set recycling targets of 10% for their recovered waste. However, this was not met because often the material was too fouled by marine organisms to be considered for recycling, and also the quantities recovered were too small for waste companies to consider taking unless pre-sorted, for which there was no budget and such a requirement viewed as a potential discouragement for participation in the program.⁴⁹¹ More work is needed to establish whether any of these schemes are economically self-sustaining or if they could become so.

In conclusion, removal schemes appear relatively expensive given the benefits obtained, but there is difficulty obtaining enough comparable data to make a full assessment.

4.1.2.9 Other Benefits

Removal programs can also be useful for debris monitoring, such as the ICC campaign. However if they are to do so, systematic and standardized recording should be used to make the data as useful as possible.

⁴⁸⁹ Gilardi, K.V.K., Carlson-Bremer, D., June, J.A., Antonelis, K., Broadhurst, G., and Cowan, T. (2010) Marine species mortality in derelict fishing nets in Puget Sound, WA and the cost/benefits of derelict net removal, *Marine Pollution Bulletin*, Vol.60, No.3, pp.376–382

⁴⁹⁰ Morishige, C. (2010) *Marine Debris Prevention Projects and Activities in the Republic of Korea and United States: A compilation of project summary reports*. NOAA Technical Memorandum NOS-OR&R-36, Report for National Oceanic and Atmospheric Administration, 2010, <http://permanent.access.gpo.gov/gpo2954/koreawkshop.pdf>

⁴⁹¹ KIMO (2011) *Final Report. Fishing for Litter Scotland 2008-2011*, 2011, <http://www.kimointernational.org/WebData/Files/FFL%20Scotland/FFL%20Scotland%20Report%20FINAL.pdf>

The social benefits of removal schemes are generally seen as important; for example, Ghost Nets Australia has brought together indigenous communities in working together to care for the marine environment.⁴⁹²

4.2 Addressing Knowledge Gaps

Stakeholders relevant to addressing and filling knowledge gaps in the management of marine debris already in the environment are considered in this section. Ideally, stakeholders specific to reducing impacts on migratory species are required. This does not necessarily limit the group of stakeholders a great deal, given the wide-reaching impacts of all types of marine debris. Steps to filling the information gaps are addressed in Section 6.5.

Regarding monitoring, the specific information gaps most relevant to the impacts on migratory species are:

- Prevalence of types of debris that have high impacts on migratory species;
- Sources and pathways of these types of debris;
- Geographic distribution of these types of debris;
- Debris monitoring measures that consist of impacts on organisms, specific to migratory species if possible; and
- Population level effects on migratory species.

On this basis, relevant stakeholders for filling these gaps might be:

- Regional Seas area committees

In so far as they are a point of contact for national debris monitoring, and where it is done, collate the data into regional statistics, they are an important stakeholder. It has to be borne in mind that globally, debris monitoring by the Regional Seas is still not at a mature stage of co-ordination. This however might mean that it is a good juncture at which to work with the designers or implementers to make sure that the most relevant data to migratory species is collected. This might be particular types of marine debris, such as fish hooks, or micro- and meso-plastic fragments, which don't appear in every monitoring checklist, or anything else known to have particular impacts on marine species.

- Intergovernmental Organizations

The European Commission (EC) is currently considering setting marine debris targets, and many years of work has already gone into considering and developing indicators for this. These include indicators that are of the nature of impacts on migratory species, and there is still development going on in this area. There may be opportunities to influence this debate and in the process

⁴⁹² Gunn, R., Hardesty, B.D., and Butler, J. (2010) Tackling 'ghost nets': Local solutions to a global issue in northern Australia, *Ecological Management & Restoration*, Vol.11, No.2, pp.88–98

garner useful data relevant to migratory species. This might be for example, impact data on both non-migratory and migratory species; as mentioned above, the choice of species has implications as to what the indicator means, and so needs careful consideration.

➤ National governments

Governmental decision makers have a general role to play in pushing forward appropriate national legislation regarding marine debris that as a consequence will require monitoring to be stepped up, and providing the motivation and funding for the research needed to address current knowledge gaps.

➤ NGOs, university groups or governmental departments that carry out environmental monitoring

These stakeholders tend to be national in terms of scope but not always; examples of both have been found.

- There are examples of groups that take a special interest in particular item types or sources of debris, such as the International Pellet Watch, (Tokyo University of Agriculture and Technology)⁴⁹³ Tangaroa Blue (NGO) and weather balloons, GhostNets Australia, or Global Green USA (NGO) and military waste.⁴⁹⁴ Ideally the key here would be to identify groups who have interests in debris which is particularly impactful for migratory species. As regards microplastics, for which there is a working group, GESAMP Working Group 40, who will report on “Sources, fate & effects of microplastics in the marine environment – a global assessment” in November 2014.⁴⁹⁵ This is a general assessment to complement the UN GA Regular Process on the State of the Marine Environment. This working group is supported by UNESCO - IOC, UNEP, IMO, UNIDO, UNDP, NOAA, ACC and Plastics Europe, to give an idea of the number and variety of stakeholders involved.
- Research groups of any kind could carry out research to help elucidate pathways, such as via estuarine litter monitoring, for improving information we have about source and type of debris, specific to different countries and regions.
- If it is decided that a key part missing from the case for action is the demonstration of population level effects on species, this can be pursued by research groups of any kind, given a political mandate and appropriate funding if necessary. NGOs with focuses on particular groups of species, such as BirdLife International, who already

⁴⁹³ <http://www.pelletwatch.org>

⁴⁹⁴ <http://www.globalgreen.org/events/174>

⁴⁹⁵ Kershaw, P.J. (2013) *Marine Litter - where are we?*, Global Conference on Land - Ocean Connections, Jamaica

coordinate lots of bird monitoring initiatives, could be a partner, for example, in undertaking threat-specific monitoring such as impacts of marine debris on migratory birds. WSPA is working toward the establishment of the “Untangled Alliance”,⁴⁹⁶ a multi-stakeholder alliance to catalyse action for a ghost-gear free sea; monitoring and feedback will be a part of this and so they could be a source of data relevant to these issues. The International Whaling Commission has established a Marine Debris Working Group and is conducting a two-year investigation into the interaction of marine debris with cetaceans, including whales and dolphins. Microplastics have been recognized as having a potential impact on baleen whales, including through digestion of associated chemical pollutants and microbes. The overall objective is to assess, by 2014, the extent of the problem and to propose potential mitigation and management solutions. They make an ideal partner for CMS to work on this given how many cetaceans are migratory and that they already work with CMS. There are various independent research groups who have undertaken high level reviews on marine debris impacts such as those by STAP/GEF⁴⁹⁷, WSPA⁴⁹⁸ or reviews according to high level taxa and impact type, such as ones on turtles and ingestion,⁴⁹⁹ or whales and ingestion.⁵⁰⁰ More of these types of reviews would be useful for leveraging the research that has already been done to its greatest potential.

- Other agencies or NGOs concerned with wildlife such as UNEP –WCMC (Wildlife Conservation Monitoring Centre), (which already support CITES and CBD Conventions), WWF (Worldwide Fund for Nature), IFAW (International Fund for Animal Welfare) or WSPA (World Society for the Protection of Animals) could help to establish standardized reporting methods for threats to species such as marine debris impacts.
- NGOs, university groups involved in data curation
 - In order to store and integrate information with the greatest relevance to migratory marine species, the IUCN Red List, the Global Biodiversity Information Facility (GBIF) and the Global Register of Migratory Species

⁴⁹⁶ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

⁴⁹⁷ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

⁴⁹⁸ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

⁴⁹⁹ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

⁵⁰⁰ Simmonds, M.P. (2012) Cetaceans and Marine Debris: The Great Unknown, *Journal of Marine Biology*, Vol.2012

(GROMs – which has found a new home with Bonn University and the Museum Koenig Natural History Museum) could be partnered with to ensure accurate and consistent recording and mapping of the threats posed by marine debris to migratory species. This could perhaps integrate information from independent research groups who have undertaken high level reviews on marine debris impacts.

➤ Citizen science

Many research efforts rely heavily on volunteer effort (for example, the ICC's beach monitoring, the Sea Education Association's at-sea monitoring and International Pellet Watch's monitoring of POPs on plastic pellets).⁵⁰¹ In order to be systematic and comparable, they should be organised via official monitoring programmes. There are also particular groups of citizens such as divers and surfers who are notable for their involvement with the issue of marine debris. Perhaps other groups such as anglers and recreational boaters might also provide a fruitful resource for researchers.

➤ Commercial sector

- The potential contribution of sectors of industry may be best directed to filling gaps about sources; specifically, by monitoring their own production of marine debris. Perhaps to guarantee the independence of the estimates, it could be done in conjunction with NGOs or public research institutes. For example, port owners (e.g. PSA International) could be engaged with (a number of harbours already engage with Fishing for Litter schemes for example and monitor the amount and composition of waste landed). Shipping companies (e.g. A.P. Moller – Maersk Group), fishing and aquaculture companies (e.g. Pescanova), passenger line companies (e.g. Carnival Cruise Lines) and waste contractors similarly, could be approached to participate. A coordinating role could be played by industry or regulatory bodies such as the World Shipping Council or regional fisheries boards or bodies.
- Currently, land-based industries are not obliged to report emissions and incidents for debris release into waterways as they are for other pollutants. A voluntary disclosure initiative could be set up in conjunction with industry, which would provide useful information in an area where there is so little.
- The plastics industry is an important stakeholder that might become engaged in monitoring endeavours in some way, such as funding, or development of research techniques regarding the identification of different types of plastic, or isolation of plastic from the marine environment, for example.

⁵⁰¹ Law, K.L., Morét-Ferguson, S., Maximenko, N.A., Proskurowski, G., Peacock, E.E., Hafner, J., and Reddy, C.M. (2010) Plastic Accumulation in the North Atlantic Subtropical Gyre, *Science*, Vol.329, No.5996, pp.1185–1188

- Consultants. There are examples of private sector commercial enterprises conducting research relevant to marine debris, such as the EW Wells group and their research into marine military disposal sites in collaboration with Global Green USA.⁵⁰²

The kind of information gaps most relevant to the impacts on migratory species as regards debris removal management initiatives are:

- Efficacy in terms of impact on stock and flow of marine debris;
- Efficacy in terms of mitigating impacts on marine species, specific to migratory species if possible;
- Efficacy in terms of public awareness and behaviour change – public, fishermen, industry, and other stakeholders; and
- Cost-effectiveness.

It is this information that would provide the basis for deciding whether and where these sorts of management strategies would be appropriate in areas relevant to migratory species particularly.

Relevant stakeholders for filling these gaps will include any of the organisations that partner in removal schemes. There are a very large number of these because they are usually multi-stakeholder partnerships between national or local government and industry, whether the plastics industry or the fishing industry. However, they may have staff allocated to coordination for the schemes who would be the most appropriate contact for obtaining more information. Via the removal schemes themselves, information could be provided on all the above points apart from on the stock and flow of marine debris. Also, not every removal scheme will be appropriate for monitoring the mitigation of impacts on species, whether migratory or not.

We are aware of one research project that aims to evaluate removal programs in the EU, a pilot project for the MARELITT research endeavour. This again is a multi-stakeholder effort, involving research from Milieu Ltd and its partners ARCADIS, MEGAPESCA Lda, IMARES, LEI, RSS Marine, Plymouth University, the Coastal & Marine Union (EUCC), EUCC Mediterranean Centre, the Baltic Environmental Forum and Mare Nostrum. This is a mix of private and public sector research organizations, consultancies and NGOs. It is likely that it would take research projects of this kind, in partnering with removal schemes, to be able to fill information gaps regarding them.

Regarding estimates of stock and flow and further work on the effect of removal schemes on species impacts, we refer the reader to the section on filling knowledge gaps in monitoring.

⁵⁰² Stauber, R. (2011) Research effort to document military munitions disposal sites worldwide, *Technical Proceeding of the 5th International Marine Debris Conference* (2011)

5.0 Preventing Waste Reaching the Marine Environment

While there is considerable spatial variation, overall, the majority of marine debris is understood to be land based in origin.⁵⁰³ Awareness of the importance of reducing (land-based) littering is increasing, and is, albeit slowly, leading to legislative action. This is encouraging, as the adage of ‘prevention being better than cure’ would seem particularly apt in the case of marine debris.

While there is clearly merit in removing debris, especially plastic debris and fishing gear, from the marine environment, it is more cost-effective to implement measures that prevent (land-based) littering in the first place. As well as ultimately reducing the flow of debris to the marine environment, preventing land-based littering delivers a number of benefits, such as improved local environmental quality. Research suggests that a less littered local environment can lead to lower levels of crime, improved mental health and wellbeing, as well as reducing the likelihood that further littering will occur.⁵⁰⁴ Moreover, depending upon the instrument chosen to reduce littering, the costs of waste treatment can be considerably reduced, and notable carbon savings achieved.

The choice of instrument is very important. In the example below, two scenarios are presented, both of which achieve zero littering, and hence no flows of land-based material to the marine environment:

- Scenario 1 involves extensive provision of litter bins, with a ‘zero tolerance’ approach to littering supported by punitive fines, backed up by considerable public expenditure on enforcement.
- Scenario 2 involves economic instruments such as deposit-refunds on beverage containers and a levy on single-use carrier bags, alongside obligations requiring the use of reusable beverage containers, cutlery and crockery at public events. Provision of litter bins is moderate, and while fines for littering exist, they are rarely used.

While the littering outcomes may be identical, Scenario 2 delivers a segregated stream of high quality, and valuable, materials for recycling, through the container deposit scheme. Recycling these materials, avoiding the requirement for primary manufacture, can lead to considerable carbon savings. The levy on single-use carrier bags, and the event obligation both incentivise the use of re-usables, preventing waste and the associated management cost. By contrast, Scenario 1, already involving expensive enforcement and infrastructure provision, will incur further expense in that the collected materials are mixed together, and hence any recyclables

⁵⁰³ GESAMP(1991) *The State of the Marine Environment*, Oxford: Blackwell Scientific Publications

⁵⁰⁴ Eunomia Research & Consulting (2013) *Indirect Costs of Litter*, Report for Zero Waste Scotland, 2013

will be of a lower quality (due to contamination) and hence less valuable if subsequently segregated for recycling. If destined for residual treatment, this is typically more expensive for public authorities than recycling (depending upon the legislative context and the location) and will lead to much greater carbon impacts.

In the section below, we outline a number of instruments that have been shown to be effective in reducing littering. Key among these are economic instruments, that use price signals to incentivise appropriate behaviour.

5.1 Key Knowledge Gaps

In respect of the routes by which land-based litter reaches the marine environment, there is considerably uncertainty as to the proportions attributable to each specific pathway. For example it is known that items that end up as marine debris:

- Could be dropped by members of the public, or arise from commercial / industrial sites, or during transport of materials; or
- Could escape from formal waste management systems; and
 - From litterbins, including from waste left at the side of bins that are full;
 - At the doorstep of the household;
 - At 'bring' sites;
 - During transportation;
 - At poorly managed landfill sites;
- Could then be washed, during periods of heavy rainfall and surface water flooding into rivers and hence travel to the sea;
- Could be windblown and hence travel to the sea; or
- Could be deposited directly on the beach and then enter the sea directly; or alternatively
- Could enter the sea via the sewage system, including combined sewer overflows.

While it would undeniably be of interest to develop a better understanding of the pathways by which litter reaches the sea, we would suggest that this should not be the immediate priority, or at least it should not be the sole priority. Furthering our knowledge of pathways should not take precedence over implementing measures that are known to be effective in reducing debris at source. Such measures, which include deposit-refunds for beverage containers, and levies on single-use carrier bags, are described in subsequent sections (Section 5.5.1 and Section 5.5.2 respectively).

Prioritising the implementation of measures also makes sense from the perspective of making the best use of limited budgets for research. If the contribution to marine debris of priority items such as plastic bottles and carrier bags can be significantly reduced, this allows researchers to focus more closely on what remains. As an example, might there be a way of incentivizing the return of crisp packets in a similar manner to that possible for beverage containers?

5.2 Links with Waste Prevention

Measures that seek to prevent waste from occurring in the first place also tend to bring about positive impacts in respect of reducing the flow of land-based debris into the marine environment. The approach to waste prevention and management, and the associated legislation, is relatively well developed within the EU. Accordingly it is appropriate to look towards the European example and draw lessons from this. In European law, the key piece of legislation relating to land-based waste prevention and management is the revised Waste Framework Directive (2008/98/EC) (WFD). The Directive does not, however, refer to litter explicitly. Article 36, however, on Enforcement and Penalties, obliges Member States to:

Take the necessary measures to prohibit the abandonment, dumping or uncontrolled management of waste.

In principle, this should imply that littering, by virtue of being ‘uncontrolled management of waste’, is prohibited in Member States. The fact that litter remains a problem, albeit varying in extent across the EU, implies that this ‘prohibition’ is not enforced with great vigour in many locations.

The revised WFD places great emphasis on the role of waste prevention.⁵⁰⁵ Preventing materials from becoming waste in the first instance holds considerable potential for reducing the amount of litter entering the marine environment. The WFD:⁵⁰⁶

- Makes waste prevention one of its primary objectives (Article 1);
- Specifically defines waste prevention (Article 2 (2));
- Places it at the top of the waste hierarchy (Article 4), to which Member States are now required to give force in policy and law (with some latitude for deviations where clearly justified on environmental grounds);
- Encourages Member States to make use of extended producer responsibility with a view, in particular, to increasing that responsibility (Article 8);
- Requires the Commission to produce various reports, accompanied where necessary by proposals for any measures necessary to support preventive activities and the implementation of prevention programmes (Article 9);
- Obliges Member States to promote re-use (Article 11); and
- Makes the implementation of prevention programmes an essential requirement (Article 29).

⁵⁰⁵ European Parliament, and Council of the European Union (2008) Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, *Official Journal of the European Union*

⁵⁰⁶ Bruxelles Environnement (2011) New European Legal Requirements Relating to Waste Prevention. Background paper to the International Pre-waste Workshop, Brussels, 28 March 2011.

This represents a significant development from the previous Directive (2006/12/EC), in which prevention was addressed in only one provision, which outlined a waste hierarchy (Article 3).

The requirement to implement waste prevention programmes (Article 29) includes an obligation on Member States to:

- Set out waste prevention objectives;
- Describe the existing prevention measures; and
- Evaluate the usefulness of the examples of measures indicated in Annex IV or other appropriate measures.

Examples of waste prevention measures that have associated benefits in terms of reduced littering include:

- Taxes/levies/charges on single use carrier bags;
- Obligations on event organisers to use reusable containers (as in, for example, Munich, Vienna etc.);
- Use of refillable beverage containers (as is the case for wine in the Styria region of Austria). These are often accompanied by a deposit, which is then refunded upon return to the retailer.⁵⁰⁷

One potential weakness, relating to litter impacts, in the application by Member States of the waste hierarchy, is the formulation of Paragraph 2 of Article 4, which states that:

When applying the waste hierarchy referred to in paragraph 1, Member States shall take measures to encourage the options that deliver the best overall environmental outcome. This may require specific waste streams departing from the hierarchy where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste.

The obvious example here is of single-use plastic carrier bags, where life-cycle assessments have been used to justify *not* implementing measures to reduce their use.⁵⁰⁸ However, such studies typically focus on the carbon impacts of different types of bags, and explicitly exclude from consideration the effects of littering. While LCA as a methodology is unable to account for a number of the downstream consequences of litter, Cost-Benefit Analysis, although better placed to incorporate such effects, only

⁵⁰⁷ Such a 'two-way' refillable deposit system is less common than 'one-way' deposits, where beverage containers are returned for recycling rather than for reuse. However, from discussion with drinks industry representatives we understand that they believe that one-way deposits, in increasing the upfront cost may bring about a waste prevention effect, albeit through reduced sales as consumers switch to alternatives such as tap water. Whether a waste prevention measure or simply a way to boost recycling, the evidence on the reductions in litter that are associated with one-way deposit refunds is compelling.

⁵⁰⁸ Intertek Expert Services (2011) *Life Cycle Assessment of Supermarket Carrier Bags: A Review of the Bags Available in 2006*, Report for Environment Agency, February 2011

rarely does so. The primary reason in the case of CBA has until recently been a lack of studies relating to all the different impacts, although progress is now being made in areas such as local neighbourhood litter disamenity, and indeed beach litter disamenity values.⁵⁰⁹

5.2.1 European Marine Debris Targets

In addition to giving legislative priority to waste prevention through placing it at the top of the waste hierarchy, the European Commission is considering implementing marine debris targets. The Technical Subgroup (TSG) on Marine Litter has reviewed EU monitoring efforts and made recommendations on the setting of targets for reductions in marine debris. In addition they have drafted guidance for the harmonization of marine debris monitoring methods. A further two initiatives have involved the consideration of targets by Member States.

Subsequent to the TSG's review of EU marine litter monitoring efforts, it became clear that there is more data on beach debris than for debris in the water column, even though TSG ML states that there is:⁵¹⁰

Not so much information available in EU marine waters to set quantitative thresholds related to the reduction of marine litter washed ashore and/or deposited on coastlines.

TSG ML does, however, go on to say that quantitative reduction targets for beach litter should nevertheless be considered. For litter on beaches, it was proposed that the goal of a general measurable and significant reduction of marine litter by 2020 be adopted in the first instance, albeit it was felt that reductions in abundance of marine litter in the order of 50% per decade are a feasible target when adequate measures are taken. Research which showed that changing methods in production and transport processes were associated with a halving of the abundance of industrial plastic pellets in seabird stomachs was cited in support of this statement.⁵¹¹

An interesting point to note in this respect is that if higher targets are set, and appropriate measures are instituted to meet the targets, it will be easier to determine, through monitoring, that a change has indeed occurred, then if weak targets had been set.⁵¹² For example, if a 5% reduction target were set, it would be very difficult

⁵⁰⁹ Eunomia Research & Consulting (2013) *Indirect Costs of Litter*, Report for Zero Waste Scotland, 2013

⁵¹⁰ TSG ML (2011) *Marine Litter - Technical Recommendations for the Implementation of MSFD Requirements*, Report for JRC-IES, 2011, http://books.google.be/books/about/Assessing_potential_ocean_pollutants.html?id=kiYRAAAAYAAJ&redir_esc=y

⁵¹¹ TSG ML (2011) *Marine Litter - Technical Recommendations for the Implementation of MSFD Requirements*, Report for JRC-IES, 2011, http://books.google.be/books/about/Assessing_potential_ocean_pollutants.html?id=kiYRAAAAYAAJ&redir_esc=y

⁵¹² p18 - TSG ML (2013) *DRAFT MSFD Monitoring Guidance for Marine Litter in European Seas*, 2013, <https://circabc.europa.eu/d/a/workspace/SpacesStore/b627cfb6-cece-45bc-abc1-e4b3297adb91/DRAFT%20MSFD%20Monitoring%20Guidance%20TSG-ML%2011072013.pdf>

to identify whether or not this had actually been achieved, or whether what was being measured was simply 'background noise', i.e. the variation one might reasonably expect to be exhibited in measurements. The extent of the monitoring that would be required to have sufficient confidence that such a modest target had been met would make it more expensive to determine than would be the case for a more ambitious target.

Moreover, politically, one could foresee a situation where an apparent failure to achieve a modest target (due to the uncertainty involved in the monitoring) may be cited by some as evidence that more ambitious targets are not feasible, and should not be pursued.

European Member States' initial assessments of marine environmental status and target proposal as mandated by Marine Strategy Framework Directive Articles 8 and 10 respectively have been completed and targets proposed.⁵¹³ Examples of the types of targets proposed so far are as follows:⁵¹⁴

- To reduce litter from beaches based on a five year moving average;
- Negative annual trend in beach litter;
- Reduction in litter on sea surface, water column and seabed;
- Litter proved to be harmful to marine organisms (especially microplastic) reduced towards zero over the long term;
- Entanglement and strangulation reduced towards a minimum;
- Less than 10% of Fulmars having more than 0.1g of plastic in their stomachs;
- Various operational targets regarding better waste collection in coastal regions;
- Reduced inflow from rivers and sewers; and
- Targets related to changes in behaviour, such as littering on beaches.

5.2.2 Existing Commission Studies Supporting MSFD Implementation

In support of the implementation of the Marine Strategy Framework Directive (which is driving consideration of targets for marine debris), the European Commission has funded background research. In 2011 the Commission launched three pilot projects to improve understanding of the sources and routes by which debris, and plastic debris in particular arrives in the marine environment. The projects dealt with:

- Loopholes in the plastics cycle in the EU's four marine regions (See Section 5.2.2.1);

⁵¹³ European Commission website. http://ec.europa.eu/environment/marine/good-environmental-status/index_en.htm Accessed August 2013.

⁵¹⁴ InterSus, University of Trier, Milieu, UBA, and COM (2013) Issue Paper to the 'International Conference on Prevention and Management of Marine Litter in European Seas'

- Loopholes in the recycling of plastic packaging material in the EU (and a selection of countries outside the EU but sharing European seas) (See Section 5.2.2.2); and
- The feasibility of introducing instruments to prevent littering (See Section 5.2.2.3).

The key findings from these reports are summarised below.

5.2.2.1 Pilot Project on Loopholes in Plastic Recycling Cycle in Regional Seas Areas

The European Commission launched this pilot project to support the implementation of the Marine Strategy Framework Directive.⁵¹⁵ The aim was to identify the main possible sources of marine litter in the four regional seas areas relevant to the EU. Further to this, a set of feasible measures was designed to address the identified sources of litter. These sources were identified as:

- Tourism and recreational activities in coastal areas (all regional seas areas);
- Land-based household waste entering the marine environment via the sewage system, poorly managed landfill sites in coastal areas, and in some cases, via rivers (especially the Mediterranean, Baltic and Black Sea areas); and
- Shipping and fisheries (North Sea area especially).

Many measures were proposed to tackle these different sources, including

- Enforcement of littering laws;
- Adequate provision of bin infrastructure;
- Educational and awareness campaigns for members of the public;
- Clean-up activities;
- Improved collection, treatment and disposal of municipal solid waste, including improved street cleaning;
- Waste prevention (e.g. by encouraging re-use, or via levies);
- Incentivising of collection of specific materials (e.g. deposit refund systems, extended producer responsibility); and
- Enforcement of compliance with Landfill Directive.

In addition, a number of potential measures aimed specifically at commercial and industrial waste producers were recommended.

⁵¹⁵ Arcadis (2012) *Case studies on the plastic cycle and its loopholes in the four European regional seas areas*, Report for DG Environment, 2012

5.2.2.2 Pilot Project on Loopholes in Plastic Packaging Waste Management in Member States

This study was also launched in support of the implementation of the MSFD, by the European Commission. Its objective was the identification of the largest loopholes in the plastic packaging life cycle through which plastic packaging waste could escape and enter the marine environment, hence contributing to marine litter.⁵¹⁶ Plastic packaging was chosen as the focus because of the prevalence of this waste item and material type in compositional analysis of marine litter (reported here as 50%). The study also emphasised that of this type of litter, plastic bags and bottles make up the largest proportion.

The largest loopholes identified were related to:

- The production of plastic packaging;
- Consumption and disposal behaviour of consumers;
- Suboptimal collection infrastructure;
- Illegal dumping; and
- Poor landfilling practices.

These loopholes match those identified in the previous study on the plastics recycling cycle quite closely, and this study also makes recommendations on how to address these production, consumption and disposal loopholes. These are:

- Reducing the high consumption of plastic packaging products (particularly bags and bottles);
- Improving the disposal behaviour of consumers;
- Optimise the design of plastic packaging production (e.g. design for re-use, recycling, low material demand);
- Better enforcement of extended producer responsibility; and
- Improved performance of the waste management system (e.g. increase waste collection frequency and recovery/recycling or close non-compliant landfills particularly close to the coast).

5.2.2.3 Feasibility Study of Introducing Instruments to Prevent Littering

A third study undertaken in support of the implementation of the MSFD considered the feasibility of introducing specific instruments to prevent littering.⁵¹⁷ The report highlights a wide range of possible instruments, and considers relevant issues associated with their implementation. However, there appears to be something of a 'disconnect' between this report and the first two studies relating to loopholes.

⁵¹⁶ BIPRO (2013) *Study of the largest loopholes within the flow of packaging material*, Report for DG Environment, 2013, [about:newtab](#)

⁵¹⁷ ABP MER, Arcadis, and RPA (2013) *Feasibility Study of Introducing Instruments to Prevent Littering*, Report for DG Environment, 2013

While the first two studies emphasise the pre-eminence of plastic packaging waste in marine litter, notably single-use plastic bags and plastic bottles, the report by RPA, Arcadis and ABPmer fails to recommend that Member States might implement measures that demonstrably lead to reduced littering of these items namely levies on single-use carrier bags, and deposit-refunds on beverage containers.⁵¹⁸

5.3 Provision for Waste Management

Globally, there is considerable variation in the provision of waste collection and management services. Clearly where provision is poor, or non-existent, the potential for items to be littered, and ultimately end up as marine debris, is greater. However, the absence of a formal waste management service should not be a reason for holding back on the implementation of measures that can effectively tackle littering – notably of priority items such as plastic bottles and single-use carrier bags.

Significant reductions in the use of single-use carrier bags, an effective form of waste prevention, can be achieved through imposing a ban, or introducing a levy, requiring no investment in the provision of waste management services. Similarly, a deposit-refund system for beverage containers does not depend upon the existence of a waste management service for households.

Waste management projects funded by international donors tend to focus on large scale infrastructure provision, typically of facilities such as incinerators. Rather than prioritise prevention, to reduce the overall amount of the waste to be managed, these focus on the bottom of the ‘waste hierarchy’ on disposal or ‘recovery’ activities – the latter actually requiring a steady throughput of waste, and therefore arguably inimical to large scale reductions in waste. Prioritising investment in such a way is not the most effective way of tackling littering.

5.3.1 Poorly Managed Landfill

Landfills that are badly managed can contribute to the problem of marine debris, especially if they are adjacent to rivers, or near the coast. However, the extent of the contribution is poorly understood. The problem is not just with landfills that are currently operational, but also those that have been closed, but are now being eroded.

A particular knowledge gap is that of the relative scale of the contribution of landfills to the problem of marine debris, and moreover, of identifying which particular landfill sites are the priorities for action, on the basis of their contribution and the associated impact.

⁵¹⁸ See for example Eunomia Research & Consulting (2011) *A Comparative Study on Economic Instruments Promoting Waste Prevention*, Report for Bruxelles Environnement, December 2011, www.ibgebim.be/uploadedFiles/Contenu_du_site/Professionnels/Formations_et_s%C3%A9minaires/Waste_Prevention_Conference/Formulaire_WPC/Waste%20Prevention%20Final%20Report%2008.11.2011%202.pdf?langtype=2060

An interesting example of where this issue is being addressed is in Alaska. The Alaska Department of Environmental Conservation recognises that:⁵¹⁹

Coastal and river erosion has the potential to cause hazardous substances and garbage from Alaska's eroding landfills, closed dump sites, and contaminated sites to be released into the ocean and the state's rivers, jeopardizing Alaska's waters, fish and wildlife.

The Department is now engaged in a four-year \$1.4 million project to create an inventory of such sites, identify priority locations, and generate action plans to mitigate the impacts of erosion. The inventory, ranking and action plans will help state and federal agencies, as well as rural communities seeking funding, to control eroding areas or relocate landfills that are in danger of eroding.

This is an approach that could usefully be replicated elsewhere. Another high profile example relates to the coastal landfill on the southern coast of the city of Saïda in Lebanon. Since 1982 this has been the main waste disposal site for the city and its surrounding municipalities. The dumpsite has a surface area of 3 ha and a height of 55 m, and is understood to receive 300 tons of waste per day. The dumpsite is said to be ineffectively managed and is reported not to meet basic environmental requirements.⁵²⁰ The dumpsite thus represents an environmental and human health risk, in particular given its location near a water body. Waste from the dumpsite regularly slides into the Mediterranean, littering coastlines and degrading the marine environment. The impact of the dumpsite is not restricted to the coastal area of Saïda. Reportedly, waste from the landfill is washing ashore in northern Lebanon, Syria, Cyprus and Turkey.

⁵¹⁹ <http://dec.alaska.gov/eh/sw/wear.html>

⁵²⁰ <http://www.wastefreeoceans.eu/sites/default/files/projects/Press%20Release%20WFO%20Saïda.pdf>

5.4 Prevalence of Land-Based Items in Marine Debris

As indicated in Section 2.2.2, of the 43 different item types in the ICC Clean-Up Scorecard (relating to identifiable debris on beaches), the most prevalent items, by count, are as shown in Table 7

Table 7: Prevalence of Item Types in International Coastal Clean-up

Sector	Item Type	Overall Prevalence
Smoking-Related Litter	Cigarettes/Cigarette Filters	18.9%
Shoreline & Recreational Activities	Food Wrappers/Containers	10.2%
Shoreline & Recreational Activities	Plastic Beverage Bottles	9.5%
Shoreline & Recreational Activities	Plastic Bags	9.1%
Shoreline & Recreational Activities	Caps/Lids	8.6%
Shoreline & Recreational Activities	Plastic Cups, Plates, Forks, Knives, Spoons	6.2%
Shoreline & Recreational Activities	Plastic Straws/Stirrers	5.5%
Shoreline & Recreational Activities	Glass Beverage Bottles	4.6%
Shoreline & Recreational Activities	Beverage Cans	3.0%
Ocean/Waterway Activities	Rope	2.2%
Ocean/Waterway Activities	Plastic Sheeting/Tarps	1.7%
Ocean/Waterway Activities	Fishing Line	1.2%

Source: *The Ocean Conservancy 2012 - The Ocean Trash Index.*

The majority of these items are categorized by the ICC as belonging to the 'Shoreline & Recreational Activities' sector. The exceptions are Rope, Plastic Sheeting/Tarps, and Fishing Line ('Ocean/Waterway Activities'), and Cigarettes/Cigarette Filters ('Smoking-Related Activities'). What is clear from this list is that debris originally derived from land-based activities appears to make the greatest contribution to the debris on surveyed beaches.

This prevalence by type does not necessarily reflect the relative extent of impacts on migratory species from such items of debris. In part, this may be due to the focus in the ICC on beach debris. Debris discarded offshore, having impacts offshore, and remaining offshore, would clearly not be counted.

The report commissioned by the Convention on Biological Diversity found that around 80% of the impacts on marine species were associated with plastic debris, while

paper glass and metal together accounted for less than 2%.⁵²¹ Within the plastics category were:

- Rope and netting (24%);
- Fragments (20%);
- Packaging (17%)
- Other fishing debris (16%); and
- Microplastics (11%).

Rope and netting, and fishing debris, are likely to be predominantly from marine-based sources (albeit some marine debris from recreational fishing may be from inland waterways or (land-based) fishing on the coastline).

'Fragments', which by their nature cannot be allocated to a particular source or item type may be land-based in origin to a large degree, and the same could be said for microplastics. Primary microplastics will almost certainly be land-based in origin, given their application as cleaning agents and their use in personal care products.⁵²² Secondary microplastics (which have fragmented from larger plastic fragments) may be from either land or marine derived sources of debris. Packaging materials will predominantly be land based in origin.

The available data suggests that the majority of the flow of debris into the marine environment is land-based in origin (possibly up to 80%). There are numerous difficulties associated with monitoring and enforcement in respect of reducing the flow of debris from marine-sources (e.g. fishing, shipping). However, for land-based sources, with clearer lines of legal responsibility, reducing the flow of debris should, in theory, be more straightforward. This point was highlighted by Achim Steiner, UN Under-Secretary-General and UNEP Executive Director at the launch of UNEP's 2009 report: *Marine Litter: A Global Challenge*.⁵²³

Marine litter is symptomatic of a wider malaise: namely the wasteful use and persistent poor management of natural resources. The plastic bags, bottles and other debris piling up in the oceans and seas could be dramatically reduced by improved waste reduction, waste management and recycling initiatives. Some of the litter, like thin film single use plastic bags which choke marine life, should be banned or phased out rapidly everywhere there is simply zero justification for manufacturing them anymore, anywhere. Other

⁵²¹ Secretariat of the Convention on Biological Diversity, and Scientific and Technical Advisory Panel - GE (2012) *Impacts of Marine Debris on Biodiversity: Current Status and Potential Solutions, Technical Series No. 67*, 2012

⁵²² <http://www.stowa.nl/upload/publicaties/Inventarisatie%20risico%20microplastics%20engels.pdf>

⁵²³ <http://www.rona.unep.org/documents/pressreleases/2009PR-LaunchOfMarineLitterReport.pdf>

waste can be cut by boosting public awareness, and proposing an array of economic incentives and smart market mechanisms that tip the balance in favor of recycling, reducing or reuse rather than dumping into the sea.

For a number of the item types referred to above, and listed in Table 7, there are indeed specific measures that can be implemented in order to prevent them reaching the marine environment. These are detailed in Section 5.5.

5.5 Item-Specific Measures

A range of item-specific interventions are available to prevent waste reaching the marine environment. Such measures also prevent terrestrial debris, leading to a number of, arguably, more immediately tangible benefits for the residents and authorities in the country/region/city where the measures are implemented.

5.5.1 Deposit-Refunds for Beverage Containers

In 2011 Australia's Commonwealth Scientific and Industrial Research Organisation (CSIRO), in partnership with Earthwatch, commenced a three year marine debris research survey. The aim of the survey is to identify and understand the threat marine debris poses to wildlife and ecosystems by mapping out where – and how – it is accumulating along Australian coastlines.⁵²⁴

To date, CSIRO researchers have visited more than 170 sites around Australia, completing over 575 transects, stopping at 100 kilometre intervals along the Australian coast, investigating:

- Sources, distribution, and ultimate fate of marine debris;
- Exposure of marine wildlife to debris; and
- The effects of ingestion and entanglement on marine wildlife populations.

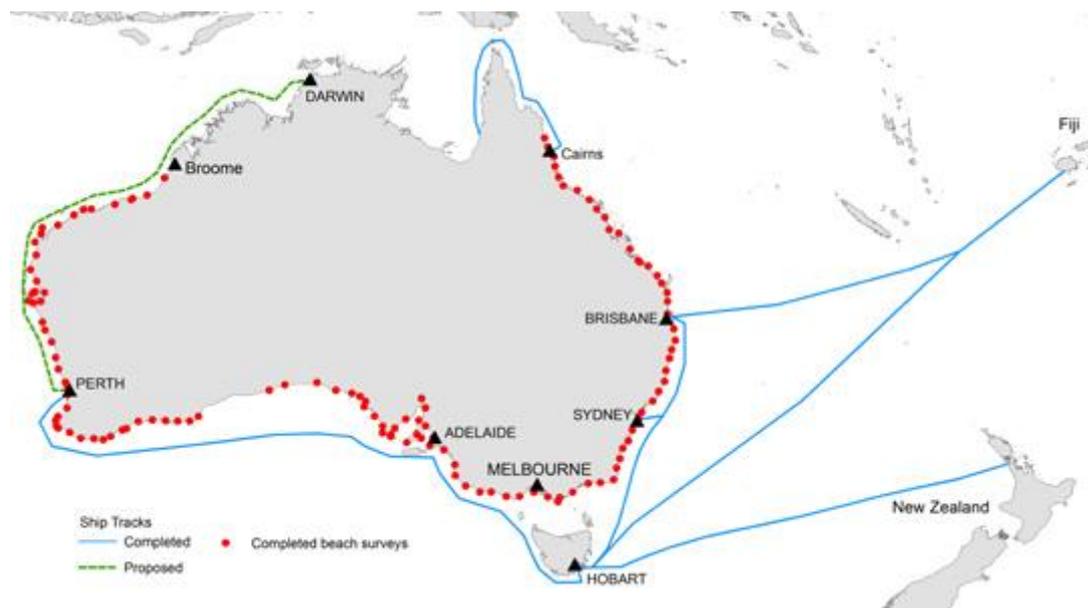
The research team is being led by Dr Britta Denise Hardesty. On being interviewed by the Australian Broadcasting Corporation in 2012, she noted that:⁵²⁵

Observationally we do not find full plastic bottles or cans or glass bottles in [...] South Australia and I would likely attribute that [...] to the container deposit scheme that they have there.

⁵²⁴ <http://www.csiro.au/Organisation-Structure/Flagships/Wealth-from-Oceans-Flagship/marine-debris.aspx>

⁵²⁵ <http://www.abc.net.au/catalyst/stories/3583576.htm>

Figure 3: CSIRO Marine Debris Survey Locations



Source: CSIRO

There is considerable evidence to suggest that deposit refund policies can reduce litter and even reduce associated direct impacts on members of the public, such as the number of lacerations caused by glass in the environment.⁵²⁶ Several one-way deposit systems were implemented with the clear objective of reducing littering (e.g. Sweden, British Columbia, California, Michigan and others). Hawaii is a more recent example of this trend.

The potential for deposit systems to be effective in reducing littering has an intuitively plausible rationale - if the deposit is significant, then if the consumer does decide to litter, the possibility exists that someone else will pick up the container to redeem the deposit.

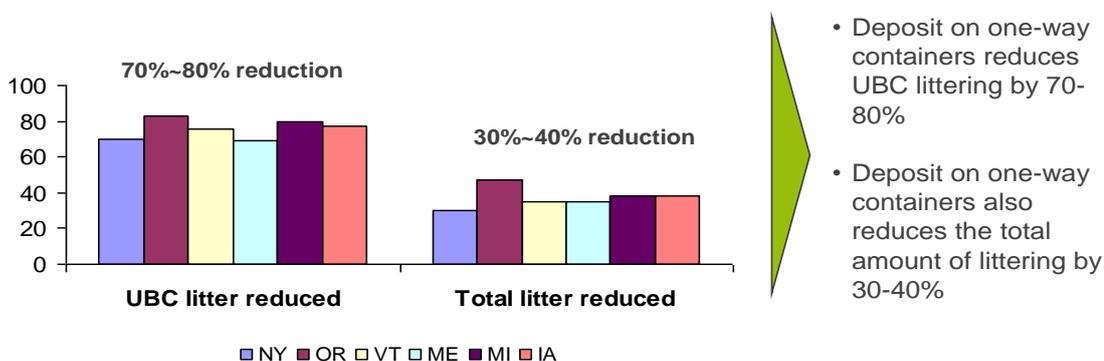
The Container Recycling Institute suggested significant reductions in littering following introduction of deposits in some US states (see Figure 4). The effects on used beverage containers (UBCs) and on total litter are shown as being between 70-80% and 30-40%, respectively. It must be said, however, that all studies of this nature suffer in terms of the lack of clarity about the metric used to measure the contribution of beverage containers to total litter. It is not clear what the most relevant indicator should be (counts, volume, hazardousness, etc.) partly because no systematic studies have been carried out, to our knowledge, to understand the contribution of different attributes of litter to the disamenity felt by those who experience litter. There is also

⁵²⁶ M. Douglas Baker, MD, Sally E. Moore, and Paul H. Wise, MD, PhD, MPH, "The Impact of 'Bottle Bill' Legislation on the Incidence of Lacerations in Childhood", *American Journal of Public Health*, October 1986.

the matter of cost to be considered since cleaning up litter costs money. The effect of litter reduction on costs is considered below.

Figure 4: Reduction in Littering in US States Linked to Deposit Schemes

Reduction of littering in 6 US states after the introduction of container deposit systems.



Source: Container Recycling Institute, USA

Where supposed counter-arguments to the 'litter reduction' effect are put forward, these very rarely challenge the likely reality of this effect. Indeed, the counter-arguments tend to adopt the view that this effect is not significant because beverage containers constitute only a small proportion of litter. Even if one accepts the argument that this might be true, implicit in the counter-argument appears to be an assumption that if litter 'is there', then the amount of it is not a matter of any importance, or more specifically, that the reduction in the quantity of beverage packaging in litter is of no significance. Yet none of the literature actually offers any evidence to support this implied claim. The validity of the implied claim is also affected by the nature of the assumption (as highlighted above) concerning the metric used to measure 'litter'. What the right metric might be has not, as discussed above, been given adequate consideration by either advocates, or detractors, of the effects of deposit schemes.

In Ireland, Perchards argue that:⁵²⁷

The National Litter Survey for 2006 indicates that drinks containers (excluding cartons) represent 5.36% of total litter, with all packaging representing 13% of litter. This indicates that a deposit could reduce the incidence of drinks containers in packaging, but it would have little impact on total litter. Other litter surveys undertaken around the world have reached the same conclusion. Through Repak, Irish industry is already helping to combat litter, and it is unlikely that a deposit

⁵²⁷ G. Bevington (2008) *A Deposit and Refund Scheme in Ireland*, Report commissioned by Repak Ltd., September 2008.

would result in significant cost savings for Irish local authorities on litter abatement activities.

A problem with this analysis is that it assumes that the relevant indicator regarding litter is the measure used in the Litter Survey. This actually measures 'counts' of litter.

It could be argued that the disamenity effect of litter, and indeed its impact on migratory species, is a function more of its volume, and possibly, its potential to persist, than the number of items (i.e. the counts). In this respect, it is worth reporting that the 2007 National Litter Survey reports that the two most prominent items in litter in terms of counts are cigarette related litter, accounting for 46.7% of counts, and food related litter, accounting for 28% of counts. The majority of the two combined – though certainly requiring clean-up – are less visible cigarette ends and chewing gum. Chewing gum clearly has the potential to cause nuisance in its own particular way. After these categories, the component with the highest number of counts is packaging items, at 11.75%, of which around 5.64% - roughly half – were beverage containers.⁵²⁸

Given the relative insignificance – in volume terms – of chewing gum and cigarette ends, it might reasonably be considered that beverage containers could actually constitute a significant proportion of litter when considered in volume terms. As a result, one might argue that they are not as insignificant – in terms of their contribution to the disamenity associated with litter – as the count number would suggest if, as seems not entirely implausible, some of the litter-related disamenity experienced by communities relates to litter's visibility.

Furthermore, in terms of value of materials in the litter stream, their contribution may also be significant. It is notable that the contribution of beverage containers to the litter count associated with packaging is around 50%, even though in weight terms, such containers account for only 10% or so of packaging in the waste stream. In other words, where packaging is concerned, beverage containers appear to figure in a disproportionately significant manner within litter. Hence, whilst many argue that deposits only address a fraction of all packaging, their effect on litter may address a form of packaging which contributes disproportionately to the problem of litter.

In jurisdictions such as Hawaii, the prevalence of beverage containers in terrestrial and marine debris has been a motivation for the scheme. One report from the State of Hawaii shows how beverage containers have changed in terms of their prevalence in debris over time.⁵²⁹ The data are shown in Table 8 and Table 9.

⁵²⁸ TOBIN (2008) *Litter Monitoring Body: System Results 2007*, The National Litter Pollution Monitoring System Survey, Report for DoEHLG, June 2008, <http://www.environ.ie/en/Environment/Waste/LitterPollution/NationalLitterMonitoringSystem/PublicationsDocuments/FileDownload.18616.en.pdf>

⁵²⁹ State Of Hawaii Department Of Health (2008) *Pursuant To Sections 342g-102.5(H), 342g-114.5(B), And 342g-123, Hawaii Revised Statutes, Requiring The Department Of Health To Give A Report On The Activities Of The Deposit Beverage Container Program*, Report To The Twenty-Fifth Legislature State Of Hawaii 2009, November 2008.

Table 8: Number of Debris Found During Cleanup

Beverage Container Type	2003	2004	2005	2006	2007
Glass Bottles	7,687	11,362	7,194	5,759	5,008
Plastic Bottles	5,246	5,215	3,824	4,799	2,965
Metal Cans	4,946	6,894	3,518	3,959	2,932
Total	17,879	23,471	14,430	14,517	10,905

Source: State Of Hawaii Department Of Health (2008) Pursuant To Sections 342g-102.5(H), 342g-114.5(B), And 342g-123, Hawaii Revised Statutes, Requiring The Department Of Health To Give A Report On The Activities Of The Deposit Beverage Container Program, Report To The Twenty-Fifth Legislature State Of Hawaii 2009, November 2008

Table 9: Percentage of Total Debris Collected During Cleanup

Beverage Bottles & Cans	2003	2004	2005	2006	2007
Glass, Metal, & Plastic	15.9%	14.5%	12.3%	8.7%	6.7%

Source: State Of Hawaii Department Of Health (2008) Pursuant To Sections 342g-102.5(H), 342g-114.5(B), And 342g-123, Hawaii Revised Statutes, Requiring The Department Of Health To Give A Report On The Activities Of The Deposit Beverage Container Program, Report To The Twenty-Fifth Legislature State Of Hawaii 2009, November 2008

The report notes:

While there appears to be a downward trend in the number of bottles and cans found at beaches, beverage containers, along with associated caps and lids, continue to be a large portion of beach litter. This is why it is important to continue to place a deposit on beverage containers to decrease the temptation to litter and increase the incentive to recycle.

A somewhat interesting feature of the Hawaii data is that they show that beverage containers appear to be (relatively) more problematic in underwater cleanups (see Table 10).

Regarding plastics in particular, UNEP's 2009 report notes the prevalence of plastic bottles, caps (and bags) among the key forms of debris giving rise to increasingly serious problems in the marine environment due to the longevity and potential harm caused by the material.⁵³⁰

⁵³⁰ Ljubomir Jeftic, Seba Sheavly, and Ellik Adler (2009) *Marine Litter: A Global Challenge*, Report for UNEP, April 2009, http://www.unep.org/regionalseas/marinelitter/publications/docs/Marine_Litter_A_Global_Challenge.pdf

Table 10: Top 5 Debris Items Collected During the 2007 Cleanup

Land Cleanups Only	Number of Debris Items	Percent of Total Collected
1. Cigarettes & Filters	72,053	44.7%
2. Caps & Lids	21,210	13.1%
3. Food Wrappers and Containers	16,554	10.3%
4. Beverage Containers (<i>glass, metal, plastic</i>)	10,505	6.5%
5. Cups, Plates, and Utensils	7,331	4.5%
Underwater Cleanups Only	Number of Debris Items	Percent of Total Collected
1. Fishing Line	1,081	54%
2. Beverage Containers (<i>glass, metal</i>)	393	19.6%
3. Cigarettes, Filters, & Cigar Tips	248	12.3%
4. Food Wrappers and Containers	55	2.7%
5. Caps & Lids	39	1.9%

Source: State Of Hawaii Department Of Health (2008) Pursuant To Sections 342g-102.5(H), 342g-114.5(B), And 342g-123, Hawaii Revised Statutes, Requiring The Department Of Health To Give A Report On The Activities Of The Deposit Beverage Container Program, Report To The Twenty-Fifth Legislature State Of Hawaii 2009, November 2008

Interesting evidence of the effects of deposits on littering comes from Denmark. In Denmark, there is a prominent cross-border trade in alcohol from Germany owing to the differences in excise duties between the countries. The Danish Society for Nature Conservation is the largest nature conservation and environmental organization in Denmark. With the support of 140,000 members, they work to protect nature and the environment, and each year conduct debris clean-up campaigns. What is most intriguing about these campaigns is the proportion of littered cans which do not carry a deposit, because they are imported from Germany from areas specifically exempted from the German deposit system. A short summary of the main results concerning beverage cans since 2008 from the “Clean Up Denmark” campaigns is given below:

- 2008: 154,400 cans, of this only 7,800 with a paid Danish deposit;
- 2009: 153,000 cans, of this only 10,000 with a paid Danish deposit; and
- 2010: 197,000 cans, of this only 7,800 with a paid Danish deposit.

The data indicates that the vast majority of cans which are found in litter are those which bear no deposit. The suggestion appears to be that the deposit system has a significant bearing upon whether cans are littered or not. The Danish EPA notes that the majority of the machines receiving containers bearing the Danish deposit are also equipped to receive those which do not. Hence, the only differences between the German and Danish containers is that the Danish ones bear a deposit, which seems to act as a significant incentive to motivate return to the appropriate system. The absence of incentive in the case of German containers leads to greater littering,

A 2009 study undertaken in Australia suggested that deposit schemes were likely to be the most effective policy option for reducing litter amongst those considered for improving recycling:⁵³¹

A national CDS [container deposit scheme] is expected to provide the greatest reduction in overall litter levels, with the potential to provide a 6% reduction in the total national litter count and a 19% reduction in the total national litter volume.

Finally, there is another way in which removal of used beverage containers from litter could contribute to cleaner streets. To the extent that beverage containers are relatively voluminous items, then their removal from litter bins would leave more room for other waste. The CPRE's Litterbugs report reports that 91% of the public believe that increasing the number of bins is the most effective way of reducing litter.⁵³² An equivalent approach might be to free up space in existing bins. The report cites the New York bottle bill as reducing container litter by 70-80%. Clean-up costs, as well as landfill costs, were reduced. The scheme enjoys solid public support (84% of voters in 2004) and so has been extended in 2009 to cover non-carbonated drinks, which make up 27% of beverage sales.

5.5.1.1 Effects on Disamenity

Discussion of impacts of litter is often framed in terms of costs. The most obvious type is the 'direct cost', which is the cost to local authorities and other duty bodies of clearing away litter. Beyond these direct costs is what one might term 'indirect costs' – i.e. the costs to other stakeholders. While these are less well understood, initial estimates suggest that they are considerable - far outweighing the direct costs.

Research commissioned in early 2013 by Zero Waste Scotland (ZWS) has begun to explore a number of these indirect cost categories, looking both at costs that are 'internalised' within market transactions, and 'externalities', for which no market exists. An example of an internalised cost is that arising from having to deal with a bicycle puncture caused by broken glass from a littered bottle. An externalised cost, by contrast, could be the sense of 'welfare loss' associated with the visual disamenity of a beach being strewn with litter.

⁵³¹ BDA Group (2009) *Beverage Container Investigation*, Report for the EPHC beverage Container Working Group, March 2009.

⁵³² A. Lewis, P. Turton and T. Sweetman (2009) *Litterbugs How to Deal with the Problem of Littering*, Report for CPRE, March 2009.

The ZWS research identified evidence that a littered environment can contribute to poor mental health, increase the likelihood of crime, and reduce property values.⁵³³ Other types of indirect costs identified were associated with road traffic accidents, fires, and vermin. The study also built upon research into local environmental quality undertaken for Defra in 2011.⁵³⁴ Looking at externalised costs, this report identified the public's mean willingness to pay (WTP), via an increase in council tax, for a number of improvements in a range of local environmental factors.

Litter was identified in the research as the factor with the most significant effect on local environmental quality, with the highest mean WTP to reduce it, at over £100 per person per year. Applying the values from this research to Scotland, an aggregate WTP of between £500 million and £770 million was identified. This can be taken as a broad measure of the disamenity impact, i.e. just how upset people feel about the level of litter in their local neighbourhood.

A 2010 study for CPRE on the introduction of a UK-wide deposit-refund system for beverage containers found that the benefits of such a system outweighed the costs once account was taken of the disamenity impact of litter.⁵³⁵ At the time, prior to the publication of the Defra study cited above, there was an absence of reliable estimates on disamenity, and the values selected were much lower than those more recently identified. On the basis of the revised disamenity figures, the case for deposits looks even stronger. What is important to note about these findings is that such interventions appear to be able to be justified even *without* considering the benefits associated with reduced impacts on the marine environment. Once these positive impacts are taken into account, the argument in support of actions such as deposit refunds becomes even more compelling.

While ultimately it seems intuitive that reducing the amount of debris entering the marine environment is in everyone's self-interest, evidence such as that relating to local disamenity strengthens the case for countries to take action on litter, even on the narrowest definition of self-interest.

⁵³³ Eunomia Research & Consulting (2013) *Exploring the Indirect Costs of Litter in Scotland*, May 2013

⁵³⁴ Mark Wardman, Abigail Bristow, Jeremy Shires, Phani Chintakayala, and John Nellthorp (2011) *Estimating the Value of a Range of Local Environmental Impacts*, Report for Dept. for Environment, Food and Rural Affairs, April 2011

⁵³⁵ Eunomia Research & Consulting (2010) *Have We Got the Bottle? Implementing a Deposit Refund System in the UK*, Report for Campaign to Protect Rural England (CPRE), September 2010, www.cpre.org.uk

5.5.2 Levies on Single-use Carrier Bags

In early 2013 the European Commission published three studies looking into the composition, and sources, of marine litter in European seas. In a chapter integrating results from all three studies it noted that:⁵³⁶

Plastics are the most abundant debris found in the marine environment and comprise more than half of marine litter in European Regional Seas. More than half of the plastic fraction is composed of plastic packaging waste with plastic bottles and bags being predominant types of plastic packaging.

This summary chapter then goes on to say that:

Therefore, measures within a strategy to close the largest loopholes in the plastic packaging cycle should target plastic bottles and plastic bags.

Plastics dominate marine litter and represent a significant threat to the marine environment due to their abundance, longevity in the marine environment and their ability to travel vast distances.⁵³⁷ Despite representing only 10% of all waste produced, plastics account for between 50-80% of marine litter and this is not expected to decline for the foreseeable future (particularly as plastics do not degrade quickly).⁵³⁸ Of all plastics it is single use plastic bags that are arguably the most iconic symbol of the impact of marine debris on migratory species in the mind of the public, notably in respect of their ingestion by turtles.

Data taken from the International Bottom Trawl Survey and the Clean Seas Environmental Monitoring Programme indicate that plastic bags make up 40% of all marine litter in the waters of the North East Atlantic. The French research institute IFREMER has also found that in the Bay of Biscay most of the waste items found on the seabed were plastic (92%) and of those 94% were plastic bags.⁵³⁹

⁵³⁶ See

<http://ec.europa.eu/environment/marine/pdf/Integration%20of%20results%20from%20three%20Marine%20Litter%20Studies.pdf>

⁵³⁷ KIMO (2010) Economic Impacts of Marine Litter, Kommunernes Internationale Miljøorganisation Local Authorities International Environmental Organisation, September 2010, available at <http://www.kimointernational.org/Portals/0/Files/Marine%20Litter/Economic%20Impacts%20of%20Marine%20Litter%20Low%20Res.pdf>

⁵³⁸ Thompson, R.C., Swan, S.H., Moore, C.J. and vom Saal, F.S. (2009a) Our Plastic Age. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 1969-2166; Barnes, D.K.A., Galgani, F., Thompson, R.C. and Barlaz, M. (2009) Accumulation and fragmentation of plastic debris in global environments. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 1985-1998; Thompson, R.C., Moore, C.J., vom Saal, F.S., and Swan, S.H. (2009b) Plastics, the environment and human health: current consensus and future trends. *Philosophical Transactions of the Royal Society B: Biological Sciences* 364(1526): 2153-2166.

⁵³⁹ Seas at Risk (2011) Commission Consults on Binning Plastic Bags, available at http://www.seas-at-risk.org/news_n2.php?page=408

Fortunately, evidence suggests that measures to reduce the use of single-use plastic carrier bags are effective. The Irish plastic bag levy was introduced in March 2002 under the Waste Management (Environmental Levy) (Plastic Bag) Regulations 2001. Initially, the tax was set at €0.15 per plastic bag, with exemptions for smaller plastic bags that met specific conditions and were used to store non-packaged goods such as dairy products, fruit and vegetables, nuts, confectionary, hot or cold cooked food and ice –these are known as levy-free bags (reusable plastic bags are also exempt as long as the charge for the bag exceeds €0.70).⁵⁴⁰ The tax is passed directly to consumers at the point of sale, and has thus been reported to provide a clearer, more consistent message than systems where retailers are responsible for the levy (such as in Denmark and South Africa).^{541,542}

It has been reported that this policy has been very effective and has *‘proved so popular with the Irish public that it would be politically damaging to remove it’*.⁵⁴³ The tax was implemented to *‘change consumers’ behaviour to reduce the presence of plastic bags in the rural landscape, and to increase public awareness of littering’*. Revenues from the tax are paid into an Environmental Fund which is administered by the Department of Environment, Heritage and Local Government. The fund is used to cover administrative costs (3% of total revenues) and support a wide range of environmental programmes. The costs of implementation are reported to be very low because bookkeeping and reporting has been integrated with VAT returns.⁵⁴⁴

The levy is not a Pigouvian tax, in that the rate of the tax was not devised with the intention of internalising the marginal external costs. Instead, the Irish Government’s intention was to set a rate of tax which would act to change consumer behaviour. As such, the initial rate of tax was set at six times consumers’ average maximum willingness to pay for the purchase of plastic bags.⁵⁴⁵ This ensured that there was a

⁵⁴⁰ According to the Department of the Environment, Community and Local Government ‘Bags not exceeding 225mm in width (exclusive of any gussets), by 345mm in depth (inclusive of any gussets), by 450mm in length, (inclusive of any handles) have been marketed as “Levy Free Bags”. The regulations, however, do not provide for “Levy Free Bags”. The Plastic Bag Levy applies on all plastic bags, even if marketed as “Levy Free Bags”, when used in circumstances not exempted by the regulations’. See: Department of the Environment, Community and Local Government (2007) Plastic Bags, Date Accessed: 19 September 2011, www.environ.ie/en/Environment/Waste/PlasticBags/.

⁵⁴¹ Dikgang, J. Leiman, A. and Visser, M. (2010) *Analysis of the Plastic-Bag Levy in South Africa*, Policy Paper No. 18, Environmental Policy Research Unit, School of Economics, University of Cape Town, July 2010, www.econrsa.org/papers/p_papers/pp18.pdf

⁵⁴² Plastic Bag: Friend or Foe? (no date given) *Market Based Examples*, Date Accessed: 20 September 2011, www.plasticbageconomics.com/index.php?option=com_content&task=view&id=26&Itemid=40

⁵⁴³ Convery, F., McDonnell, S. and Ferreira, S. (2007) The Most Popular Tax in Europe? Lessons from the Irish Plastic Bags Levy, *Environmental and Resource Economics*, September 2007, Vol. 38, No. 1, pp. 1-11

⁵⁴⁴ Convery, F., McDonnell, S. and Ferreira, S. (2007) The Most Popular Tax in Europe? Lessons from the Irish Plastic Bags Levy, *Environmental and Resource Economics*, September 2007, Vol. 38, No. 1, pp. 1-11

⁵⁴⁵ Ibid.

marked decrease in the use of plastic bags in the short term, a trend which has been reversed slightly over the years. The per capita usage of plastic bags decreased from an estimated 328 to 21 plastic bags per capita per annum after the introduction of the tax. However, the results of the 2006 census indicated that plastic bag usage had risen to 32 bags per capita over the course of 2006. Consequently the levy was increased to €0.22 on 1st July 2007 under Plastic Bag (Amendment) (No. 2) Regulations of 2007.⁵⁴⁶

An evaluation of the impact of the levy on householders and retail sector was undertaken by Convery et al.⁵⁴⁷ The authors interviewed seven leaders in the retail sector and conducted random telephone interviews with consumers, the results were as follows:

- Retailers found the effects of the tax on their well-being neutral or positive, closely related to the fact that the additional costs of implementation were generally less than the savings resulting from not having to purchase plastic bags. Implementation costs were low because book-keeping was integrated with VAT returns; and
- Overall, consumers were very much in favour of the levy. While the levy had caused them some expense, through either paying the levy or buying long-life bags, virtually all respondents responded that they felt the impact on the environment was positive, producing a noticeable reduction in plastic bags 'in the environment'.

The main objective of Ireland's plastic bag levy has been to reduce quantities of litter. In this regard the tax has had a marked effect and again Convery et al report that:

'A combined project by Irish Business Against Litter and An Taisce (National Trust of Ireland) produced a number of litter surveys. These have found that between January 2002 and April 2003 the number of "clear" areas (i.e. areas in which there is no evidence of plastic bag litter) has increased by 21%, while the number of areas without "traces" has increased by 56%.⁵⁴⁸ These numbers are remarkably high given the long lasting nature of plastic bags in the environment. A different source, the National Litter Pollution Monitoring System notes that plastic bag litter accounted for 5% of national litter composition before the introduction of

⁵⁴⁶ Department of the Environment, Community and Local Government (2007) *Plastic Bags Levy to be Increased to 22c from 1 July 2007*, Press Release: 21/02/2007, Date Accessed: 19 September 2011, www.environ.ie/en/Environment/Waste/PlasticBags/News/MainBody,3199,en.htm

⁵⁴⁷ Convery, F., McDonnell, S. and Ferreira, S. (2007) The Most Popular Tax in Europe? Lessons from the Irish Plastic Bags Levy, *Environmental and Resource Economics*, September 2007, Vol. 38, No. 1, pp. 1-11

⁵⁴⁸ "Traces" of litter is defined as up to five items over a linear distance of 1 m.

the levy. In 2002, this number fell to 0.32%, in 2003 to 0.25% and to 0.22% in 2004'.⁵⁴⁹

This rate has remained more or less constant since this time.⁵⁵⁰ In addition, the public commonly believes that the amount of plastic bag litter has decreased substantially since the introduction of the tax.⁵⁵¹

5.5.2.1 Welsh Carrier Bag Charge

The Welsh Government introduced a £0.05 (€0.06)⁵⁵² compulsory charge for single-use carrier bags at the point of sale in October 2011. Unlike Ireland this mechanism is not a levy, but a minimum charge that retailers are guided to pass on to local and environmental causes (although this is not mandatory).⁵⁵³ Additionally it also applies to all single-use bags including those composed of paper and other plant based material, not just plastic.

Nine months after the introduction of the charge, reductions are cited by Welsh Government as between 70% and 96%, depending upon the sector.⁵⁵⁴ Retailers in the following sectors reported a range of reductions:

- Food retail – between 96% and 70% reduction;
- Fashion – between 75% and 68% reduction;
- Home improvement – 95% reduction;
- Food service – up to 45% reduction;
- Telecommunications – 85% reduction.

Data released by WRAP in 2011 shows a reduction of 22% in usage across supermarkets in Wales from 2010 to 2011.⁵⁵⁵ This would appear to be consistent

⁵⁴⁹ Convery, F., McDonnell, S. and Ferreira, S. (2007) The Most Popular Tax in Europe? Lessons from the Irish Plastic Bags Levy, *Environmental and Resource Economics*, September 2007, Vol. 38, No. 1, pp. 1-11

⁵⁵⁰ Litter Monitoring Body and TOBIN Consulting Engineers (2011) *The National Litter Pollution Monitoring System – Litter Monitoring Body: System Results 2010*, Report for the Department of the Environment, Heritage and Local Government, April 2011, www.litter.ie/system_survey_results/index.shtml

⁵⁵¹ Convery, F., McDonnell, S. and Ferreira, S. (2007) The Most Popular Tax in Europe? Lessons from the Irish Plastic Bags Levy, *Environmental and Resource Economics*, September 2007, Vol. 38, No. 1, pp. 1-11

⁵⁵² Based on a £:€ exchange rate of 1:1.27650, ft.com currency converter, 26th July 2012.

⁵⁵³ Welsh Government (2012), Carrier Bag Charge Wales, Accessed 19th July 2012. <http://www.carrierbagchargewales.gov.uk/?lang=en>

⁵⁵⁴ Welsh Government (2012), Reduction in Single-use Carrier Bags, Accessed 7th August 2012. http://wales.gov.uk/topics/environmentcountryside/epq/waste_recycling/substance/carrierbags/reduction/

⁵⁵⁵ WRAP (2012), UK Supermarket Retailers Voluntary Carrier Bag Agreement: 2011 Carrier Bag Use, Presentation for the WRAP website, WRAP July 2012

with the reductions noted by the Welsh Government, bearing in mind that the charge was only in place for the final three months of 2011.

A study produced for The Welsh Government by Cardiff University conducted surveys both before and after the introduction of the charge regarding attitudes and behaviours towards it in England and Wales.⁵⁵⁶ Results show that the charge has helped to increase greatly own bag use in Wales with a 21% increase in consumers taking a reusable bag to the supermarket (increased from 61% to 82% of the sample).

5.5.2.2 Chinese Plastic Bag Ban

In January 2008, The State Council, China's parliament, prohibited shops, supermarkets, and sales outlets from providing free plastic bags less than 0.025 mm thick. The State Administration of Industry and Commerce also threatened to fine shopkeepers and vendors as much as 10,000 yuan (US\$1,465) if they were caught distributing free bags.

In its first review of the ban, the National Development and Reform Commission (NDRC) announced in June 2009 that supermarkets had reduced plastic bag usage by 66% since the policy was implemented one year previously.⁵⁵⁷ The China Chain Store and Franchise Association undertook an analysis of the ban as well. The association announced that foreign-owned and local supermarkets reduced plastic bag usage by 80% and 60% respectively. However, compliance with the ban appears to be inconsistent across the country. A survey by Global Village, a Beijing-based environmental group, found that more than 80% of retail stores in rural regions continued to provide plastic bags free of charge.

5.5.3 Incentivizing / Obligating the Use of Reusable Items

Plastic Cups, Plates, Forks, Knives, Spoons account for 6.2% of the items in the ICC Clean-Up Scorecard as shown in Table 7. One possible way to reduce the contribution of these items to marine debris is to ban them. Plastic cutlery was banned in Haryana, India in 2011, although this measure does not appear to be fully enforced, with many people ignoring the ban.⁵⁵⁸

Another approach is to subject such 'single-use' items to a tax or levy, to discourage their consumption. Such an approach has been implemented in Belgium, where under the "picnic tax" wholesalers are liable to pay a tax on various single-use items.⁵⁵⁹ It has been reported that the tax on disposable plastic bags – set at €3.00

⁵⁵⁶ Poortinga et al (2012), Evaluation of the Introduction of the Single-Use Carrier Bag Charge in Wales: Attitude and Behavioural Spillover, Report for the Welsh Government, Cardiff University 2012.

⁵⁵⁷ <http://www.worldwatch.org/node/6167>

⁵⁵⁸ <http://www.fridaygurgaon.com/news/2717-get-real-say-no-to-plastic.html>

⁵⁵⁹ These include the following taxes: €3.00 per kg of non-biodegradable disposable plastic carrier bags; €2.70 per kg for plastic food wrapping (product price increase of approximately 70%); €4.50 per kg for aluminium foil (product price increase of approximately 100%); €3.60 per kg of disposable kitchen utensils.

per kg – has had a marked impact in terms of reducing their use over recent years (decrease of 80% between 2003 and 2007, during this time the sale of reusable bags rose from 4.5million units in 2004 to 25.4million in 2007). However, it is also reported that *despite the fact that ‘the retail prices of disposable kitchen utensils, food wrap and aluminium foil have gone up substantially, the impact on consumption has been less marked’.*⁵⁶⁰

While the tax may have led to less consumption, and presumably thus levels of associated debris, than would have been the case in the absence of the tax, it does not appear to have been particularly successful. Accordingly, the following actions may be necessary, or supportive when implementing taxes on single-use disposable products:

- Apply taxes to items where alternatives are clearly available (this is likely to ensure a reasonable response to the tax);
- Continual review of the tax to ensure that its effectiveness is not being eroded over time (e.g. through inflation);
- Ensure the tax is designed with sufficient inbuilt flexibility to adapt to changing economic conditions; and
- Prior to introducing the tax, develop an effective communication campaign to advertise the rationale behind the tax. In this respect, there should be a clear rationale for the tax.

A third approach is to ban the use of disposable beverage containers, cutlery and crockery at public events.

Since 1991, the City of Munich has banned the use of disposable cutlery and crockery at large-scale public events that take place on land owned by the city and retail spaces owned by the city.⁵⁶¹ The event organisers instead use reusable items which are made available using a deposit-refund system. The deposit is normally only applied to cups, bottles and plates, but not to cutlery, but when people return cups and plates, any cutlery used is usually returned as well. A similar scheme has been in place in Vienna since 2011. A study for the Brussels Capital Region in 2012 identified that an obligation for event organisers to use reusable cups would lead to both environmental benefits and financial savings to organisers, while extending the obligation to include cutlery and crockery would increase costs to organisers, without

⁵⁶⁰Bruxelles Environment (2010) *Mapping Report on Waste Prevention Practices in Territories within EU27 - Pre-Waste: Improve the Effectiveness of Waste Prevention Policies in EU Territories*, October 2010, [http://www.bruxellesenvironnement.be/uploadedFiles/Contenu_du_site/Professionnels/Formations_et_s%C3%A9minaires/Conf%C3%A9rence_Pre-waste_2011_\(actes\)/p3-%20prewaste-mapping-report.pdf](http://www.bruxellesenvironnement.be/uploadedFiles/Contenu_du_site/Professionnels/Formations_et_s%C3%A9minaires/Conf%C3%A9rence_Pre-waste_2011_(actes)/p3-%20prewaste-mapping-report.pdf)

⁵⁶¹ Pre-waste (2011) Ban on disposal drink containers and tableware in Munich, Germany (Münchener Einwegverbot).

demonstrating clear environmental benefits.⁵⁶² However, a key shortcoming of the environmental analysis, in common with many 'life cycle' approaches was the exclusion of the downstream impacts of littered items.

5.5.3.1 Tackling Single-use Coffee Cups

Reusable cups for take-away coffee are becoming increasingly popular and are gaining support from the coffee shop chains. Market leader Starbucks aims to serve 5% of beverages in personal tumblers by 2015. The company has rewarded customers using personal tumblers with a discount since 1985 and has recently launched a \$1 reusable cup to further facilitate their goal.⁵⁶³ Popular chains of coffee shops often charge more to drink the item on the premises which in many respects encourages the use of a single-use disposable cup. However, if a levy were placed on beverages purchased in disposable cups, this would be expected to lead to a change in consumer behaviour.

In addition to directly reducing the likelihood of coffee cups becoming littered, such a measure would also have the effect of *indirectly* reducing litter. Coffee cups are high-volume items that, along with plastic bottles, for example, quickly fill up litter bins, meaning that they will be more likely to overflow, and that further items will be placed next to, rather than within, the bins.

5.5.4 Tackling Styrofoam

Legislation to ban Styrofoam (expanded polystyrene foam) food and drinks containers in New York City was passed in December 2013, making it the latest in a string of almost 100 towns and cities to do so.⁵⁶⁴ A large number of the bans are found in California, with some having been adopted as early as 1989.⁵⁶⁵ The bans vary in nature as some are limited to food and drink containers, some include packaging peanuts and some ban all Styrofoam products. Other related legislation requiring food packaging to be biodegradable or compostable also effectively bans Styrofoam use.

Opposition to Styrofoam bans tends to focus on tackling the waste management issues rather than the health implications of harmful chemicals leaching out of the Styrofoam into food and drink and the wider environment. Dart Container Corp. suggested a kerbside recycling solution for Styrofoam in New York City but the

⁵⁶² Eunomia (2012) A Feasibility Study on a Legal Obligation Aimed at the Systematic Use of Reusable Containers for Drinks and Food Served at Events Held in Public Places in the Brussels Capital Region, Final Report to Bruxelles Environnement

⁵⁶³ Cup and Materials | Starbucks Coffee Company, accessed 13/1/2013, <http://www.starbucks.com/responsibility/environment/cups-and-materials>

⁵⁶⁴ Plastic-Foam Container Ban Approved by New York City Council – Bloomberg, accessed 6/1/2014, <http://www.bloomberg.com/news/2013-12-19/new-york-city-council-approves-ban-on-plastic-foam-containers.html>

⁵⁶⁵ Polystyrene: Local Ordinances | Californians Against Waste, accessed 7/1/2013, http://www.cawrecycles.org/issues/plastic_campaign/polystyrene/local

economics of such a scheme are thought to be prohibitively costly.⁵⁶⁶ The American Chemistry Council states that Styrofoam is currently recycled in over 65 communities in California but such schemes do nothing to tackle the litter problem or the pathway of Styrofoam litter to the marine environment.⁵⁶⁷ Furthermore, once outside of the city jurisdiction the fate of the recycled product at end of life is unknown and may be lost, become litter or be landfilled.

5.5.5 Drinking Straws, Plastic Stirrers, Lollipop Sticks

Sustainable alternatives to plastic drinking straws, stirrers and lollipop sticks have recently grown in popularity.

Glass and steel reusable drinking straws are available from a range of manufacturers and have been promoted across the mainstream media by sources including The Guardian newspaper and Oprah Winfrey.⁵⁶⁸ Metal straws are popular in Latin America and elsewhere to drink hot *mate* and paper straws were used for almost 100 years before plastic straws became commonplace, which demonstrates the viability of reusable and compostable alternatives to plastic.

Wooden stirrers are now common in coffee shops although they are often provided alongside plastic stirrers or plastic single-use spoons. There is no reason why non-biodegradable materials cannot be avoided without any disbenefit to the customer or business. Furthermore, although a large proportion of coffee shop customers buy drinks to take away (over 50% in the UK) many will add milk and sweeteners at the self-service stand *before* leaving the premises.⁵⁶⁹ This suggests that reusable products such as stainless steel teaspoons could be provided, limiting the generation of waste and litter and potentially saving businesses money.

A Facebook campaign asks Chupa Chups to stop using plastic sticks in their lollipops. Pressure from the campaign caused the manufacturer to release a statement of their intention to use a more sustainable material in October 2012 although no such change has been realized yet.⁵⁷⁰

⁵⁶⁶ Why DART Corp's Bribe To New York's City Council Won't Stop Polystyrene In The Environment - 5 Gyres, accessed 7/1/2014, http://5gyres.org/posts/2013/11/25/why_dart_corps_bribe_to_new_yorks_city_council_wont_stop_polystyrene_in_the_environment/

⁵⁶⁷ MB Public Affairs, Inc., Fiscal & Economic Impacts of a Ban on Plastic Foam Foodservice and Drink Containers in New York City, accessed 7/1/2013, <http://www.putalidonitnyc.com/sites/default/files/NYC%20Foodservice%20Impact%20Study%20March%202013.pdf>

⁵⁶⁸ 10 ways to make your New Year's resolution a life with less plastic | Leila Monroe, Darby Hoover, Haley Bowling | Comment is free | theguardian.com, accessed 7/1/2014, <http://www.theguardian.com/commentisfree/2014/jan/04/10-ways-new-years-resolution-life-with-less-plastic>

⁵⁶⁹ CoffeeTalk | A Coffee Shop Ratio that Boosts Profits by 50%, accessed 13/1/2014, <http://magazine.coffeetalk.com/may13-boost-profits/>

⁵⁷⁰ Sam Judd: Never underestimate the little people - Opinion - NZ Herald News, accessed 13/1/2014, http://www.nzherald.co.nz/opinion/news/article.cfm?c_id=466&objectid=10843416

Drinking straws, plastic stirrers and lollipop sticks are prevalent in beach surveys of marine debris although viable alternatives exist in all cases. Public-awareness raising campaigns can gather popular support for plastics to be replaced by other materials and put pressure on the manufacturers to do so. However stronger measures such as bans or levies may produce a greater and more immediate change.

5.5.6 Cotton Bud Sticks

The shape and size of cotton bud sticks mean that they are able to pass through sewage filtration systems after being flushed down the toilet, leading to large numbers entering the marine environment. Cotton buds with paper or wooden sticks are available although less common than plastic ones. Wooden sticks have been reported as being better quality and better suited to certain applications such as medical use and gun cleaning.⁵⁷¹ An awareness raising campaign was conducted in the UK over seven years to prevent cotton buds and other sanitary items being flushed down the toilet. The campaign received support from leading retailers and key manufacturers and saw a drop in the number of cotton bud sticks found on UK beaches.⁵⁷²

5.5.7 Six Pack Rings

In the USA, EPA regulation has required that all six pack ring carriers be made of photodegradable material since 1994 and the leading manufacturer has used photodegradable plastic since 1988.⁵⁷³ However, while this may ultimately reduce the chances of entanglement, photodegradability does nothing to prevent pollution of the marine environment and is likely to increase the chances of ingestion by animals as the plastic breaks down into smaller pieces. Six pack rings are still a common item listed in ICC data and therefore warrant attention as marine debris.⁵⁷⁴ Promoting the use of cardboard or other compostable materials will prevent both entanglement and long-term pollution from this item as marine debris. Economic or legislative measures could be used to initiate the change of materials used in the manufacturing of six pack rings. In the USA such measures would benefit from an accompanying public awareness campaign to counter claims that the environmental impact of the product is negated by its photodegradability.

⁵⁷¹ For Those Who Use Q-Tips for Gun Cleaning...Found Some Old Style Wooden Shaft Q-Tips For Sale - AR15.Com Archive, accessed 13/1/2014, <http://www.ar15.com/archive/topic.html?b=6&f=2&t=297941>

⁵⁷² Bag It and Bin It - Don't Flush it. (UK) – MARLISCO, accessed 13/1/2014, <http://www.marlisco.eu/bag-it-and-bin-it-dont-flush-it-uk.en.html>

⁵⁷³ Environmental Protection Agency (1994), *40 CFR Part 238 Degradable Plastic Ring Carriers; Rule*

⁵⁷⁴ Ocean Conservancy (2011), *Marine Debris Report*, http://act.oceanconservancy.org/pdf/Marine_Debris_2011_Report_OC.pdf

5.5.8 Balloons

Balloon releases are popular for launching new initiatives and as a fund raising spectacle. Large numbers of helium filled balloons are released into the environment with no attempt to recover the balloons. The resulting balloon litter can easily enter the marine environment and is found to be a particular problem for ingestion by turtles (see Section 3.1.2). Various organisations are campaigning to stop balloon releases (for example The Marine Conservation Society's Don't Let Go Campaign, see Report III) and suggest alternative activities. As the debris is created at a high profile event that is usually designed to produce support and goodwill, public awareness-raising is likely to be relatively effective in stopping balloon releases although legislative measures would ensure more widespread change.

5.5.9 Monofilament Line

Boat U.S. Foundation has a campaign to recycle monofilament fishing line called "Reel In and Recycle!" This program created a network of monofilament recycling collectors so that proper disposal of monofilament is more accessible. They have many local sponsors in states of the US such as Texas, Michigan, and New Jersey who distribute recycling bins and educational materials to marinas, camps and boating access sites. The line is collected and sent to the Berkley Conservation Institute, a branch of the monofilament fishing line manufacturer Berkeley, and is incorporated along with other post-consumer materials into items such as artificial fish habitat. They have recycled 9 million miles of line since 1990.⁵⁷⁵ Florida has its own "Monofilament Recovery and Recycling Program" that functions in a similar way.⁵⁷⁶

A similar UK based campaign is the "Hold on to your Tackle" campaign from the Marine Conservation Society, which encourages local sponsors to buy, and install angling litter bins.⁵⁷⁷

5.6 Addressing Knowledge Gaps

Stakeholders relevant to filling and addressing knowledge gaps in the prevention of marine debris are as follows. Ideally, the stakeholders would be specific to reducing impacts on migratory species. Finding stakeholders that are specific to the reduction of impacts on migratory species is not easy, as this last criterion does not necessarily limit the group of stakeholders a great deal, given the wide-reaching impacts of all types of marine debris.

⁵⁷⁵ <http://www.miseagrant.umich.edu/explore/fisheries/monofilament-recycling-program/>, <http://mrrp.tamu.edu/>, <http://wetlandsinstitute.org/conservation/monofilament-recycling-station-program/>

⁵⁷⁶ <http://mrrp.myfwc.com/>

⁵⁷⁷

http://www.mcsuk.org/what_we_do/Clean+seas+and+beaches/Campaigns+and+policy/Hang+on+to+your+tackle

The key knowledge gaps around some of the interventions for the prevention of marine debris, as relevant to migratory species regard:

- Cost effectiveness;
- Effectiveness in terms of flow of marine debris; and
- Effectiveness in terms of impacts on marine species, specific to migratory species if possible.

This information would determine whether particular strategies were of more relevance to migratory species than others.

Some of these gaps are concerning general monitoring information gaps, (for which refer to section 4.2); namely regarding the flow of marine debris, and impacts on marine or migratory species. This will involve a wide range of stakeholders involved in research, whether private or public, government, NGO or consultancy based.

Indications of how relevant a strategy might be to marine species can be given by looking at the types of debris that cause most impacts on marine (migratory) species, and prioritizing strategies that specifically deal with those, for example, soft plastic film and turtles – i.e. bag bans. However given that miscellaneous plastic fragments/ingestion are some of the most common ingested items for other species, this does not enable segmentation of strategies by relevance for migratory species – they all become relevant, and a holistic approach must be taken.

Stakeholders for filling these information gaps, aside from those already considered in previous sections, will be manufacturers and processors of items, who can provide information about the costs of implementing different measures; and national governments, who will have further information about the implementation of relevant legislation.

6.0 Recommendations for CMS

In this section, the general legislative, jurisdictional and financial challenges involved in managing marine debris impacts on migratory species are considered. The potential role of the Convention in addressing these obstacles is then assessed and actions are proposed. The challenges stem primarily from the transboundary nature of both the pollution and its receptors (i.e. migratory species), as well as their enormous geographical range, which in the case of marine debris, is limitless.

In the previous sections, what is known about the types, sources, pathways and prevalences of marine debris was reviewed and the limitations of the current state of knowledge were outlined. What is known about the impacts of marine debris on migratory species, or marine species more generally where information on the former is lacking, was also presented, and gaps in the current state of knowledge were also highlighted. Management strategies, including monitoring, remediation and prevention, were also reviewed and what is known about the effectiveness of these strategies, or lack of information in this regard, was examined. In the subsequent section, steps that would be needed to fill identified knowledge gaps are described. We also consider what opportunities the Convention on Migratory Species may specifically assist in.

6.1 Jurisdictional Challenges

Both marine debris and the migratory species it affects cross jurisdictional boundaries, whether between states or out of any general jurisdictional reach such as in the 'high seas'.

For migratory species, which rely on habitats in many different range states, weak 'links' along their migratory routes cannot be afforded. As a general principle, populations of migratory species should be managed as single units, irrespective of jurisdictional boundaries.⁵⁷⁸ This is precisely the goal of multilateral international Conventions such as that on migratory species, in establishing the cooperation of range states.

Correspondingly, marine debris, regardless of its source can and will produce impacts in other jurisdictions. Marine debris travels and accumulates far from its origin; states will bear the impacts of debris which does not originate from them. There are many substantiated example of this. For example, a turtle entanglement study based in the Maldives, where fishermen do not use nets, found that nets recovered from the region are likely to arrive from India and Sri Lanka, based on distinguishing features of the items such as types of floats, labels on nets or labels on debris trapped in the nets.⁵⁷⁹ On the northern Australian coast, it was possible to identify the country of manufacture or flag state of the vessels for ~55% of nets recovered, 96% of which were not of Australian origin and which included gear originating from fisheries in Taiwan, Indonesia, Korea, Japan, and Thailand as well as from Australia.⁵⁸⁰ Co-operation on a regional basis would be appropriate to address jurisdictional challenges on this geographical scale, such as within the framework provided by RSCAPs.

However, the distance that debris travels can be far beyond the areas currently defined for regional agreements on marine matters. For example, a recent model of litter accumulation suggests that South America is the largest contributor of items (59-80% depending on the scenario) to the South Atlantic Gyre. However, the debris accumulates closer to the west coast of Africa, (estimated to contribute 17-40% of the debris). Likewise, China is modelled as being responsible for 58-66% of the debris in the North Pacific gyre, while the highest concentrations of debris in this gyre are in fact near the Central and North American coast. A similar story is told in the South Pacific Gyre, where between 53-58% of debris is predicted to come from Australia/New Zealand and South East Asia/Indonesia, while the greatest accumulation of debris is found off the west coast of South America.

⁵⁷⁸ de Klemm, C. (1994) The problem of migratory species in international law, *Green Globe Year Book International Cooperation on Environment and Development*. Oxford. Oxford University Press. UK, pp.67-77

⁵⁷⁹ Carrington, D. (2013) 'CSI turtle' launches investigation into ghost fishing nets found in the Maldives, *Guardian*

⁵⁸⁰ Gunn, R., Hardesty, B.D., and Butler, J. (2010) Tackling 'ghost nets': Local solutions to a global issue in northern Australia, *Ecological Management & Restoration*, Vol.11, No.2, pp.88-98

These last examples show that marine debris has to be tackled at a global level and a very high level of co-operation is needed to tackle this issue. It is obvious that a large number of countries are responsible for the litter in any of the world's major accumulation zones. Additionally, where marine debris has its impacts on migratory species can be outside the geographical range of any legally binding commitment on marine pollution or biodiversity involving the states that produced the debris. This is one of many reasons why it is best to tackle marine debris at source.

Therefore to solve the jurisdictional issues, agreements need to be global and action concerted, with no major gaps in the geographical coverage of the legislation. A broad overview of the geographic ranges of the most relevant agreements produced the following observations regarding jurisdictional limitations. The limitations in coverage of MARPOL Annex V or the London Convention (agreements regarding the dumping of waste by marine vessels), which have not yet been ratified by a significant number of countries, are covered in Report II.

One limitation of the Regional Seas Program relates to the release of land-based debris into the ocean. In this case, RSCAPs are unable to address marine debris or other pollution that comes from landlocked states in the form of estuarine litter, at least at source, as bar few exceptions, landlocked states are not members of a Regional Sea area. Therefore other agreements must be used to encourage these countries to commit to addressing the marine debris issue.

Most coastal states are signed up to one Regional Seas area or another, with the only major country not signed up to at least one, being Burma (with significant population, >50m, and with significant coastline). There are however other significant gaps. For example, the coastal zone of southern Brazil is an important habitat for resident and migratory animals.⁵⁸¹ It is noted that there is no Regional Sea area for this area and so no RSCAP covering it (see Figure 5).⁵⁸² Likewise the North-West Atlantic and the North-East Pacific at the higher latitudes, around North America, are not covered by specific agreements. The US is involved in other neighbouring Regional Seas agreements such as the Wider Caribbean, but it is not clear that its commitments under them are extended to all bodies of water on the US coastline. The same is true of Canada, which though involved in agreements covering areas at the poles, as there is no regional agreement relevant to most of its coastline, has no formal mechanism for co-operation with other countries in the region regarding these bodies of water.

Again, other agreements can be used to some extent to encourage some of the relevant countries to commit to addressing the marine debris issue – for example, Brazil, Uruguay and Argentina, the countries with the largest expanse of coastline on the Southwest Atlantic, have signed up to MARPOL Annex V. However, this does not address land-based sources of debris. Brazil does have a National Program of Action for the implementation of the GPA Marine (UNEP's Global Programme of Action for the

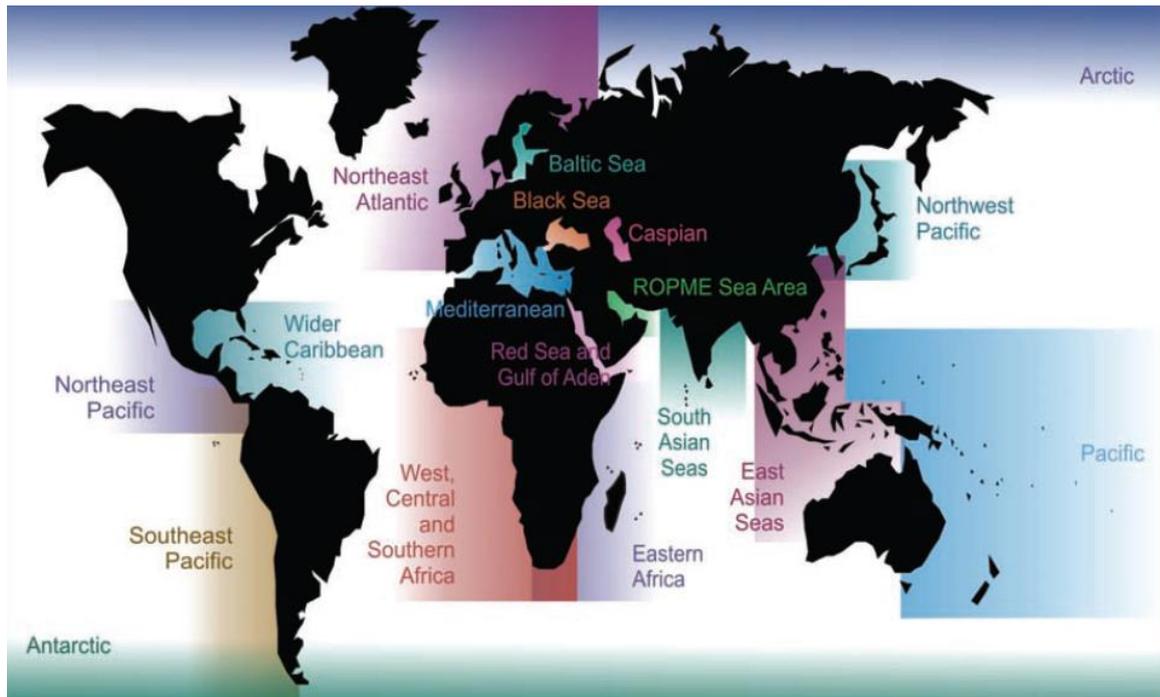
⁵⁸¹ Tourinho, P.S., Ivar do Sul, J.A., and Fillmann, G. (2010) Is marine debris ingestion still a problem for the coastal marine biota of southern Brazil?, *Marine Pollution Bulletin*, Vol.60, No.3, pp.396–401

⁵⁸² <http://www.unep.org/regionalseas/default.asp>

Protection of the Marine Environment from Land-based Activities) which potentially covers that – but this is not legally binding.

Within the Regional Seas programs, only 14 out of the 18 have set up legally binding Conventions detailing how the Regional Action Plans will be implemented. This represents further jurisdictional limitations, with the Arctic, East Asian seas, North-West Pacific and South Asian seas regions having no legally binding mechanism for co-operating on issues regarding the protection of the marine environment.

Figure 5: The Regional Seas Areas. Source: UNEP 2009



The number of Parties to the Convention on Migratory Species has increased significantly since its initial signing in 1979, to the present total of 119 countries.⁵⁸³ There are major countries which are not Parties to the Convention such as the United States, Canada, and some Latin American countries such as Mexico and Brazil. These countries are of relevance to many migratory American waders, for example. There is an independently negotiated Memorandum of Understanding between Canada, Mexico and the US but it is restricted to ducks, geese and swans. There are many more migratory waterbirds that migrate farther South and so are not covered by any agreement. Similarly, in the Far East, Russia and China are not Parties, together with many other countries in the region. 35 countries which are not Parties to the Convention have still signed Agreements or MOUs under the Convention. However the number of species covered in this way is rather limited, albeit these agreements, for

⁵⁸³ http://www.cms.int/about/part_1st.htm

nations with coastline, do include species that spend time on the coast or are fully marine, reducing the number of countries that have made no commitment of any kind regarding any migratory marine species and its habitat at all. However it may be unrealistic to expect to be able to leverage the one agreement that a country has signed up to on marine/coastal species (e.g. Russia or China and the Siberian Crane MOU) to encourage it to act on marine litter. Only around 60% of countries with coastline are Parties to the Convention, Family Agreements or MOUs with relevance to a marine species. This means that even if the Convention or Agreements were considered to constitute specific obligations regarding marine debris, alone, they probably would not have adequate coverage to deal effectively with marine debris at present.

The high seas are the areas outside countries' Exclusive Economic Zones (extending not more than 200 nautical miles from the the baselines from which the breadth of the territorial sea is measured)⁵⁸⁴ and constitute around two-thirds of the area of the ocean. However, even if all existing relevant maritime agreements were enforced, there would still be no formal recognition of the need to protect biodiversity in the high seas, legal instruments to do so, or way of enforcing them.⁵⁸⁵ The taking of catadromous and anadromous species is prohibited on the high seas by UNCLOS (Articles 66 and 67), but these are the only species this applies to and there is little scope for enforcement. Ships on the high seas are generally in the jurisdiction of the ship's flag country, with few exceptions, one being that if a boat is involved in piracy on high seas, any country can claim jurisdiction over it (UNCLOS Art 105).⁵⁸⁶ This is not the case for almost any other type of crime, yet if it were, it would increase possibilities for enforcement, for example of the UNCLOS provision described above or waste crime such as that outlawed by MARPOL Annex V or the London Convention. In terms of pollution in the high seas, there is no mechanism for making any state assume responsibility for mitigation efforts. There is no recourse regarding pollution on the high seas when there is no direct impact on the interests of a particular state. The UN General Assembly has an ad-hoc informal working group studying issues relating to the conservation of marine species in the high seas and has committed itself to address this by making a formal decision on developing an international instrument under UNCLOS.⁵⁸⁷ However whether this would be capable of addressing the pollution impacting said species, rather than only the taking of individuals, for example, remains to be seen. If it is to provide the required mechanism to make nations responsible for the impacts of their marine debris, it will have to make provision for this.

⁵⁸⁴ http://www.un.org/depts/los/convention_agreements/texts/unclos/part5.htm

⁵⁸⁵ <http://www.globaloceancommission.org/the-global-ocean/the-global-governance-gap/>

⁵⁸⁶ UN (2013) *United Nations Convention on the Law of the Sea: Chronological lists of ratifications of, accessions and successions to the Convention and the related Agreements as at 29 October 2013*, accessed 23 October 2013, http://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

⁵⁸⁷ Para 162 UNGA (2012) *The Future We Want*, A/66/L. 56

There is, however, one way in which legislation can drive reductions in marine debris even if legislation is not universally consistent. If enforcement and legislation is strong in one region, it can drive best practice for marine vessels, as ships cross the jurisdictional boundaries and will need to comply with the most stringent legislation they are likely to encounter. However this principle does/would not apply to agreements concerning land-based sources of waste, existing pollution in the ocean, or marine species.

6.2 Legislative Challenges

The discussion on jurisdictional challenges introduced the main legally binding instruments applicable to marine litter and/or migratory species at global and regional levels. There is plenty of scope under these existing multilateral agreements for dealing with marine debris. It is a major gap in the legislation that there is no specific, legally binding global agreement for the tackling of marine debris sourced from land-based activities. Therefore it is significant that the Regional Seas Conventions and Action Plans (RSCAPs) have the potential to address both land and at-sea sources of debris. The London Convention and MARPOL Annex V are the global conventions with most specific relevance to debris produced at sea. There may also be opportunities within the Convention on Migratory Species to encourage more specific action on marine debris, whether from land or at sea activities.

At present, these agreements tend to suffer from one or both of the following limitations regarding marine debris:

- Either they have little specific content regarding marine debris; and/or
- There is no mechanism for enforcing them.

There are also very few specific legal instruments dealing with marine litter at the national level.⁵⁸⁸ This exacerbates issues with enforcement.

The Regional Seas programme generally involves the establishment of a National Action Plan, then the ratification of a legally binding Convention. These tend to include general statements regarding the protection of the marine environment from pollution. The Convention acts as a framework through which further legally binding Protocols with more specific provisions for different issues can then be made. Some of the Regional Seas have such Protocols that are relevant to at least some fractions of the marine debris problem. For example, seven Regional Seas areas have established Protocols on Pollution from Land-based Sources and Activities. Some of them are not fully ratified by all countries in the Regional Seas areas and not in force. Two have protocols on dumping, though one is specifically from ships and aircraft (Mediterranean). Two of the Regional Seas areas have (non-legally binding) Action Plans to address pollution from land-based activities.

⁵⁸⁸ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

As part of UNEP's GPA Marine (the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities), at least 72 nations have created National Programs of Action (considered the 'backbone' of GPA-Marine implementation),⁵⁸⁹ but these are of course, not legally binding. The North-West Pacific Regional Sea area, to our knowledge, is alone in having a specific "Regional Action Plan on Marine Litter", which should in theory cover all sources of debris. The North-East Atlantic region will develop one in 2014.⁵⁹⁰ This region has also made a recommendation on the development of fishing for litter initiatives as a way of raising awareness and changing behaviour regarding waste in the fishing industry, and directly removing waste.⁵⁹¹

So there are a few specific pieces of legislation and agreements on marine debris, but taking these things all together, it is obvious that there is a considerable way to go in fully elaborating the available legislation to give good, legally binding global coverage on the marine debris issue.

There is some scope within the Regional Seas Program for agreements based on the conservation of species. For example, The Mediterranean has a "Strategic Action Programme for the Conservation of Biological Diversity", adopted in 2003. OSPAR has made several (non-legally binding) "Recommendations" for conservation of particular species, however the recommendations have been completed for only 27 out of 57 species that are considered in need of protection. Additionally there is little explicit mention of marine debris in the supporting documentation for the recommendations, with the exception of those for leatherback and loggerhead turtles.⁵⁹²

In the Convention on Migratory Species, there is the general statement that all Parties:

"shall endeavour to provide immediate protection for migratory species included in Appendix I" (Article II Para 3b)

This may be considered too general to include all sources of pollution that adversely affect migratory species, especially given how difficult it is to demonstrate population level effects of marine debris. More specific obligations are made in Article III where it states that relevant Parties must endeavour:

"a) to conserve and, where feasible and appropriate, restore those habitats of the species which are of importance in removing the species from danger of extinction;

⁵⁸⁹ UNEP (2012) Progress in Implementing the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities at the National Level, UNEP/GPA/IGR.3/INF/3/Rev.1 (2012)

⁵⁹⁰ http://www.ospar.org/content/news_detail.asp?menu=00600725000000_000021_000000

⁵⁹¹ OSPAR (2010) *Quality Status Report 2010*, 2010, http://qsr2010.ospar.org/en/media/chapter_pdf/QSR_complete_EN.pdf

⁵⁹² http://www.ospar.org/content/news_detail.asp?menu=00600725000000_000022_000000

b) to prevent, remove, compensate for or minimize, as appropriate, the adverse effects of activities or obstacles that seriously impede or prevent the migration of the species;"

These obligations are limited to range states, but it is likely that, as most Parties to the Convention are coastal states, they are all range states for one marine migratory species or another, and so addressing marine debris may well be within the remit of this provision for most of the Parties. The legally binding Agreements that the Convention recommends be made for species in Appendix II suggest similar obligations and furthermore provision for

"prevention, reduction or control of the release into the habitat of the migratory species of substances harmful to that migratory species"

An analysis of the relevant marine Agreements was carried out to ascertain if they do in fact have this provision.

ACAP contains several general references to the obligation (within a certain frame of reference) to conserve marine habitats. It is only in the annexed Action Plan, which the Parties are bound to 'implement progressively' that makes reference to pollution:

"Annex 2, 2.3.1 The Parties shall endeavour individually and collectively to manage marine habitats so as to:

...b) avoid pollution that may harm albatrosses and petrels."

ACCOBAMS, similarly makes a general commitment to "protect habitats"; and again it is in the Conservation Plan, which Parties undertake to implement in so far as is feasible, that explicit mention is made of pollutants:

"Annex 2, 1d) [Parties shall] "Regulate the discharge at sea of, and adopt within the framework of other appropriate legal instruments stricter standards for, pollutants believed to have adverse effects on cetaceans"

The relevant provision made by the ASCOBANS Agreement is found in the annexed Conservation and Management Plan, which states that Parties should:

"Work towards (a) the prevention of the release of substances which are a potential threat to the health of the animals,"

The Wadden Sea Seals Agreement requires that the Parties

"Art VII,2. The Parties shall preserve habitats and seals present from undue disturbances or changes resulting, directly or indirectly, from human activities";

and makes specific reference to pollution in Article VIII

"The Wadden Sea States are determined to do their utmost to further reduce pollution of the North Sea from whatever source with the aim of conserving and protecting the Agreement Area. To this end they shall a) endeavour to identify the sources of such pollution;"

AEWA's Action Plan contains explicit mention of pollution in section 3.3:

“Parties shall endeavour to rehabilitate or restore, where feasible and appropriate... areas that suffer degradation as a result of the impacts of factors such as climate change, hydrological change, agriculture, spread of aquatic invasive non - native species, natural succession, uncontrolled fires, unsustainable use, eutrophication and pollution .

Unusually, specific mention of solid wastes is made:

“4.3.9 Parties shall establish and effectively enforce adequate statutory pollution controls in accordance with international norms and legal agreements, particularly as related to oil spills, discharge and dumping of solid wastes, for the purpose of minimizing their impacts on the populations listed in Table 1 “

It is important to establish that the above provisions, individually or together, are considered to constitute an obligation to act upon marine debris. This would strengthen the case for action on marine debris and migratory species for many nations.

Significantly for the filling of information gaps, all of these agreements also have some kind of wording to the effect that Parties should undertake research and monitoring on populations, and/or identify threats to the relevant species, sometimes specifically stating as regards current or potential threats of pollution.

MARPOL Annex V and the London Convention, which deal with at-sea sources of debris, are very explicit with regard to their limitations or prohibition of the disposal of waste at sea. However, they do not cover all sizes of vessels, are not ratified by as many countries as would be desired and their enforcement is lacking. Perhaps it is also considered that their focus is more on intentional discarding of waste and not unintentional discarding of waste, which may play a part in the generation of a significant proportion of marine debris. The limitations of these agreements are dealt with in detail in Report II.

6.3 Financial Challenges

Globally, inadequate funding is a problem for even basic waste management infrastructure - hence the particular importance of economic incentives when considering the management of marine debris. However these will not be able to contribute towards funding monitoring and the filling of information gaps. Neither will they help fund the negotiation and administration of international agreements, field projects, or the implementation of legislation and enforcement.

Regarding international agreements, part of the cost is incurred simply by administration such as the creation of a secretariat or regular meetings. The remainder of costs are incurred by field projects. In the case of CMS, mandatory contributions are collected from Parties to the Convention and Signatories of Agreements. This ‘core funding’ provides for most administrative costs. For some CMS agreements, the CMS Secretariat also functions as the Secretariat of the agreement (e.g. ASCOBANS). Sometimes finance and personnel are donated in part

or in full by a Party state. So for example, range states host the secretariat of some agreements (e.g. Wadden Sea Agreement (Germany). NGOs also sometimes donate staff time. In a few cases, voluntary contributions by Parties may also contribute to staffing costs (e.g. AEWA). In 2009, mandatory contributions for the Convention were around \$1.9m and for the Agreements, \$1.5m. At present, there is a feeling that current funding allows for the maintenance of the status quo, but not for establishing and administering new Agreements.⁵⁹³ Important information databases have not been able to be maintained by CMS because of lack of funding, such as GROMS, the database on migratory species, and the System of Online National Reporting (SONAR), a system of online reporting for range states on migratory species has incurred many delays owing to funding difficulties. Several Agreements have not achieved everything in their work plan due to a lack of funding. Voluntary funding is by nature uncertain. This may be a constraint on the establishment of dedicated strands within Family Agreements or Action Plans on marine debris, or further development of specific CMS Initiatives concerned with marine debris (for example the appointment of designated personnel and establishment of a working group) .

Voluntary contributions are generally for specific conservation projects that are part of CMS's work programme, for organizing meetings and new agreement development and for publishing. Voluntary contributions come from money or donations in kind pledged by states, institutions (including UNEP and NGOs) or the private sector. In 2009 voluntary contributions were around \$0.2m and \$0.3m respectively. Voluntary contributors have shown a preference towards supporting specific time limited projects or meetings rather than longer term activities or those of an operational nature, therefore there are difficulties in planning for the future.

A similar story unfolds for a relevant environmental agreement, the Convention on Biological Diversity (CBD). Within the Convention, Articles 20 and 21 make provision for a funding mechanism for the implementation of the Convention by developing country Parties, whereby Parties make predictable, adequate and timely contributions in accordance with the amount of resources needed, to be decided periodically by the Conference of the Parties.⁵⁹⁴ These consist of both mandatory and voluntary contributions.⁵⁹⁵ Contributions presently amount to tens of millions of dollars per year, as a rule. Globally, national budgetary support to biodiversity and ecosystem services is estimated to be between \$15-\$45 billion per year. A sum of \$60-\$150 billion per year that has been estimated necessary for the implementation of national biodiversity strategies and action plans.⁵⁹⁶

⁵⁹³ Lee, R., Filgueira, B., Caddell, R., and Frater, L. (2010) *Review of the current organization and activities of CMS and the CMS family. First step of the Inter-Sessional Future Shape Process*, 2010, http://www.cms.int/bodies/future_shape/future_shape_review.pdf

⁵⁹⁴ United Nations (1992) *Convention on Biological Diversity*

⁵⁹⁵ <http://www.cbd.int/convention/parties/contributions.shtml#tab=0>

⁵⁹⁶ CBD (2012) *State of Financing For Biodiversity: Draft Global Monitoring Report 2012 on the Strategy for Resource Mobilization under the Convention*. UNEP/CBD/COP/11/INF/16

For taking action on marine debris, which will take sustained concerted effort, the contributions possible via these international agreements are at most likely to be strategic. Accessing sustained funding is one of the greatest conservation challenges, and the same is true where this involves addressing marine debris.

Regarding the funding of addressing marine litter on a wider scale, here we examine briefly the funding of the implementation of UNEP's GPA for the Protection of the Marine Environment from Land-based Activities. At the first intergovernmental review of the GPA-Marine, the Montreal Declaration on the Protection of the Marine Environment from Land-based Activities, was adopted; aside from the general pledge to further the aims of the GPA-Marine, it also promised to "identify new and additional financial resources to accelerate GPA implementation by building capacity for effective partnerships among governments, industry, civil society, international organizations and financial institutions, and by making better use of domestic and international resources." Domestic financing is intended to be the main source of financing for the GPA⁵⁹⁷ and a variety of sources of funding have been suggested, from water service pricing and tax and subsidy reform, water funds, water markets, pollution trading and pollution permits; national development program budgets and major financial institution's work programs' budgets; debt relief, ODA, the removal of environmentally destructive subsidies including agricultural subsidies; instruments using the polluter pays principle; tourism tax; and it was pointed out that engagement with stakeholders was essential for mobilizing resources. UNEP has recommended that regional programmes for marine litter should be incorporated into national budgets to support implementation and participation.⁵⁹⁸ Some countries in the Americas receive Inter-American Development Bank support for their integrated coastal zone management programmes.⁵⁹⁹ Subsequent meetings appear to have resulted in little more than urging for the provision of adequate voluntary financial resources and encouragement to employ market-based instruments to support solid waste minimization and management.

It is recognized that enforcement is an important part of the implementation of legislation regarding marine litter – for example, "building capacity to monitor and enforce compliance regarding litter, dumping, solid waste management, storm water and surface runoff", is a strategy included in GPA Marine's Programme of Work for 2012-2016. Part of the enforcement challenge is practical – monitoring individual vessels on the high seas or much of the EEZs to see whether they are producing marine debris – would require an unreasonable investment of resource. However, there are examples where enforcement is feasible with adequate funding, such as, inspection of ships and waste management plans, logs and facilities, or inspection of port reception facilities. These are not adequately funded. There needs to be enough

⁵⁹⁷ <http://www.iisd.ca/sd/gpa/sdvol65num5.html>

⁵⁹⁸ UNEP (2009) *Marine Litter - A Global Challenge*, 2009

⁵⁹⁹ UNEP (2012) *Progress in Implementing the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities at the National Level*, UNEP/GPA/IGR.3/INF/3/Rev.1 (2012)

personnel, with adequate training. Additionally, political support for their enforcement efforts is necessary, and awareness-raising is important to bring this about (for which funding is also needed).

6.4 Recommendations

6.4.1 Opportunities for CMS Engagement

Opportunities for CMS to engage with these challenges have been identified below. Consideration of funding issues both within and outside CMS is subsequently discussed in Section 6.4.2.

The core role of CMS is to support international collaboration. This is ideal considering the multi-jurisdictional challenges of managing marine debris impacts on migratory species. More simply, marine debris is a shared problem requiring a shared response. The more countries CMS can include under its umbrella, the better its coordinating role can be.

Its main potential for influence is on Parties to the Convention or Signatories of Family Agreements and Memoranda of Understanding, (just under half of which are relevant to marine migratory species). The Convention itself has specific provisions for habitat conservation and reduction of impacts of activities that endanger species or impede migration. These commitments can be seen as highly relevant to the management of marine debris, and CMS can use its coordinating role to remind Parties of their commitments under the Convention.

As outlined above, one of the legislative challenges is that there may not be specific enough reference to marine debris within these agreements. Therefore making more specific reference to marine debris in existing agreements and Action Plans should be considered.

CMS Resolution 9.2 (2008) indicates that future agreements that should be developed with relevance to marine species (in a very broad sense) are Sturgeons, Marine Turtles – Pacific Islands, Cetaceans in the Indian Ocean and South-East Asia, Central Asian Flyway, the East-Asian Australasian Flyway, the Pacific Flyway, and the American Flyways. There is the potential to make specific reference to particular threats, such as marine debris in these agreements.

Some CMS Initiatives already exist that are themed by threat rather than species group (e.g. climate change, bycatch); pursuant to Resolutions passed upon the respective issues, a Councillor was appointed by the Conference of the Parties for each issue. The Appointed Councillor sits on the Scientific Council and there are associated thematic Working Groups for the themes. A similar initiative could be launched that is marine debris themed, with a nominated members and a dedicated workstream. This may have the advantage of not duplicating effort across all the Family Agreements; it is nevertheless desirable that the Family Agreements are aligned on this issue.

The CMS could use appropriate meetings or publications to encourage countries to ratify other relevant conventions such as MARPOL and the London Convention as a

way of beginning to address their commitments on marine debris under the Convention on Migratory Species.

It could also encourage its Parties and Signatories to engage with other global marine debris initiatives, such as those being co-ordinated by UNEP, for the same reason – i.e. as a way of addressing their commitments on marine debris under the Convention on Migratory Species. These are many and include:

- GPA-Marine – including completion of GPA-Marine National Plans of Action, and to ensure these have specific mention of marine debris,
- Regional Seas Programme – including conclusion of specific Protocols on protection of the marine environment from land-based activities, and completion of Regional Action Plans either containing specific mention of marine debris, or completion of a specific Action Plan exclusively on marine debris,
- Participation in the Global Partnership on Marine Litter (GPML),
- Participation in the Global Partnership on Waste Management (GPWM)
- Adoption of the Honolulu Commitment and putting Honolulu Strategy into action

There are also specific actions which CMS could encourage its parties to undertake by way of meeting its obligations on marine debris under the Convention, such as:

- Implementing deposit-refund schemes;
- Implementing levies on single-use carrier bags; and
- Creating obligations for the use of reusable items at events.

- If examples of best practice in public awareness campaigns on marine debris can be successfully identified, CMS can encourage Parties to engage in marine debris campaigning. As there are few examples of campaigns specifically with relevance to migratory species CMS might co-ordinate or encourage the creation of some, and/or give its endorsement to appropriate campaigns. CMS might also consider giving endorsement to more general campaigns where it considers it appropriate (e.g. IOSEA could endorse plastic bag specific campaigns, given the evidence suggesting that soft plastic film particularly impacts turtles, for example), which would reinforce the link between marine debris and the vulnerabilities of migratory species in the minds of different stakeholders.

Co-operation with other Biodiversity related agreements. There are few groups of marine organisms that are not impacted negatively by marine debris. So as not to duplicate effort, perhaps an inter-Convention working group can agree an approach to encourage signatories to take action on marine debris. A Secretariat report highlighted how CMS might integrate some of its work with the Convention on Biological Diversity. It suggested that national CMS Focal Points establish contact with CBD Focal Points and work together to ensure migratory species and threats to them

are taken into account in National Biodiversity Strategy and Action Plans (NBSAPs), which are the tool for action on biodiversity developed by CBD.⁶⁰⁰

Engagement with as wide a range of stakeholder groups as possible. For action on marine debris, co-operation between specific sectors, such as fishing, shipping, tourism, diving, local authorities etc. is very important. The private sector and civil society must also be involved. CMS is already involved with a number of NGOs and special interest groups. If it can continue to expand this network so that it includes as great a variety of stakeholders as possible, then it will have an ideal audience for its marine debris themed work. Perhaps small field projects could be dedicated to engaging with new stakeholders, with priority given to those that have most relevance or contact with migratory species. This will also have knock-on effect for financing, as it is held that stakeholder engagement is important for the mobilization of resources from those stakeholders.

Finally, the Convention can play a role in the following important tactic in the fight against marine debris. Stakeholders must be informed that marine debris is important and needs to be dealt with. The foundation for this is good information, but it can be argued that there is sufficient information available to make the case for action clear. Policy makers especially have to be made aware of the marine debris issue so that marine debris management is included in relevant legislation, that funding is provided for it and that there is a mandate for enforcement. All of the Convention's actions on marine debris will contribute to this awareness raising and it should take advantage of all the fora it participates in to draw attention to the issue.

6.4.2 Funding

As discussed in Section 6.3, funding for marine debris management can come from a variety of sources, from national budgets, to development banks, to economic instruments used to change behaviour, to any funds generated by the application of the 'polluter pays' principle. Innovative financial mechanisms are advocated in many quarters and this is an area of ongoing work.

It may be worth bearing in mind facts such as that clean-up campaigns are expensive relative to prevention in terms of the direct impact they can have on marine debris. They are excellent awareness raising initiatives and may reduce some of the impacts of coastal marine debris if sustained and frequent. However they may be easier to fund because they can be run as discreet, time-limited projects. Educational awareness campaigns generally have the same advantage.

Funded by voluntary contributions, CMS and some of its Family Agreements (e.g. AEWA) have a small grants program. In 2012, twelve projects were funded via CMS. For the 2013-2014 around €75,000 is available and each project may apply for up to €15,000. These are small amounts of money compared to the scale of the challenges

⁶⁰⁰ CMS (2011) Guidelines on the Integration of Migratory Species into National Biodiversity Strategies and Action Plans (NBSAPs). UNEP/CMS/Conf.10.27, <http://www.cms.int/en/education/capacity-building/nbsaps>

faced by migratory species due to marine debris, however, they may be helpful for small strategic projects.

It has been suggested that the Convention on Migratory Species and Range States could prepare projects to submit to utilize the funds held for the purposes of the CBD.⁶⁰¹ As outlined in 'financial challenges' this is unlikely to be a source of adequate sustained funding, but may be suitable for smaller field projects. There is currently a great deal of discussion and negotiation ongoing regarding how to mobilize resources for the achievement of the objectives of the CBD. Their 2012 report categorizes the following funding or resource opportunities:

- Official Development Assistance (ODA);
- Domestic budgets at all levels;
- Private sector;
- Non-governmental organizations, foundations, and academia;
- International financial institutions;
- United Nations organizations, funds and programmes;
- Non-ODA public funding;
- South-South cooperation initiatives;
- Technical cooperation

In 2006, CBD published a guide to funding sources.⁶⁰² In it there are really only two organizations that seem orientated towards marine issues, The Pew Charitable Trusts⁶⁰³ and the Institute of Marine Research;⁶⁰⁴ however there are plenty of organizations listed that deal with conservation across the globe.

Research projects, even where considered vital for the state of knowledge of a CMS Family Agreement, have been deemed "highly cost-prohibitive".⁶⁰⁵ Many monitoring and research programs are carried out with the help of volunteers, whether monitoring of animals (e.g. the international network of partners producing the Global

⁶⁰¹ de Klemm, C. (1994) The problem of migratory species in international law, *Green Globe Year Book International Cooperation on Environment and Development*. Oxford. Oxford University Press. UK, pp.67-77

⁶⁰² CBD (2006) *Catalogue of Funding Sources*, 2006, <http://www.cbd.int/doc/guidelines/fin-sources.pdf>

⁶⁰³ http://www.pewtrusts.org/our_work_category.aspx?id=126

⁶⁰⁴ <http://www.imr.no>

⁶⁰⁵ Lee, R., Filgueira, B., Caddell, R., and Frater, L. (2010) *Review of the current organization and activities of CMS and the CMS family. First step of the Inter-Sessional Future Shape Process*, 2010, http://www.cms.int/bodies/future_shape/future_shape_review.pdf

Wild Bird Index relies heavily on volunteers to produce the data),⁶⁰⁶ or monitoring of marine debris (e.g. the Ocean Conservancy's International Coastal Cleanup is conducted entirely by volunteers). This has been effective, in the absence of funding from other sources. By associating marine debris monitoring with other oceanographic surveys, savings can be made. These can also be supported by the participation of volunteers (e.g. the Seas Education Association (SEA) used 7,000 volunteers (undergraduate students) in their monitoring program).⁶⁰⁷

There may be other sources of significant funding for research and field projects, such as the Global Environment Facility (GEF), which is the largest public funder of projects to improve the global environment. It funds large scale projects – over 20 years it has channelled \$15 billion dollars of funding.⁶⁰⁸ It also has a small grants programme that gives directly to civil society and community based organisations.⁶⁰⁹ The issue of marine debris spans multiple focal areas of their funding programme such as Biodiversity, International Waters and Persistent Organic Pollutants. The Scientific and Technical Advisory Panel for GEF has recommended that it focus its support on pilot projects testing the life-cycle approach to plastic debris prevention, reduction and management in one of the Regional Seas areas; and by helping to establish private-public partnerships on reducing the environmental impacts of single-use plastics by transforming their use and utilization.⁶¹⁰

The World Bank's 'Global Partnership for Oceans' hopes to raise \$300m of 'catalytic finance' plus \$1.2 billion of investment for the protection of the marine environment. When funds are available, they may be appropriate for funding research on or mitigation of marine debris.

There are also regional research funding programs that can be approached, such as the EU's FP7 (Framework Programme for Research 7). The latter, for example, funded the EU CleanSea multidisciplinary research project that is a collaboration of four universities, five research institutes, six small to medium enterprises and a network of coastal local authorities (KIMO). The purpose of the research project is to answer questions regarding the monitoring and management of marine debris. Not every world region has such funding programmes, but there are several examples such as the Australian National Competitive Grants Program, the US National Research Council, and the National Natural Science Fund of China.

⁶⁰⁶ <http://www.ebcc.info/index.php?ID=516#1.1%20Counting%20birds>,
<http://www.bipindicators.net/WBI>

⁶⁰⁷ Law, K.L., Morét-Ferguson, S., Maximenko, N.A., Proskurowski, G., Peacock, E.E., Hafner, J., and Reddy, C.M. (2010) Plastic Accumulation in the North Atlantic Subtropical Gyre, *Science*, Vol.329, No.5996, pp.1185–1188

⁶⁰⁸ http://www.thegef.org/gef/trust_funds

⁶⁰⁹ <https://sgp.undp.org/>

⁶¹⁰ STAP/GEF (2011) Marine Debris as a Global Environmental Problem: Introducing a Solutions Based Framework Focused on Plastic

For species that are commercially exploited, such as migratory waterfowl that are hunted, there are examples of conservation efforts being funded by stakeholders involved in commercial exploitation – for example a large pro-hunting NGO, Ducks Unlimited, collects contributions from its members and acquires and manages wetland habitat in Canada, Mexico and the United States. This can be contrasted however with the management of fishing stock, where stakeholders have been slow to take up any responsibility for safeguarding the habitats of relevant species, such as inshore spawning or nursery areas, and fishing treaties do not provide for protection of habitats; therefore it is not a foregone conclusion that this strategy can be successful. Anglers and amateur fishermen comprise an economic sector that is the same size as the commercial fishing sector in the UK, and this provides an example of a large stakeholder group regarding the issue of marine debris that has not been managed successfully, yet could be in the future.⁶¹¹ There is traditionally a division between agreements on commercial and non-commercially exploited species; hence there are almost no commercially exploited species within the remit of the Convention on Migratory Species.⁶¹² However, when it comes to marine debris, private sector groups or stakeholders in the marine environment generally can still appreciate that it is in their interest to co-operate on this issues. Stakeholder groups of this kind can be a significant source of funding.

6.5 Filling in Knowledge Gaps

In this section, steps needed to fill in knowledge gaps are considered. However, it is also important to bear in mind that there will be a limit to how much information can be feasibly obtained given the resources that would be required. The case is made that this need not be a barrier to action.

6.5.1 Information on Marine Debris Sources, Pathways and Types

The considerable and very general gaps regarding the abundance, composition and distribution of debris will require a coordinated effort that is rather beyond the scope of the immediate interests of the Convention on Migratory Species. If better information about the amount and distribution of marine debris is required, this will require investment in monitoring programs globally. Methodologies should be standardized, so that better regional distinctions can be made, which may have relevance for the targeting of actions regarding migratory species. An important step forward has been the publishing of guidelines on Survey and Monitoring of Marine Litter published by UNEP/IOC, which can serve as a template for the standardization

⁶¹¹ Monbiot (2014) Anglers are Our Allies Against Unsustainable Industrial Fishing, *The Guardian* 24/01/2014
<http://www.theguardian.com/environment/georgemonbiot/2014/jan/24/anglers-sport-fishers-fishing-george-monbiot>

⁶¹² de Klemm, C. (1994) The problem of migratory species in international law, *Green Globe Year Book International Cooperation on Environment and Development*. Oxford. Oxford University Press. UK, pp.67–77

of monitoring worldwide.⁶¹³ This covers both sampling method and the categorization of items by object and by material. It also allows for subdivision of recommended litter codes with further finer distinction if required, and also has ‘other’ categories. This means the methodology has some flexibility, which allows for more specific information to be obtained if deemed relevant, and avoids bias against non-listed types. It is recommended that both counts and weights (where possible) be recorded; which gives most flexibility for trying to assess absolute quantities and making regional comparisons. It also covers different marine compartments, such as beach litter monitoring, benthic monitoring and surface litter monitoring.

In terms of providing information regarding sources, the guidelines suggest that this is a key question for the surveys to answer; and should be done by relating item types to sources where possible (“indicator items”). However, it does not go into very much detail as to how to define these relationships. The guidelines suggest that a relational database could provide lookup tables to re-aggregate litter types to support different analyses, such as the analysis of debris type by source.

Additionally, the guidelines recommend the compilation of a site characterization data sheet which contains information on proximity to likely litter sources, such as the direction and distance of the nearest town, nearest river, whether there is input from pipes or drains, whether the area can be classified as urban or rural etc. This would help to inform the relationship defined for particular item types, by looking at the relationship between proximity to these sources and litter composition.

It is important to note that the methodology in these guidelines does not consider microplastics, as it was considered that its monitoring is technically demanding and requires specialist equipment and training. However it is important that the knowledge gaps in this regard are filled. There is a working group that has been convened for the purpose of studying microplastics (GESAMP Working Group 40). A consensus definition of microplastics should also be reached.

It will be very difficult to fill knowledge gaps related to pathway or vector, although an approach based on a relational database was covered in Section 2.1.2, so it is possible to carry out some analysis of the issue in this way. Other approaches would have to be individually tailored to the local area and carried out on point sources of concern, such as different parts of the waterways with (e.g., estuarine monitoring). Currently this is not a feature of the UNEP/IOC guidelines, but the development of other litter monitoring indicators is possible and should be undertaken. Estuarine systems are important habitats for many migratory species, and better data in this regard could be useful for prioritizing management approaches.

UNEP (2009) suggested that databases be established at the national level and a clearinghouse for information at the regional and global levels.⁶¹⁴ It also pointed out the need for regular publishing of this data on the status and trends of marine debris. It will be helpful for CMS to have access to good data on marine debris if it is to make

⁶¹³ UNEP (2009) *UNEP/IOC Guidelines on Survey and Monitoring of Marine Litter*, 2009

⁶¹⁴ UNEP (2009) *Marine Litter - A Global Challenge*, 2009

decisions about its strategy for mitigating its effects on migratory species and these steps would make this possible. Perhaps the Global Partnership on Marine Litter's online platform could be a home for this sort of database.

6.5.2 Information on Impacts

In the UNEP/IOC guidelines for monitoring marine debris, one of the objectives of monitoring is stated as answering the question "Is there a threat to marine biota and ecosystems?" There are two different ways in which this can be done. Firstly, it recommends that all methodologies should record entanglements and include them in the additional notes section, and additional guidance should outline reporting requirements with respect to animal type, tangle type and status (alive or dead). Secondly, it suggests that indicator items that are considered to present specific risks to wildlife such as looped materials, discarded fishing nets or plastic bags, be defined. The data could then be aggregated, using a relational database, to allow monitoring and analysis based on, for example, risks to wildlife of different kinds such as entanglement or ingestion. It is also significant that the recommendations suggest that both debris counts and weights be recorded, which is important with regard to any subsequent mapping onto potential impacts, because sometimes impact will be more related to count (e.g. plastic bags) than weight and vice versa (e.g. fishing nets).

Not all impact monitoring can be carried out, however, by debris surveys. Co-operation should be encouraged between natural resource agencies, academics conducting field research and conservation groups, to help obtain data and collate existing and future information on wildlife entanglements etc. and habitat impacts from marine debris. Standardization of methods, centralised databases and curation, would all be important steps to undertake to ensure that data is comparable between regions, and provide the right presentation of information to give a chance of filling information gaps such as population level effects. Methods for estimating total mortality based on sampling of stranded individuals or sampling that does allow total mortality to be modelled should be pursued. Standardization of the recording of the material and item type causing the impact is important if it is to be compared with data regarding ambient debris, and targeted approaches attempted. It is important that the whole variety of impacts be considered, whether entanglement, ingestion, toxicological or habitat related.

There are many unanswered questions regarding the specific vulnerability of migratory species, such as, vulnerability according to life history traits and behaviours i.e. migratory vs. non-migratory, migration style, feeding behaviour, physiology, higher taxa belonging to. These are all interesting and valid research questions; however it is perhaps not necessary to understand these fully to understand that the impacts on migratory species are likely to be as great if not greater than those on marine species generally. Therefore it is not necessary to wait for this data before taking action which is known to be effective to combat marine debris.

6.5.3 Information on Management Strategies

One problem when making strategic decisions about which management strategies to invest in is that the strategies are sometimes specific to a particular source, yet the

data regarding source of debris is generally poor and/or incomplete. However improved monitoring will help, and we already do have a reasonably good idea that in many places, land based debris is predominant. Therefore action can be taken with reasonable certainty that targeting that type of debris will be having a significant effect.

There are big gaps however in the evaluation of the effectiveness of these programs. Cost-effectiveness and impact on debris amounts and effects on impacts on wildlife all need better monitoring.

Regarding cost-effectiveness, appropriate record keeping and communication would be a start. Regarding the impact on the amount of debris, monitoring debris by weight is a good foundation, as per the UNEP/IOC guidelines. This will help estimates of flow into the sea and the estimation of abundance of debris in the sea. Only then can the relative effectiveness of management strategies be estimated. Regarding impacts on wildlife, it is important that methodologies first be standardized (as mentioned above).

However, based on the information available, it is likely that prevention is more effective in all senses than removal. Unless the removal strategies can clearly be shown to be having an indirect preventative effect through increasing awareness or providing infrastructure for disposal, or to be having a demonstrable effect on improving impacts on wildlife, preventative measures should be prioritized.

6.5.3.1 Targeted Approaches

It is worth considering whether targeted approaches can be helpful when addressing the impacts of marine debris on marine species. The rationale here is to direct limited resources to places where they would have most impact. The relevant evidence is mixed. The benefits of such an approach will probably differ depending on species, specific impact, associated debris type, migratory habit and management strategy. Definitely answering this question would take a considerable amount of research in itself, and if it was decided it could be of benefit, would require the integration of several different datasets, i.e.

- The distribution and migration paths of the species;
- The spatial distribution of the debris; and
- Information on debris related impacts.

The development of such a model for planning debris management strategies would be a further research project in itself. There are databases that contain some of the necessary elements and these could be leveraged (for example, the Red List allows the designation of marine debris as a threat and could be a repository for more specific information on this threat; it also has geographic range information. GROMs has information on migratory pathways. GBIF is a platform for the exchange of biodiversity related information). Information on the distribution of marine debris is probably not at a high enough resolution to make it particularly informative. Also, as most information currently relates to composition alone, this does not enable comparison of relative threat, for which abundance data is needed. In theory, a model

such as that made by Lebreton *et al.* (2012) could be used to provide this type of information.⁶¹⁵

Examples of targeted approaches to conservation issues are:

- The designation of ‘Important Bird Areas’ (IBAs) by Birdlife International. These are breeding or staging areas deemed particularly important for birds where >1% of the global population congregate, and includes migratory birds. Marine (at-sea) IBAs are also currently being identified worldwide. They do not have any legal status but can be used as priority lists for the designation of protected areas by multi-lateral environmental agreements such as the Ramsar Convention.
- A model of the distribution of marine mammals estimated that 2.5% of marine areas need be protected to protect 84% of the world’s marine mammal species.⁶¹⁶

However, BirdLife’s assessment of the use of IBAs in directing management of the competition between birds and fisheries is informative also for the marine debris issue:

*“Bycatch mitigation needs to occur across ocean basins if conservation gains are to be made, mitigation only in marine IBAs is not likely to achieve this,”*⁶¹⁷

Like overfishing, marine debris is a threat that extends across boundaries, and generally will have to be addressed on a wide scale if conservation gains are to be made at a local scale.

It is tempting to consider that removal strategies may be effective at local levels – for example, the clearing of debris from haul-out sites where seals breed. However, data on Hawaiian Monk Seals (*Monachus schauinslandii*) in the northwestern Hawaiian Islands over a period of 16 years, showed that despite the implementation of MARPOL Annex V, and yearly clearance of the islands of entangling debris, the amount of debris was not altered and the incidence of entanglement did not go down.⁶¹⁸ Additionally, the seals that suffered most entanglement were not the ones on the island with most debris, suggesting they were encountering debris in a different local area, perhaps at sea. This demonstrates how high the spatial resolution would need to be to successfully identify areas of high risk for wildlife in the first place; and also that yearly clear-ups may make no impact locally.

⁶¹⁵ Lebreton, L.C.-M., Greer, S.D., and Borrero, J.C. (2012) Numerical modelling of floating debris in the world’s oceans, *Marine Pollution Bulletin*, Vol.64, No.3, pp.653–661

⁶¹⁶ Pompa, S., Ehrlich, P.R., and Ceballos, G. (2011) Global distribution and conservation of marine mammals, *Proceedings of the National Academy of Sciences*, p.201101525

⁶¹⁷ <http://www.birdlife.org/datazone/info/marfaqs>

⁶¹⁸ Henderson, J.R. (2001) A Pre- and Post-MARPOL Annex V Summary of Hawaiian Monk Seal Entanglements and Marine Debris Accumulation in the Northwestern Hawaiian Islands, 1982–1998, *Marine Pollution Bulletin*, Vol.42, No.7, pp.584–589

A study that mapped marine floating debris and 11 species of marine mammal using extensive modelling off the coast of British Columbia, Canada, found that areas of overlap were often far removed from urban centres, suggesting that the extent of interactions would be underestimated by coastal sightings and stranding records and beach litter monitoring.⁶¹⁹ This kind of survey may be possible in small areas, but would be difficult to undertake on a wider scale. It is also not clear what sort of management techniques could be appropriately targeted based on the 'risk' maps produced. The approach may be of most value for estimating impacts and total mortality, once impact data can be fed into the model.

There is one example on turtles and entanglement in the Gulf of Carpentaria, Northern Australia, where spatial mapping of ghost nets was shown to be a good predictor of risk for turtle entanglement. Observations also revealed that the drift pattern of nets might allow for many of them to be headed off at the point they tend to enter the Gulf. This is an example where it makes sense to try a targeted approach for debris removal.⁶²⁰

On the other hand, a study on turtles and ingestion that carried out a worldwide literature review found no relationship between the incidence rate of debris ingestion and local abundance of debris, and this was held to be a direct consequence of the large distances travelled by turtles.⁶²¹ In this case the only management strategy that is a serious candidate for addressing marine debris over a wide range is prevention. It is unlikely that there will be many instances of prevention initiatives that are of particular value carried out in a targeted manner; as modelling of debris distribution shows, countries' debris does not necessarily end up near their coastline,⁶²² so detailed knowledge would be needed to match the spatial distribution of threat to the location where prevention initiatives would have to be targeted, and these are very widescale patterns, so there would be quite some inaccuracy in attempting to influence one particular area by this method.

The following example illustrates the kind of level of detail about a species that might be needed to assess whether a hotspot approach might possibly be of value, as it may not only depend on the species but on the subpopulation of a species. Apparently, leatherback turtles use narrow migration corridors in the Pacific Ocean and this led to the suggestion that fishing should be restricted in these areas. However, satellite tracking showed that in the North Atlantic Ocean, there was no

⁶¹⁹ Williams, R., Ashe, E., and O'Hara, P.D. (2011) Marine mammals and debris in coastal waters of British Columbia, Canada, *Marine Pollution Bulletin*, Vol.62, No.6, pp.1303–1316

⁶²⁰ Wilcox, C., Hardesty, B. D., Sharples, R., Griffin, D. A., Lawson, T. j., and Gunn, R. (2013) Ghostnet impacts on globally threatened turtles, a spatial risk analysis for northern Australia, *Conservation Letters*, Vol.6, No.4, pp.247–254

⁶²¹ Schuyler, Q., Hardesty, B.D., Wilcox, C., and Townsend, K. (2013) Global Analysis of Anthropogenic Debris Ingestion by Sea Turtles, *Conservation Biology*, p.n/a–n/a

⁶²² Lebreton, L.C.-M., Greer, S.D., and Borrero, J.C. (2012) Numerical modelling of floating debris in the world's oceans, *Marine Pollution Bulletin*, Vol.64, No.3, pp.653–661

such equivalent, and they had highly varied and unpredictable migration routes.⁶²³ Combined with the high level of dispersal of marine debris, this limits the potential for hotspot approaches for that population.

6.5.4 Recommendations

CMS has a goal of coordinating scientific research programmes based on identification of common issues/threats shared across the CMS Family, and already there are some thematic initiatives in place, such as that on climate change, or by-catch, which include a specifically appointed Councillor on the Scientific Council and Associated Working Group. If there were similar provision were made for marine debris, it could provide more support for the co-ordination of relevant research.

A specific Working Group on marine debris could help co-ordinate programmes and projects relevant to marine debris between Agreements. Regarding information gaps, it could facilitate the sharing of relevant information between Family Agreements on the marine debris issue.

CMS Resolution 10.4, item 6 requests that the Parties provide data on **amounts, sources and impacts of marine debris on Convention-listed migratory species as follows:**

“6. Requests that Parties provide available information on the amounts, impacts and sources of marine debris in waters within their jurisdiction on marine species listed on Appendix I and II of the Convention in their National Reports;”

Although this will cover currently existing data, it could also be used as an opportunity to focus attention on and request data which is deemed necessary in the future, under the guidance of CMS.

For the purpose of filling information gaps, it is also worth keeping in mind that many Family Agreements explicitly require that monitoring and reporting to the Secretariat on the status on threatened species and also on impacts and potential threats to those species, is carried out. National Reporting mechanisms for Family Agreements could therefore be used to return data related to the impacts of marine debris on the migratory species relevant to the Agreements. This includes the on-line reporting system.⁶²⁴

Some CMS Family Agreements already have developed partnerships with Regional Seas areas such as ACCOBAMS and the Black Sea (HELCOM). ACCOBAMS has also a programme for conferring ‘partner status’ upon (e.g. NGOs and university laboratories), one of the benefits of which is that the Agreement may receive scientific information relevant to the implementation of the Agreements on a priority basis. More of this type of collaboration could help CMS to fill relevant knowledge gaps.

⁶²³ OSPAR (2009) *Background Document for Leatherback turtle *Dermochelys coriacea**, 2009, http://www.ospar.org/documents/dbase/publications/p00421/p00421_leatherback_turtle.pdf

⁶²⁴ <http://cms-family-ors.unep-wcmc.org/>

The Convention should encourage its Parties to participate in marine debris monitoring programs under the Regional Seas program. There are specific Regional Seas areas that have not yet started to assess their marine debris status and have not yet reported in this regard, namely the Arctic, Northeast Pacific, ROPME region, Pacific, and West and Central Africa. Countries in these regions especially should be encouraged to implement marine monitoring strategies.

The CMS should support the standardization of monitoring and work with Regional Seas and other relevant stakeholders to make sure high impact items are included, that both weight and count be measured, that some sort of microplastics monitoring is implemented, and that monitoring of impacts on marine species be clearly recommended and included to the extent possible. The guidelines for marine litter survey and monitoring programmes for beaches, floating litter and the sea floor, developed by IOC/UNEP and the Regional Seas program provide for most of these considerations and should be distributed and implemented at the national, regional and global levels. In addition, the establishment of a relational database to provide estimates of debris by source, to guide management strategies, should be encouraged, also under the auspices of the Regional Seas program. The Convention should also support the creation of a global clearinghouse for information on marine debris at the regional and global levels.

A relational database could also be created to translate information on marine debris into risk presented to wildlife. This would provide particularly relevant information for the Convention, who could support this by working with Regional Seas programs and University groups.

Impact monitoring should also be carried out in other contexts as the kind of information that can be provided in conjunction with marine debris monitoring programs will be limited. The Convention on Migratory Species should look to encourage co-operation between organizations that have the capacity to carry out this kind of monitoring, including the standardization of methods so that comparable and compelling statistics can be obtained. Suitable stakeholders are suggested in Section 4.2.

In so far as the setting of marine debris targets encourages the implementation of monitoring programs, the Convention could support the setting of marine debris targets. Different types of targets are relevant to different types of information gaps: at-sea targets for improving the state of information about abundance, operational targets such as estuarine monitoring for improving information on pathway, source and regional differences; and targets related to impacts on wildlife improving information in that regard. Targets are an issue currently under discussion for example in the EU. A public consultation was carried out in Autumn 2013 on the establishment of a quantitative reduction headline target for marine litter.⁶²⁵ Similar opportunities to make the Convention's views heard should be sought.

⁶²⁵ http://ec.europa.eu/environment/consultations/marine_litter_en.htm

The information gaps regarding management strategies mainly relate to their evaluation in terms of cost, process evaluation and mitigation of impact on wildlife. The Convention can recommend that any strategy undertaken by Parties should plan for and execute evaluation, and may wish to recommend indicators that are consistent between regions and reporting mechanisms. It can also insist that any initiative undertaken under its auspices must include evaluation, and require that this data be made available.

The final recommendation is that action should not be delayed while information gaps are filled. Although it would be useful to have information on the stock of debris in the ocean, especially with regards to targets or evaluating the effectiveness of removal strategies, and monitoring prevention strategies, the extent of the sampling required to provide robust information regarding abundance of debris in the ocean may not be generally accepted as feasible in various contexts. It is therefore worth considering whether more information gathering is fruitful, when it does not necessarily alter the selection of many of the initiatives and approaches that have a high likelihood of being successful in combating marine litter. Certainly, if there is information which it is feasible to obtain that would help to clarify what investment it is reasonable to make for a stakeholder or in targeting a particular stakeholder, then this should be done. Furthermore, some measures of debris are more stable and have more power to reliably detect change than others, such as composition rather than abundance, or beach debris vs floating debris, so it is more feasible to implement them. However it must be kept in mind that uncertainty can be taken advantage of by stakeholders as a welcome excuse to delay action, or to favour less expensive actions for combatting debris that are limited in time and scale, even though they might be less effective than even a moderately more expensive option that is, however, holistic and wider in scope in both time and scale. A united front can help discourage stalling on this issue.

Regarding gathering information on impacts on migratory species, it might be decided that gaining more information on the impacts of marine debris on migratory species is required for building a case for action. Ideally, we would require population level effects. However it can be argued that:

- a) the extensive animal suffering caused alone constitutes a case for action; and
- b) for endangered animals with small populations, such as CMS listed species, no amount of extra mortality is acceptable.

In addition, mitigating impacts before populations become threatened will be easier than waiting for population decline to be detected, identifying causal factors, and then trying to reverse it.⁶²⁶

Regarding information on regional distinctions, the effort and expense needed to gather this information may not be justified given that because of the distance that debris travels, many of the management strategies need to be applied consistently on

⁶²⁶ Taylor, B.L., Martinez, M., Gerrodette, T., Barlow, J., and Hrovat, Y.N. (2007) Lessons from Monitoring Trends in Abundance of Marine Mammals, *Marine Mammal Science*, Vol.23, No.1, pp.157–175

a global scale. It is probably more important to plough resources into a multipronged approach rather than endless segmentation analysis in an attempt to look for 'hotspots' or special 'target issues'.

Even though not all the desired information is available on the efficacy of different management strategies, the information we do have about marine debris and/or its impacts on wildlife is sufficient to indicate that there are some sources and debris types which clearly need addressing .

For example, the predominance of debris from land based sources leads to the particular recommendation of management strategies that address this source of debris. Economic instruments and other measures preventing land based litter have the added benefit of tackling its negative impacts on land, which given the identification of emerging evidence on the indirect costs of litter in respect of crime and mental health, are considerable. Therefore the benefits are not just of relevance to the marine environment. In the context of uncertainty regarding sources of marine debris, they are 'no regrets' measures with a range of additional benefits.

Focus should also be directed on management strategies that deal with debris known to be of high impact on marine species – such as fishing gear, soft plastic and (micro)plastic fragments.

The information we do have on debris abundance in terms of stock (debris already present) and flow (debris entering the sea) also suggests that prevention must be addressed before removal can be effective.

It is important to have enough knowledge to ensure that ineffectual or counterproductive measures or strategies are not pursued. However as soon as the available knowledge allows a judgement to be made, action must not be delayed. The following quote is strongly concurred with:

“The authors believe that sufficient empirical knowledge exists to support progress on this issue now. The knowledge gaps outlined ... should be considered as means of refining actions, rather than defining or delaying them.”⁶²⁷

⁶²⁷ STAP/GEF (2011) Marine Debris as a Global Environmental Problem: Introducing a Solutions Based Framework Focused on Plastic



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REPORT II: MARINE DEBRIS AND COMMERCIAL MARINE VESSEL BEST PRACTICE

Review required under CMS Resolution 10.4 on Marine Debris

Report II: Marine Debris and Commercial Marine Vessel Best Practice

Review Required under CMS Resolution 10.4 on Marine
Debris

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March 2014

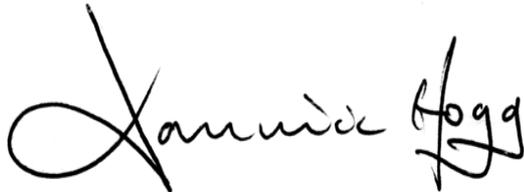
Report for:

The Secretariat of the Convention on Migratory Species

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Disclaimer

Eunomia Research & Consulting has taken due care in the preparation of this report to ensure that all facts and analysis presented are as accurate as possible within the scope of the project. However no guarantee is provided in respect of the information presented, and Eunomia Research & Consulting is not responsible for decisions or actions taken on the basis of the content of this report.

03/03/2014

EXECUTIVE SUMMARY

Eunomia Research & Consulting (Eunomia) has worked in partnership with the International Union for the Conservation of Nature (IUCN) and the Marine Conservation Society (MCS) to prepare three reports for the Convention on the Conservation of Migratory Species of Wild Animals (CMS) for 'Reviews required under Resolution 10.4 on Marine Debris'. The three reports are as follows:

- Report I: Migratory Species, Marine Debris and its Management;
- Report II: Marine Debris and Commercial Marine Vessel Best Practice; and
- Report III: Marine Debris Public Awareness and Education Campaigns.

Based on an extensive review of peer reviewed and grey literature, Report II identifies and evaluates the existing measures employed to manage waste on board commercial marine vessels and prevent the disposal of garbage at sea. Such measures include:

- Conventions;
- Legislation;
- Codes of conduct;
- Guidelines; and
- Best practice strategies.

These are categorised into international, regional, and industry / vessel based measures in Section 2.0 of the report.

Enforcement of such measures is essential to guarantee compliance, a precursor to ensuring their effectiveness. However, 'policing the seas' is one of the most challenging aspects in relation to improving waste management practices employed at sea. Enforcement mechanisms for existing measures are based on inspections and fines, where an organisation responsible for enforcement is in place and has sufficient resource. The issue of enforcement is explored further in Section 3.0.

Establishing the effectiveness of measures is also important in order to identify those which have the greatest impact and should be promoted as best practice. Key factors affecting the effectiveness of measures include the degree of participation, how well the measure is implemented, the cost of implementation, and the relevant enforcement mechanism (if any). Whilst these factors are discussed in Section 4.0, accurately establishing the effectiveness of the measures described in Section 2.0 is extremely difficult due to the significant lack of information regarding the existing baseline volume and dispersion of marine debris. This would need to be addressed in order for the impact of measures to be fully identified, thus providing a better understanding of the measures that have the most potential to reduce the disposal of garbage at sea from commercial vessels.

Despite the implementation of international legislation, gaps still remain in the regulatory framework. Key gaps identified in Section 5.0 of this report relate to the scope of specific requirements within MARPOL Annex V, which do not cover fishing vessels, despite fishing vessels constituting a significant proportion of the global commercial shipping fleet and therefore a significant potential source of marine debris at sea.

Another area where legislation does not sufficiently address the problem is the cruise shipping industry. Cruise ships have the potential to generate wastes similar in volume and character to those generated in hotels. The majority of current legislation regarding pollution and shipboard waste was developed prior to the rapid growth of the cruise market, and

consequently no international legislation exists to address this large and growing industry as a significant potential contributor to marine debris at sea.

Marine debris remains a global problem and challenge. In 2005, UNEP concluded that: “... *marine litter is not a problem which can be solved only by means of legislation, law enforcement and technical solutions. It is a social problem which requires efforts to change behaviours, attitudes, management approaches and multi-sectoral involvement.*”¹ The circumstances do not appear to have changed since 2005, as such the report’s recommendations, fully described in Section 6.0, include:

- Specific improvements to existing legislation, particularly MARPOL Annex V:
 - Suggestions include implementing zero discharge at sea, phasing out on-board waste incineration, and providing improved and harmonised port reception facilities;
- Significant gaps to address, including:
 - Lack of baseline and monitoring data surrounding marine debris;
 - Education for seafarers;
 - Targeting improvements within the cruise shipping industry; and
- The potential introduction of market-based instruments, for example:
 - Offering appropriate tax relief or a reduction in port fees to ships or fleets that operate a zero waste discharge at sea policy.

The maritime industry is a complex sector with stakeholders to be engaged at all levels. These interdependencies between fuel suppliers, ship owners, cargo owners and financing and insurance companies mean that the implementation of best practice requires not only technological, but also social and organisational changes. Ensuring success calls for a multi-stakeholder approach; the crew and ship owner are important, but a number of other players in the maritime industry must also be involved. When thinking about incentives or possible actions that are to be included it is essential to ensure they are well targeted to actors that can, and importantly are willing, to make a difference.²

As in other spheres there is always a tendency to try and shift the responsibilities to others. An example is waste collection and treatment. Ship operators complain that ports do not offer reception facilities while ports claim that the crew of visiting ships do not deliver their waste in port. Without clear directions, problems – and associated solutions – will be put on the shoulders of others.³

UNEP, perhaps through the Regional Seas Programme, can facilitate coordination between all of the different stakeholders to enable best practice measures to be implemented. International forums such as the IMO take decisions on the basis of a consensus, which

¹ UNEP (2005) *Marine Litter: An Analytical Overview*, 2005

² Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Seas%20at%20Risk%20Policy%20Analysis%20_V_W%20case%20study%201_.pdf

³ Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Seas%20at%20Risk%20Policy%20Analysis%20_V_W%20case%20study%201_.pdf

invariably means that large flag-States (particularly those acting as “open registry” for a large proportion of ships) have a loud voice and considerable influence. Therefore, the outcome of IMO deliberations may be somewhat lacking in ambition at times. It is important that key players are supported in promoting best practice and addressing the gaps identified to ensure improvements in international legislation and the global situation do not get overlooked, and UNEP, supported by CMS, can help provide this support.

To this end, CMS can encourage Parties to the Convention on Migratory Species to:

- Ratify key international legislation such as MARPOL Annex V (where CMS Parties have not yet done so);
- Initiate and support the improvement of MARPOL Annex V so that exemptions are tightened, in order to include most fishing vessels.
- Encourage ships and shipping operators from CMS Parties to sign up to measures such as the Clean Shipping Index;
- Encourage and support every seafarer to attend a marine environmental awareness course provided by ProSea or another similar organisation;
- Encourage shipping operators and other key industries from CMS Parties involved with the international transport of goods to drive environmental demands;
- Promote the wider rollout of the indirect fees system in ports, and support the improvement of port waste reception facilities in general; and
- Support and encourage CMS Parties to implement and achieve relevant ISO standards.

Many of the activities suggested here may involve approaching governments, industries and international organisations to facilitate research and explore funding potential for investigating how such actions could be best implemented. CMS may not be able to undertake all these activities alone, and so should support UNEP and the Regional Seas Programme to do so. Developing research questions around these topics and co-ordinating research to address information gaps is a good approach. For instance, initiating further research to investigate whether market based instruments are appropriate measures for preventing commercial shipping from disposing of garbage at sea. Additionally, identifying a strategy to target specific audiences and work with key industries in order to improve awareness, knowledge and behaviour with regards to marine debris would be beneficial. We recommend that one of the first industries to target would be the cruise ship industry, as they produce a significant amount of garbage at sea, therefore improving waste management and performance in this global industry would potentially have a large and beneficial impact.

Encouraging ratification of international legislation such as MARPOL is all well and good, but this report clearly shows that there are significant gaps that need to be addressed if the legislation is to become more effective. Therefore one of the key recommendations for CMS Parties and the Secretariat is to focus on the gaps identified in this report and explore the possible means to address them.

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1.0 Introduction

Globally, marine vessels are estimated to account for about 20% of marine debris (albeit this figure is subject to some considerable uncertainty),⁴ but in areas of high shipping density such as the North Sea the proportion coming from shipping is closer to 40%.⁵ The protection of the marine environment can be enhanced significantly by reducing discharges of all kind of ship-generated waste and cargo residues into the sea.⁶

1.1 Approach

The key objective of Part B is to identify best practice for commercial marine vessels in terms of preventing the disposal of marine debris at sea. Our research of both peer-reviewed and grey literature has focused on the following areas:

- **Section 2.0** identifies existing guidelines, codes of conduct, best practice strategies, and international conventions, that address the management of solid waste on board commercial vessels;
- **Section 3.0** indicates the different types of enforcement mechanisms currently being used;
- **Section 4.0** investigates the effectiveness of the existing measures and initiatives;
- **Section 5.0** highlights the gaps in current regulation and management measures; and
- **Section 6.0** details our recommendations to CMS, addressing the gaps and issues raised by the previous sections.

Where possible we have been comprehensive in identifying the different *types* of schemes, measures, and enforcement mechanisms, but it is important to note that we have not listed every single instance.

Within the literature the phrase ‘commercial marine vessels’ tends not to include fishing vessels. However, we have included best practice measures, gaps in management and recommendations that apply to fishing vessels, as they may contribute a significant amount to the issue of marine debris from ocean based sources, and therefore should be included within the definition of ‘commercial marine vessels’.

⁴ EMSA (2013) *Port Waste Reception Facilities*, accessed 18 October 2013, <http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities.html>

⁵ Zero Waste Europe (2013) *How much plastic litter is currently in EU waters?*, accessed 22 October 2013, <http://www.zerowasteurope.eu/2013/03/how-much-plastic-litter-is-currently-in-eu-waters/>

⁶ EMSA (2013) *Port Waste Reception Facilities*, accessed 18 October 2013, <http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities.html>

2.0 Existing Measures

This section identifies the existing measures, such as codes of conduct, guidelines, best practice strategies, and regulations, which have been implemented throughout the world in order to prevent or discourage commercial shipping vessels from disposing of garbage at sea.

At the global level, there are several conventions and agreements applicable to the issue of marine vessel derived marine debris. At the regional level, there are no specific legal instruments dealing with marine debris, although it is addressed in several regional conventions and protocols on controlling marine pollution. At the national level, only the Wider Caribbean and Northwest Pacific regions contain countries with specific national legislation addressing marine debris. Marine debris (from both land and sea based sources) is not usually dealt with in policies or laws as a separate category of waste, it is considered to be part of the general solid waste stream. A majority of the regions acknowledge the inadequacy of implementation and enforcement of existing laws and regulations related to solid waste management.⁷

2.1 International Measures

2.1.1 MARPOL Annex V

The Convention for the Prevention of Pollution from Ships (MARPOL 73/78) is the most significant international convention that addresses and aims to control the disposal of garbage at sea from the shipping sector. The Convention was held in 1973, and the subsequent Protocol was established in 1978.

Annex V provides specific detail regarding the type and quantity of garbage that ships may or may not discharge into the sea, and the associated restrictions according to location, see Table 1 for further information.^{8 9} As of 30th September 2013, 145 States have ratified MARPOL Annex V, which represents 98.5% of the global shipping fleet tonnage.¹⁰ According to Annex V, all ships of 100 gross tonnage and above, or ships certified to carry more than 15 persons, should develop and follow a written garbage management plan. A Garbage Record Book is supplied to every ship of 400 gross tonnage and above, and every ship which is certified to carry 15 or more

⁷ UNEP (2009) *Marine Litter - A Global Challenge*, accessed 11 October 2013, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

⁸ IMO (2013) *MARPOL Annex V Discharge Requirements*, accessed 15 October 2013, http://www.ukpandi.com/fileadmin/uploads/uk-pi/Documents/Conventions/Environmental_Compliance/Annex%20V%20discharge%20requirements%2001-2013.pdf

⁹ IMO (2011) *MARPOL Annex V*, accessed 10 October 2013, <http://www.imo.org/OurWork/Environment/PollutionPrevention/Garbage/Documents/201%2862%29.pdf>

¹⁰ NOAA, and UNEP (2013) *IMO Status of Conventions*, accessed 15 October 2013, <http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx>

persons. The details of each discharge to sea or to a reception facility, or a completed incineration must be recorded in the Garbage Record Book, as per the requirements in Annex V.¹¹

¹¹ IMO (2011) *MARPOL Annex V*, accessed 10 October 2013, <http://www.imo.org/OurWork/Environment/PollutionPrevention/Garbage/Documents/201%2862%29.pdf>

Table 1: Revised Discharge Requirements under MARPOL Annex V (resolution MEPC.201 (62)) which entered into force on 1 January 2013

Type of Garbage	Ships outside special areas	Ships within special areas	Offshore platforms and all ships within 500m of such platforms
Food waste comminuted or ground	Discharge permitted ≥ 3 nm from the nearest land and <i>en route</i>	Discharge permitted ≥ 12 nm from the nearest land and <i>en route</i>	Discharge permitted ≥ 12 nm from the nearest land and <i>en route</i>
Food waste not comminuted or ground	Discharge permitted ≥ 12 nm from the nearest land and <i>en route</i>	Discharge prohibited	Discharge prohibited
Cargo residues* not contained in wash water	Discharge permitted ≥ 12 nm from the nearest land and <i>en route</i>	Discharge prohibited	Discharge prohibited
Cargo residues* contained in wash water		Discharge only permitted in specific circumstances** and ≥ 12 nm from the nearest land and <i>en route</i>	Discharge prohibited
Cleaning agents and additives* contained in cargo hold wash water	Discharge permitted	Discharge only permitted in specific circumstances** and ≥ 12 nm from the nearest land and <i>en route</i>	Discharge prohibited
Cleaning agents and additives* contained in deck and external surfaces wash water		Discharge permitted	Discharge prohibited
Carcasses of animals carried on board as cargo and which died during the voyage	Discharge permitted as far from the nearest land as possible and <i>en route</i>	Discharge prohibited	Discharge prohibited
All other garbage including plastics, domestic wastes, cooking oil, incinerator ashes, operational wastes and fishing gear	Discharge prohibited	Discharge prohibited	Discharge prohibited
Mixed garbage	When garbage is mixed with or contaminated by other substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply		

* These substances must not be harmful to the marine environment

** According to regulation 6.1.2 of MARPOL Annex V, the discharge shall only be allowed if: (a) both the port of departure and the next port of destination are within the special area and the ship will not transit outside the special areas between these ports (regulation 6.1.2.2); and (b) if no adequate reception facilities are available at those ports (regulation 6.1.2.3).

The designation of 'special areas' under MARPOL means "a sea area where for recognised technical reasons in relation to its oceanographic and ecological condition and to the particular character of its traffic the adoption of special mandatory methods for the prevention of sea pollution by sea garbage is required".¹²

The special areas established under Annex V are:

- The Mediterranean Sea;
- The Baltic Sea Area;
- The Black Sea Area;
- The Red Sea Area;
- The Gulfs Area;
- The North Sea;
- The Wider Caribbean Region; and
- The Antarctic Area.¹³

Within these areas, discharges of all kinds of garbage (except comminuted or ground food waste and cleaning agents/additives¹⁴ contained in deck and external surfaces wash water) into the sea are prohibited.¹⁵ However, not all these areas have adequate port facilities to handle the increased amount of garbage from ships and this is a prerequisite before designation can take effect. Consequently, many of the designated Special Areas may not yet be fully recognised as Special Areas.^{16 17}

¹² IMO (2011) *MARPOL Annex V*, accessed 10 October 2013, <http://www.imo.org/OurWork/Environment/PollutionPrevention/Garbage/Documents/201%2862%29.pdf>

¹³ IMO (2011) *MARPOL Annex V*, accessed 10 October 2013, <http://www.imo.org/OurWork/Environment/PollutionPrevention/Garbage/Documents/201%2862%29.pdf>

¹⁴ These substances must not be harmful to the marine environment

¹⁵ IMO (2013) *MARPOL Annex V Discharge Requirements*, accessed 15 October 2013, http://www.ukpandi.com/fileadmin/uploads/uk-pi/Documents/Conventions/Environmental_Compliance/Annex%20V%20discharge%20requirements%2001-2013.pdf

¹⁶ Sheavly, S.B. (2005) *Marine Debris – an Overview of a Critical Issue for Our Oceans*, Sixth Meeting of the UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea, 2005, http://www.un.org/depts/los/consultative_process/documents/6_sheavly.pdf

¹⁷ Greenpeace (2006) *Plastic Debris in the World's Oceans*, accessed 16 October 2013, http://www.unep.org/regionalseas/marinelitter/publications/docs/plastic_ocean_report.pdf

All Contracting Parties to MARPOL Annex I and II should also ratify Annex V on garbage (although seven Parties have not yet done so¹⁸). Regional and national authorities must take steps to fully implement Annex V through national legislation, based on MARPOL guidance, in order to make sure that the requirements are met by all ships and ports under their jurisdiction.^{19 20}

MARPOL applies to ships through their Flag State, and to ports and terminals through the Government in Port States.²¹ Ships of signatory nations have to abide by Annex V at all times in all waters, while ships from non-signatory nations must follow Annex V when in waters of signatory countries.²²

With regards to open registry states, a total of 34 states have been identified by the International Transport Workers' Federation,²³ however only 27 of these are nations recognised by the UN. All but one (Myanmar) of these 27 states are signatories to MARPOL Annex V, meaning that even ships from an open registry state should be adhering to the requirements of Annex V. The remaining seven states that are not UN recognised nations²⁴ are either overseas territories or international ship registers, and therefore they are all covered by Annex V (to which the governing states of France, Germany, Denmark, the Netherlands and the UK are all signatories). In theory, none of the ships flying under an open registry are outside of the requirements set by MARPOL Annex V. Whether open registry states enforce MARPOL requirements is another question to be answered.

2.1.1.1 Port Waste Reception Facilities

Another requirement of MARPOL is for State Parties to provide facilities for the reception of ship-generated residues and garbage. These reception facilities must be

¹⁸ Brunei Darussalam, Cook Islands, Djibouti, Myanmar, Seychelles, Thailand and Vietnam. Of these states only the Cook Islands, Djibouti and Seychelles are signatories of the Convention on Migratory Species.

¹⁹ UNEP GPA (2001) *Marine Litter - Trash That Kills*, accessed 11 October 2013, http://www.epa.gov/owow/oceans/debris/toolkit/files/trash_that_kills508.pdf

²⁰ Derraik, J.G. (2002) The pollution of the marine environment by plastic debris: a review, *Marine Pollution Bulletin*, Vol.44, No.9, pp.842–852

²¹ Condino, D. (2013) Environmentally Sound Management of Ship's Waste and Adequate Port Reception Facilities, paper given at World Ocean Council Sustainable Ocean Summit, Washington D.C., 23 April 2013, http://oceancouncil.org/site/summit_2013/Presentation%20PDFs/2-PORT%20WASTE%20SECURED%20PDFS/2-PORTWASTE_Condino%20nn.pdf

²² Sheavly, S.B. (2005) Marine Debris – an Overview of a Critical Issue for Our Oceans, Sixth Meeting of the UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea, 2005, http://www.un.org/depts/los/consultative_process/documents/6_sheavly.pdf

²³ International Transport Workers' Federation (2012) *Flags of Convenience Countries*, accessed 22 November 2013, <http://www.itfglobal.org/flags-convenience/flags-convenience-183.cfm>

²⁴ Bermuda (UK), Cayman Islands (UK), Faroe Islands (Denmark), French International Ship Register (France), German International Ship Register (Germany), Gibraltar (UK), and Netherlands Antilles (Netherlands)

adequate to meet the needs of ships using the port, without causing undue delay for ships. The relevant MARPOL regulations on port reception facilities are:

- Annex I Regulation 38;
- Annex II: Regulation 18;
- Annex IV: Regulation 12;
- Annex V: Regulation 8; and
- Annex VI: Regulation 17.

The 42nd session of the Marine Environment Protection Committee (MEPC) in November 1998 agreed that to achieve "adequate" reception facilities the port should have regard to the operational need of users and provide reception facilities for the type and quantities of waste from ships normally using the port, without causing undue delay for the ships. Resolution MEPC.83 (44) further stated that facilities provided by the port must meet the needs of the ships normally using the port, and allow for the ultimate disposal of ships' wastes to take place in an environmentally appropriate way.²⁵ In other words, port operators must not provide mariners with a disincentive to use the waste reception facilities.²⁶

With the aim of promoting the effective implementation of MARPOL, IMO has developed a port reception facilities module in their Global Integrated Shipping Information System (GISIS) database, including a list of available port reception facilities (PRF) in ports and the possibility to report cases of alleged inadequacies.²⁷ However, research by the IMO suggests that there are still barriers to the efficient delivery of MARPOL residues/wastes ashore. One such barrier already identified is the lack of clear, easy to use guidance that outlines how the shipping community and reception facility providers can best conduct their operations in order to comply with MARPOL and to facilitate efficient, environmentally responsible disposal of MARPOL residues/wastes.²⁸

In response to this, as well as the need to tackle the long-standing problem of the inadequacy of port reception facilities, IMO has developed a number of guidelines, most recent of which have been published as a Comprehensive Manual on Port Reception Facilities. The manual provides guidance on matters such as waste management strategy, type and quantity of ship-generated wastes, planning, choice of location, collection and treatment, financing and cost recovery, and cooperation of

²⁵ EMSA (2013) *Port Waste Reception Facilities*, accessed 18 October 2013, <http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities.html>

²⁶ Condino, D. (2013) Environmentally Sound Management of Ship's Waste and Adequate Port Reception Facilities, paper given at World Ocean Council Sustainable Ocean Summit, Washington D.C., 23 April 2013, http://oceanouncil.org/site/summit_2013/Presentation%20PDFs/2-PORT%20WASTE%20SECURED%20PDFS/2-PORTWASTE_Condino%20nn.pdf

²⁷ EMSA (2013) *Port Waste Reception Facilities*, accessed 18 October 2013, <http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities.html>

²⁸ IMO (2013) Guide to good practice for port reception facility providers and users

port and ship requirements. IMO has also provided technical assistance over many years to a large number of countries in the form of seminars, symposia and workshops, mostly at the regional level. Progress has been made in certain parts of the world. It is apparent, however, that, in some oil producing regions, the situation with regard to the provision of reception facilities is not improving.

The provision of adequate reception facilities worldwide is a matter of extreme complexity which involves the shipping industry, port operators, oil and chemical companies and governments. A satisfactory solution to the shortage of reception facilities in many parts of the world has yet to be found. It is widely recognized that, if this problem is to be satisfactorily resolved, it will be necessary to address the economic as well as the technical aspects of this issue.²⁹

2.1.2 ISO Standards

The International Organization for Standardization (ISO) has established two standards with regards to ships and marine technology (marine environment protection). Both of these standards relate to MARPOL and Annex V; however it is not a requirement that port authorities and ship operators obtain these standards:

1. ISO 16304:2013 Arrangement and management of port waste reception facilities; and
2. ISO 21070:2011 Management and handling of shipboard garbage.

The scope of each standard is described in more detail below.

The main driver for a ship or ship operator achieving accreditation in either or both of the standards would be to demonstrate to stakeholders the commitment to improving environmental standard of ship activities. This may help win an advantage over competitors, providing the organisation with a lead in the market.

It is currently unknown how many applications for each standard have been submitted and awarded. This standard relating to port waste reception facilities (ISO 16304:2013) was only published in March 2013, therefore the application of this standard is likely to be relatively low until awareness is raised and requirements for port reception facilities become more specific, driving the market towards best practice.

One of the benefits of ISO standards is the requirement for monitoring, as well as internal and external auditing. This ensures credibility, and is an alternative approach to ensuring compliance where enforcement mechanisms fall short.

ISO 16304:2013

This applies to the management of ship generated waste regulated by MARPOL that is discharged at ports and terminals. It also covers principles and issues that should be considered in the development of a port waste management plan (PWMP), its

²⁹ IMO (2012) *Implications of the United Nations Convention on the Law of the Sea for the International Maritime Organisation*, accessed 27 November 2013, <http://www.imo.org/OurWork/Legal/Documents/Implications%20of%20UNCLOS%20for%20IMO.pdf>

implementation and port reception facilities (PRF) operations. The operation of any PRF is governed by the principles and procedures included in the PWMP. The procedures to operate the PRF and the development of a PWMP are closely linked and therefore are integrated into ISO 16304:2013.³⁰

ISO 16304:2013 provides guidance and sets best practice for the following areas of arrangement and management of port waste reception facilities:

- Waste segregation;
- Storage;
- Waste minimisation;
- Waste handling equipment;
- Recycling;
- Local and national regulations;
- Treatment technologies at the port; and
- Waste management planning.³¹

ISO 21070:2011

The requirements of MARPOL Annex V set the minimum standard for garbage management that apply to ships. Applicable national and regional regulations exceeding the requirements of MARPOL Annex V will also need to be observed. ISO 21070:2011 applies to the management and handling of garbage generated on board ships during the period the garbage will be on board. The definition of garbage in ISO 21070:2011 is as defined in MARPOL Annex V. ISO 21070:2011 contains procedures for the shipboard management of garbage, including handling, collection, separation, marking, treatment and storage. It also describes the vessel-to-shore interface and the delivery of garbage from the ship to the port reception facility.³²

ISO 16304:2013 provides guidance and sets best practice for the following areas of management and handling of shipboard garbage:

- Equipment/technology (compactors, comminuters, pulpers, PAWDS (Plasma Arc Waste Destruction System, shredders, and incinerators)
- Calculating the amounts of waste; and

³⁰ ISO (2013) *ISO 16304:2013 - Ships and marine technology – Marine environment protection – Arrangement and management of port waste reception facilities*, accessed 22 October 2013, http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=56129

³¹ Condino, D. (2013) *Environmentally Sound Management of Ship's Waste and Adequate Port Reception Facilities*, paper given at World Ocean Council Sustainable Ocean Summit, Washington D.C., 23 April 2013, http://oceanouncil.org/site/summit_2013/Presentation%20PDFs/2-PORT%20WASTE%20SECURED%20PDFS/2-PORTWASTE_Condino%20nn.pdf

³² ISO (2011) *ISO 21070:2011 - Ships and marine technology – Marine environment protection – Management and handling of shipboard garbage*, accessed 22 October 2013, http://www.iso.org/iso/home/store/catalogue_tc/catalogue_detail.htm?csnumber=51003

- Segregation of Wastes.³³

2.1.3 London Convention and Protocol

The Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter 1972 (the London Convention) is one of the first global conventions to protect the marine environment from human activities. It has been in force since 1975, and its objective is to promote the effective control of all sources of marine pollution and to take all practicable steps to prevent pollution of the sea by dumping of wastes and other matter.³⁴ As of 30th September 2013, 87 States are Parties to this Convention.³⁵

In 1996, the 'London Protocol' was agreed to further modernise the Convention and, eventually, replace it. Under the Protocol all dumping is prohibited, except for eight types of waste that may be considered for dumping:

- Dredged material;
- Fish waste;
- Vessels, platforms or other man-made structures;
- Inert, inorganic geological material;
- Organic material of natural origin;
- Bulky items; and
- CO2 storage in sub-seabed geological formations.³⁶

The Protocol entered into force in March 2006 and there are currently 42 parties to the Protocol.³⁷ ³⁸ The move from the London Convention, a permissive approach to

³³ Condino, D. (2013) Environmentally Sound Management of Ship's Waste and Adequate Port Reception Facilities, paper given at World Ocean Council Sustainable Ocean Summit, Washington D.C., 23 April 2013, http://oceanCouncil.org/site/summit_2013/Presentation%20PDFs/2-PORT%20WASTE%20SECURED%20PDFs/2-PORTWASTE_Condino%20nn.pdf

³⁴ IMO (2013) *London Convention and Protocol*, accessed 22 October 2013, <http://www.imo.org/OurWork/Environment/SpecialProgrammesAndInitiatives/Pages/London-Convention-and-Protocol.aspx>

³⁵ NOAA, and UNEP (2013) *IMO Status of Conventions*, accessed 15 October 2013, <http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx>

³⁶ Haag, F. (2013) Sea-based sources of marine litter: the IMO perspective, paper given at GLOC-2, Montego Bay, Jamaica, 2 October 2013, <http://www.gpa.unep.org/index.php/global-partnership-on-nutrient-management/publications-and-resources/second-global-conference-on-land-ocean-connections-gloc-2/214-haag-seabased-sources-of-marine-litter-the-imo-perspective/file?limit=100>

³⁷ IMO (2013) *London Convention and Protocol*, accessed 22 October 2013, <http://www.imo.org/OurWork/Environment/SpecialProgrammesAndInitiatives/Pages/London-Convention-and-Protocol.aspx>

³⁸ NOAA, and UNEP (2013) *IMO Status of Conventions*, accessed 15 October 2013, <http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx>

ocean dumping, towards a precautionary approach under the Protocol represents a shift in attitude towards waste and the environment.³⁹

In relation to other international legislation, both the London Convention and Protocol provide the global rules and standards on dumping as called for in Article 210.6 of the UN Convention on the Law of the Sea (see Section 2.1.5 for further information).⁴⁰

Whilst the MARPOL Convention covers technical aspects of pollution from ships, including the operational discharges by vessels, it does not cover the dumping of wastes by ships, which is covered by the London Convention. The prohibition of all incineration at sea under the London Protocol does not affect the incineration of garbage on board vessels allowed by Annex V of MARPOL (provided all conditions of that Annex are met).⁴¹

2.1.4 The Basel Convention

Marine debris from commercial shipping is partially addressed through the Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal (also known as the Basel Convention, 1992)

The main objective of this Convention, which has been ratified by 180 states, is 'environmentally-sound management', the aim of which is to protect human health and the environment by minimizing hazardous waste production whenever possible.^{42, 43}

This means addressing the issue through an 'integrated life-cycle approach', which involves strong controls, from the generation of a hazardous waste to its storage, transport, treatment, reuse, recycling, recovery and final disposal. Any hazardous (in the sense of the Convention) marine debris from land-based sources falls under the scope of the Convention. Some non-hazardous, land-based marine debris also falls under the scope of the Convention under the categories of wastes requiring special consideration. In this context, a number of technical guidelines for the

³⁹ VanderZwaag, D.L. (2011) *The International Control of Ocean Dumping: Precautionary Currents, Sea of Challenges*

⁴⁰ IMO (n.d.) *London Convention and Protocol: their role and contribution to protection of the marine environment*, accessed 27 November 2013, http://www.imo.org/blast/blastDataHelper.asp?data_id=21278&filename=LC-LPbrochure.pdf

⁴¹ IMO (2005) *London Convention Frequently Asked Questions*, accessed 27 November 2013, http://www.imo.org/blast/mainframemenu.asp?topic_id=1513

⁴² UNEP (2009) *Marine Litter - A Global Challenge*, accessed 11 October 2013, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

⁴³ UNEP (2011) *The Basel Convention: Ship Dismantling*, accessed 8 November 2013, <http://www.basel.int/Implementation/TechnicalAssistance/ShipDismantling/Overview/tabid/2762/Default.aspx>

environmentally sound management of hazardous and other wastes, adopted by the Parties to the Convention, are relevant to the marine debris problem.⁴⁴

The issue of wastes generated on board ships and how far the Basel Convention regulates the generation and management of such wastes, including their Transboundary movement, raises the question of the relationship between the Basel Convention and other treaties regulating maritime affairs that fall under the framework of the IMO. Parties to the Basel Convention and the IMO are in the process of clarifying the relationship between the Basel Convention and MARPOL; through assessing how far the current Basel Convention technical guidelines cover MARPOL wastes, in addition to developing a guidance manual on how to improve the sea-land interface to ensure that wastes falling within the scope of MARPOL, once offloaded from a ship, are managed in an environmentally sound manner.⁴⁵

2.1.5 UNCLOS

The United Nations Convention on the Law of the Sea (UNCLOS) is the international agreement that resulted from the third United Nations Conference on the Law of the Sea, which took place between 1973 and 1982. UNCLOS defines the rights and responsibilities of nations in their use of the world's oceans, establishing guidelines for the management of marine natural resources. A total of 166 States are party to this Convention.⁴⁶

Part XII of the Convention (protection and preservation of the marine environment) includes measures to prevent, reduce and control pollution of the marine environment and to prevent transfer of damage or hazards from one area to another. Article 194 (measures to prevent, reduce and control pollution of the marine environment) and Article 195 (duty not to transfer damage or hazards or transform one type of pollution into another) are relevant to marine debris.⁴⁷ Article 211 details the international rules and national legislation to be set according to UNCLOS, with regards to pollution from vessels. The enforcement required by flag states is detailed in Article 217.⁴⁸ Through these articles, UNCLOS supports the requirements set out in MARPOL Annex V.

⁴⁴ UNEP (2009) *Marine Litter - A Global Challenge*, accessed 11 October 2013, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

⁴⁵ UNEP (2013) Development of an assessment of how far the Basel Convention technical guidelines cover MARPOL wastes and of a guidance manual on how to improve the sea-land interface to ensure that MARPOL wastes, once offloaded a ship, are managed in an environmentally sound manner

⁴⁶ UN (2013) *United Nations Convention on the Law of the Sea: Chronological lists of ratifications of, accessions and successions to the Convention and the related Agreements as at 29 October 2013*, accessed 23 October 2013, http://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

⁴⁷ Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591 – 598

⁴⁸ UN (2013) *United Nations Convention on the Law of the Sea: Chronological lists of ratifications of, accessions and successions to the Convention and the related Agreements as at 29 October 2013*,

2.1.6 International Safety Management Code

The IMO adopted the International Management Code for the Safe Operation of Ships and for Pollution Prevention (the ISM Code) in 1993, and it became mandatory in 1998. The code establishes safety-management objectives and requires a safety management system to be established by “the Company”, which is defined as the person assuming responsibility for operating the ship. The Company is then required to establish and implement a policy for achieving these objectives. This includes providing the necessary resources and shore-based support.⁴⁹ The ISM Code also contains requirements for all vessels to record volumes and types of waste (in accordance with MARPOL 73/78) and method of disposal.⁵⁰

2.1.7 The Honolulu Strategy

The Fifth International Marine Debris Conference took place 20-25 March 2011, organised by the National Oceanic and Atmospheric Administration (NOAA) and UNEP, and established the Honolulu Strategy. This strategy sets forth a results-oriented framework of action with the overarching goal to reduce impacts of marine debris over the subsequent ten years. This goal will be achieved through the collective action of committed stakeholders at global, regional, country, local, and individual levels.⁵¹

The strategy establishes three main goals in a global framework for prevention and management of marine debris. The most relevant to marine debris from commercial shipping is Goal B, which aims to reduce the amount and impact of sea-based sources of marine debris, including solid waste; lost cargo; abandoned, lost, or otherwise discarded fishing gear (ALDFG); and abandoned vessels, introduced into the sea. The six strategies established to achieve this are as follows:

- Strategy B1. Conduct ocean-user education and outreach on marine debris impacts, prevention, and management
- Strategy B2. Develop incentives and markets to strengthen implementation of waste minimization and proper waste storage at sea, and of disposal at port reception facilities, in order to minimize incidents of ocean dumping
- Strategy B3. Develop and strengthen implementation of industry best management practices (BMP) designed to minimize abandonment of vessels and accidental loss of cargo, solid waste, and gear at sea

accessed 23 October 2013,

http://www.un.org/depts/los/convention_agreements/texts/unclos/unclos_e.pdf

⁴⁹ IMO (2013) *Safety Management: Development of the ISM Code*, accessed 23 October 2013, <http://www.imo.org/OurWork/HumanElement/SafetyManagement/Pages/Default.aspx>

⁵⁰ Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591 – 598

⁵¹ NOAA, and UNEP (2011) *Fifth International Marine Debris Conference: The Honolulu Strategy*, accessed 23 October 2013, <http://5imdc.wordpress.com/about/honolulustrategy/>

- Strategy B4. Develop and promote use of fishing gear modifications or alternative technologies
- Strategy B5. Develop and strengthen implementation of legislation and policies to prevent and manage marine debris from at-sea sources, and implement the requirements of MARPOL Annex V, as well as other relevant international instruments and agreements
- Strategy B6. Build capacity to monitor and enforce (1) national and local legislation, and (2) compliance with requirements of MARPOL Annex V and other relevant international instruments and agreements.⁵²

The Honolulu Strategy is being used to guide the Global Partnership on Marine Litter (GPML), a partnership formed by the Global Programme of Action (GPA) and UNEP in June 2012 following recommendations from the Manila Declaration.^{53 54} The three goals outlined in the Honolulu Strategy are the three key Partnership Areas driving research. The first partnership forum for the GPML was held during the Second Global Conference on Land-Ocean Connections, 2-4 October, 2013, Montego Bay, Jamaica. Discussions during this conference will inform the priorities of the work plan, which, as of November 2013, has not yet been published.⁵⁵

2.1.8 FAO Code of Conduct for Responsible Fisheries

As explained in Section 1.1, fishing vessels tend not to be included in the scope of 'commercial marine vessels', but as the fishing sector represents a significant proportion of seagoing vessels it is important that they are considered when discussing ocean based sources of marine litter.

The FAO (Food and Agriculture Organization of the United Nations) Code of Conduct for Responsible Fisheries is a guidance document that establishes this key message:

The right to fish carries with it the obligation to do so in a responsible manner so as to ensure effective conservation and management of the living aquatic resources.

This Code was adopted in 1995, and sets out principles and international standards of behaviour for responsible practices with a view to ensuring the effective

⁵² NOAA, and UNEP (2011) *Fifth International Marine Debris Conference: The Honolulu Strategy*, accessed 23 October 2013, <http://5imdc.wordpress.com/about/honolulustrategy/>

⁵³ UNEP (2013) *Global Partnership on Marine Litter: Draft Framework Document/Operational Guidelines*, accessed 27 November 2013, <http://www.gpa.unep.org/index.php/global-partnership-on-nutrient-management/publications-and-resources/global-partnership-on-marine-litter-gpml/170-draft-framework-document-for-gpml/file>

⁵⁴ UNEP (2013) *Global Partnership on Marine Litter - Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA)*, accessed 27 November 2013, <zotero://attachment/12140/>

⁵⁵ UNEP (2013) *Global Partnership on Marine Litter - Global Programme of Action for the Protection of the Marine Environment from Land-based Activities (GPA)*, accessed 27 November 2013, <zotero://attachment/12140/>

conservation, management and development of living aquatic resources, with due respect for the ecosystem and biodiversity.^{56 57}

Article 8.7 of the Code (protection of the aquatic environment) provides detail on the requirements with regards to preventing loss of fishing gear and the disposal of garbage at sea:

- Article 8.7.1: States should introduce and enforce laws and regulations based on the International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto (MARPOL 73/78).
- Article 8.7.2: Owners, charterers and managers of fishing vessels should ensure that their vessels are fitted with appropriate equipment as required by MARPOL 73/78 and should consider fitting a shipboard compactor or incinerator to relevant classes of vessels in order to treat garbage and other shipboard wastes generated during the vessel's normal service.
- Article 8.7.3: Owners, charterers and managers of fishing vessels should minimize the taking aboard of potential garbage through proper provisioning practices.
- Article 8.7.4: The crew of fishing vessels should be conversant with proper shipboard procedures in order to ensure discharges do not exceed the levels set by MARPOL 73/78. Such procedures should, as a minimum, include the disposal of oily waste and the handling and storage of shipboard garbage.⁵⁸

A report undertaken by the World Wildlife Fund (WWF) and the University of British Columbia Fisheries Centre assessed the implementation of the FAO Code of Conduct after the first ten years of its operation. This report evaluated the top 53 fishing countries responsible for 95% of the reported world marine fish catch, using a questionnaire to capture the level of compliance with the Code. Overall compliance with the Code is described to be 'dismal', with not one country out of the 53 achieving a 'good' compliance score.⁵⁹

With regards to preventing loss of fishing gear the report assessed the top 53 fishing nations for the mention of the topic of ghost fishing in the available literature, which yielded poor results for the majority of countries. Only five countries (South Korea, Canada, Australia, Sweden and Norway) have good compliance with the Code in terms of retrieving ADLFG, according to the WWF report.⁶⁰

⁵⁶ FAO (1995) *Code of Conduct for Responsible Fisheries*, 1995

⁵⁷ UNEP (2009) *Marine Litter - A Global Challenge*, accessed 11 October 2013, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

⁵⁸ FAO (1995) *Code of Conduct for Responsible Fisheries*, 1995

⁵⁹ WWF (2008) *Safe Conduct? Twelve years fishing under the UN Code*, accessed 27 November 2013, http://awsassets.panda.org/downloads/un_code.pdf

⁶⁰ WWF (2008) *Safe Conduct? Twelve years fishing under the UN Code*, accessed 27 November 2013, http://awsassets.panda.org/downloads/un_code.pdf

2.2 Regional Measures

2.2.1 Marine Strategy Framework Directive (European Union)

At the regional level, Europe provides a good example of where there is a developing momentum in respect of legislative approaches to marine litter. The Marine Strategy Framework Directive (2008/56/EC), adopted in 2008, aims to achieve "Good Environmental Status" (GES) of all marine waters of the European Union by 2020. The eleven qualitative descriptors for determining good environmental status are included within Annex I of the Directive.^{61 62}

The Directive establishes European Marine Regions on the basis of geographical and environmental criteria. Each Member State, in co-operation with other Member States and non-EU countries with a marine region, is required to develop strategies for their marine waters. The marine strategies to be developed by each Member State must contain a detailed assessment of the state of the environment, a definition of "good environmental status" at regional level and the establishment of clear environmental targets and monitoring programmes. Each Member State must draw up a programme of cost-effective measures. Prior to any new measure, an impact assessment, which includes a detailed cost-benefit analysis of the proposed measures, is required.⁶³

The European Commission held a Workshop on Marine Litter in Brussels (8 November 2010), and an international conference in Berlin (10-12 April 2013) on the Prevention and Management of Marine Litter in European Seas.

2.2.2 EU Directive on Port Reception Facilities for Ship-generated Waste and Cargo Residues (EC/2000/59)

This EU Directive is another example of action taken at the regional level. It aims to significantly reduce the illegal discharge of ship-generated waste and cargo residues into the marine environment by improving the availability and use of port reception facilities. The regulations entered into force in July 2003 and key terms include:

- The mandatory provision of waste reception facilities in all ports, tailored to the size of port and type of vessels calling there. Ports must draw up waste reception and handling plans to be inspected and approved by Member States every three years;

⁶¹ European Commission (2012) *A Marine Strategy Directive to save Europe's seas and oceans*, accessed 28 November 2013, http://ec.europa.eu/environment/water/marine/directive_en.htm

⁶² European Commission (2008) *Directive 2008/56/EC - Marine Strategy Framework Directive*, accessed 15 October 2013, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF>

⁶³ European Commission (2008) *Directive 2008/56/EC - Marine Strategy Framework Directive*, accessed 15 October 2013, <http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2008:164:0019:0040:EN:PDF>

- All ships must deliver their waste to the port reception facilities before leaving the port or terminal, unless they are exempt or have sufficient dedicated storage capacity to store the waste until the next port of call;
- Captains of ships bound for a port or terminal must notify it of certain information including the types and quantities of waste for discharge and the date and last port where waste was discharged;
- Ships that do not deliver waste in one port and who are not subject to an exemption will be reported to their next port of call and required to undergo a detailed inspection before cargo and passengers can be transferred;
- Ports must establish a cost-recovery system to encourage vessels to discharge their waste on land and discourage dumping at sea. All ships must pay a mandatory charge to make a significant contribution to the cost of the port reception facilities for ship generated waste, irrespective of whether they use them or not; and
- Member States must ensure proper monitoring of compliance with the directive, both by ships and ports, and submit a progress report to the European Commission every three years about the status of the Directive's implementation.⁶⁴

The ongoing review of the Port Reception Facilities Directive gives the EU an opportunity to target litter originating from ships and remove the economic disincentives to discharging waste at reception facilities.

2.2.3 Regional Seas Programme - Regional Conventions

The Regional Seas Programme aims to address the accelerating degradation of the world's oceans and coastal areas through the sustainable management and use of the marine and coastal environment, by engaging neighbouring countries in comprehensive and specific actions to protect their shared marine environment. Thirteen regions have been established under the auspices of UNEP (Black Sea, East Asian Seas, Eastern Africa, the ROPME Sea Area, Mediterranean, North-East Pacific, Northwest Pacific, Red Sea & Gulf of Aden, South Asian Seas, Pacific, South-East Pacific, Western Africa and Wider Caribbean). Similar independent agreements are in place in the Antarctica, Arctic, Baltic, Caspian and North-East Atlantic.⁶⁵

The majority of regional sea areas have a convention in place that provides the legal framework for the regional Action Plan. The Convention expresses in clear terms the legal commitment and political will of governments to tackle their common environmental problems. Most regional conventions are similar in structure but different in specifics. Six of the regional conventions draw particular attention to the

⁶⁴ European Commission (2010) *Port facilities for ship-generated waste and cargo residues*, accessed 28 November 2013, http://europa.eu/legislation_summaries/environment/waste_management/l24199_en.htm

⁶⁵ UNEP (n.d.) *Regional Seas Programme*, accessed 28 November 2013, <http://www.unep.org/regionalseas/about/default.asp>

dumping of waste at sea: Barcelona Convention (Mediterranean), Bucharest Convention (Black Sea), Cartagena Convention (Wider Caribbean), Helsinki Convention (Baltic Sea), Noumea Convention (Pacific Islands), OSPAR Convention (North East Atlantic).^{66 67} The Cartagena Convention is described below as an example.

Cartagena Convention

In the Caribbean, the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, known as the Cartagena Convention, came into force in 1987. It includes measures to prevent or reduce pollution from both ships and land-based activities.⁶⁸ Although the Caribbean has been designated as a Special Area under MARPOL Annex V, this designation has not yet entered into force because many countries in the region lack the port facilities necessary for receiving Annex V wastes from ships.^{69 70}

Article 4: GENERAL OBLIGATIONS

1. The Contracting Parties shall, individually or jointly, take all appropriate measures in conformity with international law and in accordance with this Convention and those of its protocols in force to which they are parties to prevent, reduce and control pollution of the Convention area and to ensure sound environmental management, using for this purpose the best practicable means at their disposal and in accordance with their capabilities.
2. The Contracting Parties shall, in taking the measures referred to in paragraph 1, ensure that the implementation of those measures does not cause pollution of the marine environment outside the Convention area.
3. The Contracting Parties shall co-operate in the formulation and adoption of protocols or other agreements to facilitate the effective implementation of this Convention.
4. The Contracting Parties shall take appropriate measures, in conformity with international law, for the effective discharge of the obligations prescribed in this Convention and its protocols and shall endeavour to harmonize their policies in this regard.

⁶⁶ UNEP (n.d.) *Regional Seas Programme*, accessed 28 November 2013, <http://www.unep.org/regionalseas/about/default.asp>

⁶⁷ IMO (n.d.) *London Convention/London Protocol linkages with other international conventions for the protection of the marine environment*, accessed 28 November 2013, http://www.imo.org/blast/blastDataHelper.asp?data_id=30589&filename=E-LP-Linkages.pdf

⁶⁸ Sheavly, S.B. (2005) *Marine Debris – an Overview of a Critical Issue for Our Oceans*, Sixth Meeting of the UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea, 2005, http://www.un.org/depts/los/consultative_process/documents/6_sheavly.pdf

⁶⁹ UNEP (2005) *Marine Litter: An Analytical Overview*, 2005

⁷⁰ Greenpeace (2006) *Plastic Debris in the World's Oceans*, accessed 16 October 2013, http://www.unep.org/regionalseas/marinelitter/publications/docs/plastic_ocean_report.pdf

5. The Contracting Parties shall co-operate with the competent international, regional and sub-regional organizations for the effective implementation of this Convention and its protocols. They shall assist each other in fulfilling their obligations under this Convention and its protocols.

Article 5: POLLUTION FROM SHIPS

The Contracting Parties shall take all appropriate measures to prevent, reduce and control pollution of the Convention area caused by discharges from ships and, for this purpose, to ensure the effective implementation of the applicable international rules and standards established by the competent international organization.

Article 6: POLLUTION CAUSED BY DUMPING

The Contracting Parties shall take all appropriate measures to prevent, reduce and control pollution of the Convention area caused by dumping of wastes and other matter at sea from ships, aircraft or manmade structures at sea, and to ensure the effective implementation of the applicable international rules and standards.

2.2.4 Memoranda of Understanding on Port State Control

The IMO recognises that the primary responsibility for implementing the regulations provided for in IMO conventions (such as MARPOL) rests with the flag State. However, it also acknowledges the need for port State control (PSC) with a view to promoting more effective implementation of all applicable standards for maritime safety and pollution prevention.⁷¹

A number of PSC resolutions have been adopted by the IMO over the years. Resolution A.787 (19) was adopted in 1995, amalgamating guidelines contained in several IMO resolutions, with the aim of providing one set of basic guidelines on the conduct of PSC inspections.⁷²

Through the conduct of PSC inspections and discussions at IMO, member governments realised that more effective PSC could be conducted by establishing regimes for its coordinated implementation at the regional level. Accordingly, many States have entered into Memoranda of Understanding (MoUs) with the view to enhancing compliance by all vessels with international rules and standards for the prevention, reduction and control of pollution from vessels. Each MoU identifies the relevant conventions to be enforced through that particular MoU. Most MoUs establish targets for the inspection of a minimum number or percentage of vessels visiting Member States ports. The following MoUs have been concluded so far:

⁷¹ IMO (2012) *Implications of the United Nations Convention on the Law of the Sea for the International Maritime Organisation*, accessed 27 November 2013, <http://www.imo.org/OurWork/Legal/Documents/Implications%20of%20UNCLOS%20for%20IMO.pdf>

⁷² IMO (2012) *Implications of the United Nations Convention on the Law of the Sea for the International Maritime Organisation*, accessed 27 November 2013, <http://www.imo.org/OurWork/Legal/Documents/Implications%20of%20UNCLOS%20for%20IMO.pdf>

- the Latin American Agreement on Port State Control of Vessels, signed in Viña del Mar, Chile, on 5 November 1992
- the Memorandum of Understanding on Port State Control in the Asia-Pacific Region (Tokyo MoU), signed in Tokyo, Japan, on 1 December 1993
- the Caribbean Memorandum of Understanding on Port State Control (Caribbean MoU), signed in Christchurch, Barbados, on 9 February 1996
- the Memorandum of Understanding on Port State Control in the Mediterranean Region (Mediterranean MoU), signed in Malta on 11 July 1997;
- the Indian Ocean Memorandum of Understanding on Port State Control (Indian Ocean MoU), signed in Pretoria, South Africa, on 5 June 1998;
- the Memorandum of Understanding for the West and Central African Region (Abuja MoU), signed in Abuja, Nigeria, on 22 October 1999;
- the Memorandum of Understanding on Port State Control in the Black Sea (Black Sea MoU), signed in Istanbul, Turkey, on 7 April 2000; and
- the Riyadh Memorandum of Understanding on Port State Control in the Gulf Region (Riyadh MoU), signed in Riyadh, Saudi Arabia, in June 2004.⁷³

Take for instance the Paris Memorandum of Understanding; 27 States in the North Atlantic region have signed the Paris Memorandum of Understanding (Paris MOU) and agreed to control visiting ships in their ports. More than 18,000 inspections take place on board foreign ships in the Paris MoU ports each year, ensuring that these ships meet international safety, security and environmental standards, and that crew members have adequate living and working conditions.⁷⁴ The number of detentions increased from 944 in 2005 to 1,174 in 2006.⁷⁵

2.2.5 Indirect Fee System

The concept of an indirect fee or “no special fee” system is that port fees paid for by visiting ships to use the existing facilities also include waste disposal services. Multiple factors can influence the success of this incentive to encourage delivery of wastes in ports, most importantly the institutional framework and design or roll-out of the instrument. The lack of harmonisation throughout ports in close proximity is a factor that may hinder the full potential of the system as an instrument.⁷⁶

⁷³ IMO (2012) *Implications of the United Nations Convention on the Law of the Sea for the International Maritime Organisation*, accessed 27 November 2013, <http://www.imo.org/OurWork/Legal/Documents/Implications%20of%20UNCLOS%20for%20IMO.pdf>

⁷⁴ Paris MoU (2013) *Paris MoU on Port State Control*, accessed 28 November 2013, <https://www.parismou.org/about-us/organisation>

⁷⁵ Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Seas%20at%20Risk%20Policy%20Analysis%20_V%20case%20study%201_.pdf

⁷⁶ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

2.2.5.1 Baltic Sea Example

The No Special Fee System (NSF) implemented in the Baltic Sea is defined as ‘a charging system where the cost of reception, handling and disposal of ship generated wastes, originating from the normal operation of the ship, as well as of marine litter caught in fishing nets, is included in the harbour fee or otherwise charged to the ship irrespective of whether wastes are delivered or not’. The system is not restricted to any specific type of ship-generated waste, and thus includes the most common wastes from normal operation of ships: oily waste, sewage and garbage.⁷⁷

In spite of efforts to set up a harmonised system for the Baltic Sea, it appears that implementation of the fee system for ship-generated waste reception in ports differs between the countries of the Baltic. This is partly due to the many regulations and recommendations in place (MARPOL requirements, binding EU Directive, the HELCOM recommendation and existing or new national legislation). Such differences can exist in terms of granted exemptions, waste types and amounts under the system, and the level of the waste fees.⁷⁸

Exemptions

A consultation with Baltic ports identified that the percentage of individual ships covered by the NSF could range from 2 to 100%, depending on the port. The differences between countries are caused by the decision on exemptions being a Port State responsibility. Finland appears to apply more exemptions than its neighbouring country Sweden: for example, cruise ships can be exempted in Finland, but not in Sweden. The demand for an exemption is typically due to economic criteria and the benefits of flexibility in choosing specific ports for certain types of waste (where ships may have their own agreements for waste reception and handling). Ports have no insight on waste streams from exempt ships; how these ships fulfil their waste disposal requirements is reported to the national authority.⁷⁹

Waste Types and Amounts

Differences between ports based on waste types and amounts can vary significantly. Some accept any amount of garbage within no special fee conditions, whereas others only accept a specific amount of waste (often since the last port of call) under the NSF and require an additional payment for the rest of the waste. The amount of solid

⁷⁷ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁷⁸ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁷⁹ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

waste allowed to be left at the port in the Baltic Sea ports ranges from 0.4m³ to an unlimited amount.⁸⁰

Fee Rates

Port Authorities are responsible for selecting fee rates; most ports fees are differentiated by type of ship: ships carrying freight, tankers, passengers or cruise ships. In the Baltic Sea region the fee system is described in the waste management plan of the port, and the national authority must control whether the proposed system for calculation is acceptable, but does not comment on the level of the fees. The fee calculation is based on a cost recovery perspective. Total waste costs are then allocated to different ship types according to their waste generating pattern (highest costs are charged for cruise ships as they produce the most garbage). The same principles apply for the calculation of reductions in fees, and reductions are usually granted for activities such as waste sorting or the reduction of the quantity of waste.⁸¹

In the first evaluation of the NSF in Baltic ports undertaken in 2006, almost no countries offered reductions in harbour fees to reward good waste management practices. Today, reductions on port tariffs in most ports are present. A consultation of Baltic ports in 2007 identified that international cruise vessels can save up to 33% of the fee payable per passenger by sorting their waste to the approved fractions.⁸²

Evaluating Effectiveness

The 2012 Arcadis report reviews the effectiveness of the NSF against the criteria of goal achievement and additionality. In terms of garbage and solid waste, an important objective of the no special fee system is the encouragement for ships to deliver waste in ports. There is no straightforward indicator to measure this; however some statistics on the amounts of waste delivered to PRF have been collected by HELCOM.⁸³ These show a generally increasing trend that may indicate a positive development in the use of port reception facilities across the Baltic. However due to the lack of detailed data across the region an evaluation of the effectiveness of the NSF system cannot be made at present. Furthermore, it is not feasible to identify a causal relationship between the installation of the NSF system and increased delivery of ship-generated waste in ports. Despite the increasing trend to deliver in ports, the lack of harmonisation between fee systems and differences in port reception facilities

⁸⁰ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁸¹ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁸² ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁸³ HELCOM (2010) *Ecosystem Health of the Baltic Sea 2003-2007, 2010*, <http://www.helcom.fi/Lists/Publications/BSEP122.pdf>

may hinder the overall positive effect.⁸⁴ For the full, detailed evaluation of the NSF system in the Baltic Sea please refer to the Arcadis 2012 report.

2.2.5.2 Ensuring a level playing field

There are substantial differences in charging systems for waste disposal. At one end of the spectrum ports do not charge a direct fee for waste disposal, whereas other ports charge directly for waste disposal and then a discount is provided. Differences in charging systems for waste disposal may render the situation unstable; unless initiatives to manage this are taken, ports with no direct fee for waste disposal may attract disproportionate amounts of waste. From the perspective of port authorities and port users, the level playing field should not be distorted with indirect financing, unless it is to be introduced simultaneously by all ports in the area concerned.⁸⁵

There are two policy options that would ensure an undistorted playing field and user-friendly waste disposal facilities:

1. Obligating ships to demonstrate they have disposed of their waste in their previous port of call; and
2. A system of waste-disposal vouchers.

Vouchers obtained by a shipping company could be spent with any registered waste collection firm in any regional port, with the indirect fee being set at a regional level and at the same price for all regional ports. This system would ensure a level playing field and the burden on shipping lines would be low, due to the 100% indirect charge. The system is also commercially advantageous as shipping lines can dispose of waste at their port of choice.⁸⁶ Neither of the options for achieving a level playing field mentioned above has been demonstrated yet.

2.2.5.3 Summary

The EU Directive on port reception facilities aims at the further development of these facilities in Member States, leaving ports and countries a degree of freedom to decide on the port reception facilities financing mechanism. The No Special Fee system works in combination with other policy instruments (prohibition of discharging, e.g. MARPOL special area, mandatory delivery) that are generally difficult to enforce. These difficulties cannot be overcome at national level and would require an

⁸⁴ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁸⁵ de Langen, P.W., and Nijdam, M.N. (2008) Charging systems for waste reception facilities in ports and the level playing field; a case from North-West Europe, *Coastal Management*, Vol.36, No.1, pp.109 – 124

⁸⁶ Seas at Risk (n.d.) *Ship waste dumping and the clean ship concept: how an improved EU PRF Directive can play a key role in cleaning up the seas*, accessed 12 November 2013, <http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Position%20Paper160911.pdf>

international or, at least, regional cooperation (e.g. Baltic and North Sea) in order to create a level playing field for competitors.^{87 88}

Additional difficulties arise from equity issues (fair sharing of the cost burden amongst ships and between ships and ports) or bottlenecks in the extended waste chain. Cooperation and the involvement of all stakeholders in defining the requirements (e.g. adequate port reception facilities) may help to increase acceptance and uptake of the necessary actions.⁸⁹

Based upon (some quantitative) figures for selected ports or countries, it is reasonable to assume that the No Special Fee system contributed to increased delivery of wastes in ports (effectiveness), though uniform and reliable statistics to confirm this positive evolution are generally lacking. The effect of the No Special Fee system cannot be isolated from the wider strategy to reduce (illegal) pollution from shipping. A No Special Fee system should be combined with mandatory delivery, strict legislation on the prohibition of (harmful) discharges, sufficient port reception facilities and effective control.⁹⁰

The No Special Fee system has gained acceptance from different stakeholders. The shipping industry believes it is a good and suitable system if it is applied in a transparent and harmonised manner, whereas environmental NGOs oppose direct charging for waste services as this is considered to be the largest disincentive to deliver on land. The majority of Baltic ports are also in favour of the system, while not ignoring the necessity of an increased harmonisation of the implementation in order to share the waste burden.⁹¹

The Baltic example has shown the potential positive effect of the No Special Fee or (100%) indirect fee system. No sufficient evidence could be collected, however, to demonstrate a larger incentive effect for ships to deliver waste in ports compared to other port reception facilities charging / cost recovery systems. The key element for a charging system is that mechanisms should not include any financial disincentive to use waste reception facilities in ports. Fee systems should be fair and transparent.

⁸⁷ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁸⁸ de Langen, P.W., and Nijdam, M.N. (2008) Charging systems for waste reception facilities in ports and the level playing field; a case from North-West Europe, *Coastal Management*, Vol.36, No.1, pp.109 – 124

⁸⁹ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁹⁰ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁹¹ ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

For them to be really effective, the system should preferably be harmonised over a wider geographical area. Diversity in implementation, aggravated by varying levels of adequacy of port reception facilities has maintained uneven waste flows (and associated waste costs) between Baltic ports. The risk of 'waste tourism' is even higher when regarding at the wider EU level and considering the competitive environment where ports and ships are operating.⁹²

2.3 Industry / Vessel-based Measures

2.3.1 Cruise Lines International Association

Cruise ships represent less than 1% of the global merchant fleet yet it has been estimated that they are responsible for 24% of the solid waste generated by merchant vessels. For example, a typical cruise ship catering for around 3,000 passengers and crew on a one week cruise generates about 50 tons of solid waste.⁹³ The Cruise Lines International Association (CLIA) is the major trade association of the cruise industry, representing 26 major cruise lines which operate worldwide. Their remit is to monitor domestic and international policy that directly affects the industry and to develop recommendations for its members that reflect the policy climate.⁹⁴

CLIA member cruise vessel operators agreed to incorporate mandatory standards for cruise ships in 2001; this committed them to a policy goal of zero discharges of MARPOL Annex V solid waste products. This is to be achieved by using comprehensive waste minimisation practices, and re-use and recycling waste strategies.^{95 96}

However, whilst mandatory commitments may be in place for member cruise lines, these standards have been criticised as '*simply a restatement of what is already contained in mostly inadequate legislation and international polices. They scarcely exceed the minimum requirements already in place*'.⁹⁷ Whilst the policies in place may demonstrate best practice, whether compliance with the requirements is actually achieved is another matter discussed further in Sections 3.0 and 4.0.

⁹² ARCADIS (2012) *Economic assessment of policy measures for the implementation of the Marine Strategy Framework Directive*, accessed 15 October 2013, <http://ec.europa.eu/environment/enveco/water/pdf/report.pdf>

⁹³ The Ocean Conservancy (2002) *Cruise Control: A Report on How Cruise Ships Affect the Marine Environment*, accessed 17 October 2013, <http://www.cruiseresearch.org/Cruise%20Control.pdf>

⁹⁴ UNEP (2002) *Industry as a partner for sustainable development: Tourism*, accessed 17 October 2013, <http://www.unep.fr/shared/publications/pdf/WEBx0012xPA-IndustryTourism.pdf>

⁹⁵ UNEP (2005) *Marine Litter: An Analytical Overview*, 2005

⁹⁶ Greenpeace (2006) *Plastic Debris in the World's Oceans*, accessed 16 October 2013, http://www.unep.org/regionalseas/marinelitter/publications/docs/plastic_ocean_report.pdf

⁹⁷ Klein, R. (2003) *The Cruise Industry and Environmental History and Practice : Is a Memorandum of Understanding Effective for Protecting the Environment?*, accessed 24 October 2013, <http://www.cruisejunkie.com/MOUFinal.pdf>

2.3.1.1 Royal Caribbean International: Solid Waste Management

Within their 2008 Stewardship Report, Royal Caribbean International set out their commitment to implementing the waste hierarchy in the management of solid waste, i.e. to prioritize waste management routes with waste reduction being the preferred option, followed by re-use, recycling, energy recovery and then landfilling as the least preferred. Working with local authorities, vendors, conservation groups and recycling centres, the company has agreements in 20 major ports with waste management companies to receive separated and sorted materials for recycling. These partnerships have been established in eight US ports, six European ports, three Canadian ports and several Caribbean and South American ports. Throughout the fleet, approximately 25% of all waste is recycled in US ports; the most successful ships have been able to attain an 80% recycling rate of the total waste they land.⁹⁸

The Stewardship Report sets out Royal Caribbean International's intentions to further reduce their fleet's overall waste impact, both onshore and offshore. The key target established is to decrease waste incinerated and/or moved to landfills by 50% by 2015. To meet this challenge, the company intends to develop new, innovative waste stream management practices, reducing the volume of solid waste generated by 35%. Royal Caribbean International will also seek partnerships with recycling and reuse facilities in all major ports of call, in order to reach the 2015 aspirational goal of having 50% of all waste landed ashore being recycled.⁹⁹

2.3.2 The Clean Ship Concept

The Clean Ship approach is the concept of vessels designed, constructed and operated in an integrated manner with the objective to eliminate harmful operational discharges and emissions; it is a ship that is constructed and can ultimately be recycled in an environmentally acceptable way, and one that is energy and resource efficient in its daily operation.¹⁰⁰ A Clean Ship operation maximises the opportunities for safe and environmental navigation while at the same time providing all possible safeguards in the event of an accident. It requires a shipping sector that puts safety and environmental protection first; an industry with a "safety culture" at its heart.¹⁰¹

Seas At Risk coined the phrase "Clean Ship" and launched the concept at the fifth North Sea Conference in 2002 (Bergen, 20-21st March). Ministers embraced the idea and since then it has passed into popular parlance, with regulators and other

⁹⁸ Royal Caribbean Cruises Ltd (2008) *Stewardship Report*, accessed 16 October 2013, http://media.royalcaribbean.co.uk/content/en_US/env_sitelet/flash/RCCL_sitelet.pdf

⁹⁹ Royal Caribbean Cruises Ltd (2008) *Stewardship Report*, accessed 16 October 2013, http://media.royalcaribbean.co.uk/content/en_US/env_sitelet/flash/RCCL_sitelet.pdf

¹⁰⁰ Seas at Risk (2005) *Background paper on the Clean Ship approach prepared for Gothenburg meeting*, accessed 10 October 2013, <http://www.seas-at-risk.org/1images/Background%20document%20for%20Gothenburg.pdf>

¹⁰¹ Seas at Risk (2013) *The Clean Ship concept*, accessed 29 September 2013, <http://www.seas-at-risk.org/n3.php?page=67>

stakeholders increasingly using the term to define and describe their ultimate objective for an environmentally benign shipping sector.¹⁰²

Seas At Risk welcomes this but is increasingly concerned that the concept is being used solely as an argument for more research rather than urgent regulatory action. While research and development is needed in some areas the reality is that if all shipping adopted the technologies and practices that are currently being used by the best operators then the industry would be 90% of the way to implementing a Clean Ship approach. Unfortunately the quality operators occupy a small niche in an otherwise environmentally sub-standard industry, and regulations are rarely an encouragement to high standards, normally lagging far behind current best available technologies and practices. Seas At Risk's work in this area is now focussing on closing this gap between regulatory standards and the best currently available technologies and practices.^{103 104 105}

The Gothenburg Declaration 2006 (the outcome of an OSPAR conference in Gothenburg) specifically focused on impacts of fisheries and shipping as important pressures on the marine environment of the North Sea. The Declaration reinforces the commitment of North Sea states to the "clean ship approach" as a concept of vessels designed, constructed and operated in an integrated manner with the objective to eliminate harmful discharges and emissions throughout their working life. As an integrated approach of sustainable shipping it addresses all vessel operations and possible impacts on the environment, and will provide an increased opportunity for transport managers to choose environmentally sound sea transport options. The clean ship approach has been followed up by some OSPAR countries, such as Germany through the Blue Angel eco label (see Section 2.3.3 for more details).¹⁰⁶

2.3.3 The Blue Angel

The Blue Angel is an environment-related label that may be awarded to products and services which, from a holistic point of view, meet high environmental standards. The

¹⁰² Seas at Risk (2013) *The Clean Ship concept*, accessed 29 September 2013, <http://www.seas-at-risk.org/n3.php?page=67>

¹⁰³ Seas at Risk (2013) *The Clean Ship concept*, accessed 29 September 2013, <http://www.seas-at-risk.org/n3.php?page=67>

¹⁰⁴ Seas at Risk (2005) *Background paper on the Clean Ship approach prepared for Gothenburg meeting*, accessed 10 October 2013, <http://www.seas-at-risk.org/1images/Background%20document%20for%20Gothenburg.pdf>

¹⁰⁵ Gothenburg Declaration (2006) Declaration, paper given at North Sea Ministerial Meeting on the Environmental Impact of Shipping and Fisheries, Gothenburg, Sweden, 5 May 2006, http://qsr2010.ospar.org/media/assessments/Basic_documents/Gothenburg_Declaration.pdf

¹⁰⁶ OSPAR Commission (2009) *Assessment of the impacts of shipping on the marine environment*, accessed 10 October 2013, http://qsr2010.ospar.org/media/assessments/p00440_Shipping_Assessment.pdf?zoom_highlight=clean%2Bship#search=%22clean%20ship%22

Blue Angel was created in 1978 on the initiative of the German Federal Minister of the Interior, but can be awarded to a service or product in international markets.¹⁰⁷

The Blue Angel may be awarded to environmentally-sound ship operations, recognising efforts to reduce emissions and releases of pollutants into the marine environment caused by a seagoing vessel. To achieve the Blue Angel eco-label, particularly high standards are imposed on the management of shipping companies and ships, on ship design and equipment, and especially on the measures for the reduction of emissions. Fishing vessels, tank ships, sports boats and naval vessels are excluded from the Blue Angel.^{108 109}

The standards for waste disposal under the Blue Angel eco-label refer to the requirements of MARPOL Annex V with regards to distances from the coastline for disposal at sea and the maintenance of a Garbage Record Book. The Blue Angel also refers to the EU Port Reception Facility Directive, which requires ships to dispose of their waste on land. Additional obligatory requirements under the eco-label are as follows:

- For cargo ships:
 - Implementation of a purchasing strategy aimed at waste avoidance;
 - On-board storage of all wastes and disposal on land; and
 - Ban on waste incineration at sea.
- For passenger ships:
 - Implementation of a purchasing strategy aimed at waste avoidance; and
 - Incineration of wastes provided that no intermediate shipboard storage is feasible until the waste can be disposed of ashore in an ecologically sound manner.

Ship operators can demonstrate compliance with these standards by incorporating procedural instructions in the management system stipulating a corresponding waste management (such as the purchasing strategy, storage etc.). There are no optional requirements; all must be adhered to in order to achieve the Blue Angel.¹¹⁰ The

¹⁰⁷ The Blue Angel (2013) *The Blue Angel*, accessed 7 November 2013, <http://www.blauer-engel.de/en/index.php>

¹⁰⁸ The Blue Angel (2013) *Environment-conscious Ship Operation (Edition January 2010) (RAL-UZ 110)*, accessed 7 November 2013, http://www.blauer-engel.de/en/products_brands/search_products/produkttyp.php?id=506

¹⁰⁹ Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Policy%20Analysis%20_V_W%20case%20study%201_.pdf

¹¹⁰ The Blue Angel (2013) *Environment-conscious Ship Operation (Edition January 2010) (RAL-UZ 110)*, accessed 7 November 2013, http://www.blauer-engel.de/en/products_brands/search_products/produkttyp.php?id=506

application of the Blue Angel amongst shipping operators has not yet been publicised, however a wide range of products have been awarded the eco-label, see <http://www.blauer-engel.de/en/index.php> for more information.

2.3.4 The Clean Shipping Index

The Clean Shipping Index (CSI) is an easy to use, transparent tool which can be used by cargo owners to evaluate the environmental performance of their providers of sea transport. To be included in the Clean Shipping Index, ship-owners are required to complete a questionnaire consisting of twenty questions on a vessel's operational impact. The information is entered on a ship-by-ship basis but is also added to total carrier fleet score for an overall ranking. Depending on the information provided, scoring is obtained in five different areas: SO_x and PM emissions, NO_x emissions, CO₂ emissions, chemicals, water and waste control. Questions on waste relate to garbage handling and crew awareness. Scores can only be obtained for measures that go beyond existing regulations.¹¹¹

Based on the scores, a ship is ranked as having a 'low', 'medium' or 'good' performance. The final index score is the total average score multiplied by the percentage of reported ships of the totally owned or managed fleet. Data can be analysed in much more detail, down to the level of NO_x emissions for a single engine or stern tube oil usage on a single ship for example. A vessel or shipping company cannot perform well in only one area of the index (for instance sulphur emissions) and get a good overall performance. The index is dynamic; what is perceived to be good environmental performance at one point in time may change as new technology is developed and installed, and environmental legislation becomes stricter. At the time of writing this report, data from around one thousand six hundred large vessels is included in the database; more vessels are continuously added as time goes by.¹¹²

If reasonable but significant environmental demands are coordinated from large cargo owners, a win-win situation could be created. This would be beneficial for quality shipping companies, subcontractors for clean technology and the environment itself. Submission is voluntary and data is only verified if ship owners pay Class Societies (so far Lloyd's Register and Det Norske Veritas offer these services) for third party verification. Amongst the shippers in the Clean Shipping Network, submission of data is becoming a requirement for shipping goods. For example, Volvo requires all ship-owners transporting Volvo goods to submit CSI data.¹¹³

¹¹¹ Clean Shipping Index (2011) *Clean Shipping Index: Environmental Opportunities for Shipping*, accessed 16 October 2013, <http://www.s1137723-4240.cystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf>

¹¹² Clean Shipping Index (2011) *Clean Shipping Index: Environmental Opportunities for Shipping*, accessed 16 October 2013, <http://www.s1137723-4240.cystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf>

¹¹³ Clean Shipping Index (2011) *Clean Shipping Index: Environmental Opportunities for Shipping*, accessed 16 October 2013, <http://www.s1137723-4240.cystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf>

A summary of benefits to the key users of the CSI are as follows:

- **Port authorities** can use the Clean Shipping Index as a tool to measure environmental performance of the ships calling into the port in question. Well-performing vessels could be offered a reduction in the port dues; this may help to attract high performing vessels as well as environmentally focused cargo owners;
- **Shipping companies** can add vessels to the Clean Shipping database and see the environmental performance of each vessel, and their fleet, compared to competitors. When the performance of a ship or fleet is good, information provided via the CSI can be used to gain market share from competitors; and
- **Cargo owners:** consumers are becoming more and more interested in the indirect emissions of products. The CSI helps cargo owners keep track of which carriers are best when it comes to environmental performance.¹¹⁴

2.3.5 Zero Solid Waste Policy

Preventing marine debris from ocean based sources requires the commitment and efforts of companies operating in the marine environment. This includes corporate culture, policies, protocols, and practices to ensure that company activities at sea do not generate marine debris. Matson Navigation transits the Pacific between Hawaii, California and China, and is the only commercial container operator that has a zero solid waste discharge policy.¹¹⁵

The “Greentainer” Program with Zero Solid Waste was developed in 1993 through collaboration with the Center for Marine Conservation (now Ocean Conservancy). Matson spent \$224,000 to replace existing containers with ones specifically designed for storing solid waste when at sea. This programme was designed to also engage employees of shipyards and containerised freight companies to develop controls on discharges of solid wastes into the ocean and ports. Thus far the programme has been embraced enthusiastically by Matson’s personnel, and has resulted in improved handling of solid wastes in port. ^{116 117}

The programme consists of signage, workshops for dock employees, increased waste receptacles on ships, and increased shoreline waste management facilities. Since

¹¹⁴ Clean Shipping Index (2011) *Clean Shipping Index: Environmental Opportunities for Shipping*, accessed 16 October 2013, <http://www.s1137723-4240.cystone.net/cleanshippingindex.org/wp-content/uploads/2012/12/CleanShippingBrochure.pdf>

¹¹⁵ NOAA, and UNEP (2011) *Honolulu Strategy: Technical Proceedings of the Fifth International Marine Debris Conference (Honolulu Strategy)*, accessed 23 October 2013, <http://5imdc.files.wordpress.com/2011/03/5imdc-proceedings-final1.pdf>

¹¹⁶ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

¹¹⁷ Matson (2012) *Environmental Stewardship - Zero Solid Waste*, accessed 13 November 2013, http://www.matson.com/corporate/about_us/zero_solid_waste.html

1994 approximately 12,000 tons of material has been kept on board rather than going into the ocean.^{118 119}

3.0 Enforcement Mechanisms

Regulating marine debris at an international level presents numerous challenges. The immensity of the ocean and the lack of state jurisdiction beyond approximately 200 nautical miles off the coast make effective enforcement of international legislation very challenging. Within the current regulatory system compliance with international standards is left to the decision of the captain of the ship.

Enforcement and compliance are delegated to individual states, and regulated by the International Maritime Organization (IMO). When a Government accepts an IMO Convention it agrees to make it part of its own national law, and to enforce it just like any other law. However, some countries lack the expertise, experience and resources required to do this properly. Others may implement the requirements into national legislation as required, but enforcement may be low on the priority list.¹²⁰ Furthermore, although the IMO has enacted many rules, violators are not incentivised to comply, and largely feel free to discharge without fear of being caught.^{121 122 123}

When a coastal state detects an alleged violation, it is required to either take action under its own laws or forward the case to the flag state for consideration. When an offence occurs in international waters, the responsibility for imposing the penalty lies with the flag state.¹²⁴ However, it appears that the level of enforcement depends on the both the priority that marine debris has within the nation or government

¹¹⁸ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

¹¹⁹ Matson (2012) *Environmental Stewardship - Zero Solid Waste*, accessed 13 November 2013, http://www.matson.com/corporate/about_us/zero_solid_waste.html

¹²⁰ IMO (2013) *Frequently Asked Questions*, accessed 12 November 2013, <http://www.imo.org/About/Pages/FAQs.aspx>

¹²¹ Rakestraw, A. (2012) *NOTE: Open Oceans and Marine Debris: Solutions for the Ineffective Enforcement of MARPOL Annex V*, accessed 12 November 2013, <https://litigation-essentials.lexisnexis.com/webcd/app?action=DocumentDisplay&crawlid=1&doctype=cite&docid=35+Hastings+Int%27I+%26+Comp.+L.+Rev.+383&srctype=smi&srcid=3B15&key=8ffd62b74e788907b70e5863412f38ef>

¹²² NOAA, and UNEP (2011) *Honolulu Strategy: Technical Proceedings of the Fifth International Marine Debris Conference (Honolulu Strategy)*, accessed 23 October 2013, <http://5imdc.files.wordpress.com/2011/03/5imdc-proceedings-final1.pdf>

¹²³ Palomares, M. (2006) *Prevention of Marine Litter Pollution Under IMO Conventions*, paper given at 1st NOWPAP Workshop on Marine Litter, Incheon, Republic of Korea, 9 June 2006, <http://www.unep.org/regionalseas/marinelitter/publications/workshops/nowpap/presentation/imocoventions.pdf>

¹²⁴ NOAA, and UNEP (2011) *Honolulu Strategy: Technical Proceedings of the Fifth International Marine Debris Conference (Honolulu Strategy)*, accessed 23 October 2013, <http://5imdc.files.wordpress.com/2011/03/5imdc-proceedings-final1.pdf>

concerned, and the status of the ocean area in which non-compliance has been discovered. For instance, special areas (as designated by MARPOL Annex V) are more likely to be subject to more active monitoring and enforcement by the surrounding nations.

Today, many cruise and shipping companies register their ships in open registry states, but register their corporate financial instruments elsewhere. The industry's ability to capitalize on governmental complacency often associated with flag-of-convenience countries and the strict secrecy laws associated with offshore tax havens make it difficult for federal investigators to gather information relevant to environmental crimes and to enforce penalties.¹²⁵

Open registry states undermine the enforcement regime through their inability or unwillingness to pursue violators. In the case of garbage discharge, detecting violations while in international waters is not feasible. True enforcement lies in the regular maintenance of a garbage record book and in the construction of a viable garbage management plan, both of which are overseen by flag states.¹²⁶

3.1 Fines

Fines, penalties, penalty charges and non-compliance fees are a type of market-based instrument, used in order to discourage dumping garbage at sea. The levels may be set using different criteria, such as: the costs of damage; on an "affordability basis"; or on legal limits. Sometimes non-compliance fees are a great deal higher than the costs associated with compliance, if established correctly. Collection of fees and enforcement are essential in making these instruments work.¹²⁷

Some State Parties may impose financial fines on organisations that do not comply with international and national regulations, such as MARPOL and its implementation within Member States. For instance in Australia, fines of up to \$A 1.3 million for companies and \$A 260,000 for individuals may be imposed on vessel operators illegally discharging garbage at sea. Recently there have been a number of prosecutions for garbage offences in Australian waters. Examples of penalties imposed on vessel owners include:

- Food waste discharged in the Great Barrier Reef fines ranging from \$4,825 to \$6,000; and
- Plastic discharged into the sea fines ranging from \$350 to \$35,000.^{128 129}

¹²⁵ The Ocean Conservancy (2002) *Cruise Control: A Report on How Cruise Ships Affect the Marine Environment*, accessed 17 October 2013, <http://www.cruiseresearch.org/Cruise%20Control.pdf>

¹²⁶ NOAA, and UNEP (2011) *Honolulu Strategy: Technical Proceedings of the Fifth International Marine Debris Conference (Honolulu Strategy)*, accessed 23 October 2013, <http://5imdc.files.wordpress.com/2011/03/5imdc-proceedings-final1.pdf>

¹²⁷ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

¹²⁸ Australian Maritime Safety Authority (2008) *Stow it Don't Throw it*, accessed 17 October 2013, <http://www.amsa.gov.au/forms-and-publications/Publications/Stow-it.pdf>

In the EU it is the prerogative of the individual Member State to determine what the penalty (fine, imprisonment) should be for a ship caught, or suspected, of dumping waste at sea. In Europe there are several cases of ships being temporarily banned from entry for being sub-standard under the Paris MOU (see Section 2.2.4) but very few tough penalties have been handed out.¹³⁰

In contrast, in the US, substantial fines and cases of imprisonment have often been awarded to sub-standard ships. For example, the US cruise ship *Regal Princess* was fined \$US 500,000 (€336,600) in 1993 for dumping 20 bags of garbage in to the sea and earlier in 2011 the shipping company Cardiff Marine Inc. was sentenced to pay \$US 2.4 million (€1.7 million) for falsifying records of illegal discharges of oily waste. A system of fines for vessels caught with falsified record books, for example, should provide a disincentive to discharge illegally¹³¹ and act as a genuine deterrent to dumping of debris.^{132 133}

3.2 Inspections

With the exception of very small vessels, ships engaged on international voyages must carry on board valid international certificates which may be accepted at foreign ports as prima facie evidence that the ship complies with the requirements of the MARPOL Convention. If, however, there are clear grounds for believing that the condition of the ship or its equipment does not correspond substantially with the particulars of the certificate, or if the ship does not carry a valid certificate, the authority carrying out the inspection may detain the ship until it is satisfied that the ship can proceed to sea without presenting unreasonable threat of harm to the marine environment.¹³⁴

¹²⁹ gCaptain (2012) *Shipping Company Fined \$5000 For Dumping Food Waste on Great Barrier Reef*, accessed 17 October 2013, <http://gcaptain.com/shipping-company-fined-5000-dumping/>

¹³⁰ Seas at Risk (n.d.) *Ship waste dumping and the clean ship concept: how an improved EU PRF Directive can play a key role in cleaning up the seas*, accessed 12 November 2013, <http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Position%20Paper160911.pdf>

¹³¹ Carpenter, A., and Macgill, S.M. (2001) Charging for Port Reception Facilities in North Sea Ports: Putting Theory into Practice, *Marine Pollution Bulletin*, Vol.42, No.4, pp.257 – 266

¹³² OSPAR Commission (2009) *Marine Litter in the North-East Atlantic Region: Assessment and priorities for response*, accessed 10 October 2013, http://gsr2010.ospar.org/media/assessments/p00386_Marine_Litter_in_the_North-East_Atlantic_with_addendum.pdf

¹³³ Seas at Risk (n.d.) *Ship waste dumping and the clean ship concept: how an improved EU PRF Directive can play a key role in cleaning up the seas*, accessed 12 November 2013, <http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Position%20Paper160911.pdf>

¹³⁴ IMO (2013) *MARPOL 73 - 78: Brief History - list of amendments to date and where to find them*, accessed 12 November 2013, <http://www.imo.org/KnowledgeCentre/ReferencesAndArchives/HistoryofMARPOL/Documents/MARPOL%2073-78%20Brief%20History%20-%20List%20of%20amendments%20and%20how%20to%20find%20them.htm>

However, inspections may not be achieving their full potential; under the EU Directive on Port Reception Facilities there is no requirement for port state control to check either garbage record books or the Oil Record Books. This is a stipulation of the Directive on Port State Control (2009/16/EC). However, under this directive there is no direction to verify whether the information detailed in either book correlates with the estimated quantities of garbage/oil on board the vessel. Here, it is clear that further guidance should be given as to what would entail an adequate inspection.¹³⁵

3.3 Summary

The persistence of the marine debris problem results from both a lack of global and regional strategies and deficiencies in the implementation and enforcement of existing international, regional and in particular national programmes, regulations and standards. A number of countries have taken steps at the national level to address the marine debris problem through legislation and enforcement of regional and international agreements through national regulations, provision of appropriate reception facilities for ship-generated wastes (including damaged fishing gear and nets), cooperative action within the fishing sector to prevent the abandonment and discarding of old fishing gear, improvements in waste management practices and beach clean ups, underpinned by information, education and public awareness programmes.¹³⁶

However, much more information on the scope and prevention of the marine debris problem is needed. There are many areas where no information on marine debris types, amounts, sources and impacts has been collected. With the continued presence and increasing impacts of this global problem, it is evident that current efforts are not adequate to abate this pollution issue.¹³⁷

Prevention is generally more effective and efficient than remedial action. In many cases, preventive mechanisms and the authority to enforce them are already implicit in existing global or regional conventions and action plans, even when marine debris is not specifically mentioned. They often include, for example, measures to decrease or eliminate the discharge of ship-generated waste, stop the discharge of solid wastes from land-based sources, protect rivers from pollution, and reduce the loss of fishing gear from fishing vessels. Similarly, when political agreements address the need to protect coastal habitats, sustain the health and productivity of seas and coastal areas, pursue integrated coastal zone management and sustainable development of seas and coastal zones and raise environmental awareness, the issue of marine debris is included. It is critical that these regional and international instruments are

¹³⁵ Seas at Risk (n.d.) *Ship waste dumping and the clean ship concept: how an improved EU PRF Directive can play a key role in cleaning up the seas*, accessed 12 November 2013, <http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Position%20Paper160911.pdf>

¹³⁶ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

¹³⁷ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

made effective through improved legislation, regulations, enforcement and compliance at the national level.¹³⁸

4.0 Effectiveness

Despite growing political commitment and a range of international, regional and national initiatives to address and control marine debris, it remains a global problem and challenge which requires further actions that include coordinated and multi-sectoral strategies.¹³⁹

However, before launching into an analysis on the effectiveness of implemented measures, it is important to note that a significant lack of accurate data regarding the level of marine debris, both past and present, and on different geographical scales, influences the ability to assess the effectiveness of such measures. In other words, identifying overall changes in total levels of marine debris is compromised by the lack of an established baseline, as well as the geographical dispersion of incidents.

A review and analysis of the twelve regional assessment documents on marine debris, seven Regional Action Plans on the management of marine debris and the three global reviews on specific topics (marine debris monitoring; abandoned, lost or otherwise discarded fishing gear; and economic instruments) revealed a widespread lack of systematic scientific knowledge on the amounts, sources, fates, trends and impacts (social, economic and environmental) of marine debris, which hampers development and implementation of effective mitigation actions. This deficiency, in combination with the lack of specific legislation, adequate law enforcement and funding, are the primary reasons why the problem of marine debris is far from being solved. Unless effective action is taken, the global marine debris problem will only continue to worsen in the years to come.¹⁴⁰ This shows that the effectiveness of interventions on marine debris is difficult to measure, but should not be used as a reason not to act. Gaps in the regulatory system may not be easy to address until better information regarding marine debris is obtained; this may also explain why existing regulation does not address the situation either.

Despite this lack of data, several studies have made contrasting claims on the effectiveness of MARPOL Annex V. According to one study in 2002, MARPOL was widely ignored and ships continued to dump several million tonnes of plastic every year.¹⁴¹ A more recent study from 2013 claims that despite 145 nations agreeing to eliminate plastics disposal at sea, oceanic sampling suggests that the problem has

¹³⁸ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

¹³⁹ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

¹⁴⁰ UNEP (2009) *Marine Litter - A Global Challenge*, April 2009, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

¹⁴¹ Derraik, J.G. (2002) The pollution of the marine environment by plastic debris: a review, *Marine Pollution Bulletin*, Vol.44, No.9, pp.842–852

persisted or worsened since MARPOL was signed.^{142 143} It is important to take land-based sources of debris into account, as they may contribute more to overall marine debris than sea-based sources. On the other hand, another study from 2005 suggested that MARPOL has led to a reduction of debris in the oceans and on beaches.¹⁴⁴ Different reports may make contrasting conclusions, but it has been suggested that evaluation of the impacts of MARPOL may prove difficult due to the survey samples being low and from restricted geographical areas.¹⁴⁵

An assessment by the OSPAR Commission in 2007 suggests that very little progress has been achieved in the development and implementation of programmes and measures to reduce the illegal input of wastes from its marine sources, or to introduce mechanisms for the remediation of existing debris in the coastal and marine environments.¹⁴⁶ However this study was undertaken seven years ago and may not present the current situation. A study by the German Federal Environment Agency suggests that around 60% of the wastes from shipping washed up on the beach of the German North Sea coast in 1991 – 2002 were plastic and styrofoam, with timber providing the second largest waste quantities. Since 1998, OSPAR has monitored levels of beach debris, initially through a pilot project followed by a voluntary monitoring programme which suggests no statistically significant trend in volumes of beach debris between 2001 and 2006.¹⁴⁷ It is however difficult to confirm how much debris actually is attributable to shipping and efforts should be made to improve our knowledge. Marine debris remains an outstanding pollution issue throughout the North-East Atlantic.

In light of the limited availability of relevant data, a more qualitative approach using knowledge from industry stakeholders could be taken to assessing the effectiveness of measures. There are three key indicators that can be used on this basis are:

1. Participation of relevant industries;

¹⁴² Rochman, C.M., Browne, M.A., Halpern, B.S., et al. (2013) Policy: Classify plastic waste as hazardous, *Nature*, Vol.494, pp.169 – 171

¹⁴³ NOAA, and UNEP (2013) *IMO Status of Conventions*, accessed 15 October 2013, <http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx>

¹⁴⁴ Sheavly, S.B. (2005) Marine Debris – an Overview of a Critical Issue for Our Oceans, Sixth Meeting of the UN Open-ended Informal Consultative Process on Oceans and the Law of the Sea, 2005, http://www.un.org/depts/los/consultative_process/documents/6_sheavly.pdf

¹⁴⁵ Barnes, D.K.A., and Milner, P. (2005) Drifting plastic and its consequences for sessile organism dispersal in the Atlantic Ocean - Springer, *Marine Biology*, Vol.146, No.4, pp.815 – 825

¹⁴⁶ OSPAR Commission (2007) *Background Report on Fishing-for-litter Activities in the OSPAR Region*, accessed 10 October 2013, [http://science-to-manage-uncertainty.com.au/marinedebris/files/OSPAR%20Fishing%20for%20Litter%20activities%202007\[1\].pdf](http://science-to-manage-uncertainty.com.au/marinedebris/files/OSPAR%20Fishing%20for%20Litter%20activities%202007[1].pdf)

¹⁴⁷ OSPAR Commission (2009) *Marine Litter in the North-East Atlantic Region: Assessment and priorities for response*, accessed 10 October 2013, http://qsr2010.ospar.org/media/assessments/p00386_Marine_Litter_in_the_North-East_Atlantic_with_addendum.pdf

2. Success or failure in implementation; and
3. Cost effectiveness.

These indicators are described in more detail below.

4.1 Participation

The take up and participation of relevant industries in the strategies and measures listed in Section 2.0 can be used to determine its potential success in achieving a reduction in marine debris sourced from commercial vessels. For instance, a particular strategy that is considered to be ‘best practice’ is all very well, however if the majority of the commercial shipping sector does not adopt this practice for one reason or another, it is unlikely to have any significant impact on the level of marine debris generated by commercial vessels.

As described in Section 2.3.5, only one commercial container operator has established a policy for zero solid waste disposal at sea; the fleet of this operator only represents 0.19% of the total TEU¹⁴⁸ of the top 100 container shipping companies.¹⁴⁹ ¹⁵⁰ Whilst the impact of this strategy may be low at present, if the appropriate amount of pressure and incentives (see Section 4.2) are applied to the commercial shipping sector it is possible that best practice such as this will become widely adopted.

Whilst environmental policies and Corporate Social Responsibility reports may state their participation and compliance with key international legislation (such as MARPOL Annex V, the London Convention/Protocol, and the Basel Convention) or other best practice measures, the actions of each vessel are ultimately governed by their captain. As enforcement of activities in international waters is particularly difficult, accurate and reliable data regarding participation is undoubtedly challenging to obtain.

Participation alone may not be considered as the only indicator of effectiveness, for whilst participation is key to effectiveness, it is inevitably influenced by how well the measure is implemented. For instance, MARPOL Annex V could be considered successful in that the majority of nations throughout the world have agreed to comply with its requirements; however the extent to which they have been implemented varies from one signatory state to another. Furthermore, the quality of the requirements is another question; although MARPOL was signed in 1973, a complete ban on the disposal of plastics at sea was not enacted until the end of 1988. The general prohibition on discharge of all garbage into the sea (except as provided otherwise in Annex V with regard to, for example, food waste, cargo residues, cleaning agents and additives) only entered into force as part of the revised Annex V on 1st January 2013.

¹⁴⁸ Twenty foot equivalent units (TEU)

¹⁴⁹ Matson (2012) *Environmental Stewardship - Zero Solid Waste*, accessed 13 November 2013, http://www.matson.com/corporate/about_us/zero_solid_waste.html

¹⁵⁰ Alphaliner (2013) *Top 100 Operated fleets*, accessed 13 November 2013, <http://www.alphaliner.com/top100/>

4.2 Implementation Success or Failure

The effectiveness of the measures is also affected by the implementation process, and how well this has been executed. By looking at the challenges and weaknesses encountered during implementation, it is possible to identify the areas in which the measure has been unsuccessful. Weaknesses undermining the effectiveness of a measure typically fall into one of the following categories:

- **Lack of awareness:** campaign and education initiatives targeting certain groups have a part to play in reducing marine debris, these are explored further in Report III;
- **Lack of enforcement:** as discussed in Section 3.0 if polluters don't get caught or if the fines are too low, environmental offences will remain a minor business risk; and
- **Lack of economic incentive:** port fees for handling waste may act as a disincentive if they are too high. Potential economic incentives for encouraging commercial vessels to dispose of waste on shore are described in Section 6.0.

Another potential factor reducing the effectiveness of measures depends upon the guidance issued alongside the measure concerned, and therefore how the measure is interpreted by different states. Take the example of the implementation of the EU Directive on Port Reception Facilities, which has been transposed in all Member States (MSs) through national and/or regional legislation. The level of implementation of the Directive by ports within the EU differs from MS to MS, especially regarding the provisions related to Cost Recovery Systems (CRS) as well as the incentives for ships to deliver waste in ports.

In all ports the Directive has led to an improvement (from low to high) of the solid waste handling systems and to a stronger awareness among stakeholders of the environmental impact of illegal discharges into the sea. This has resulted in an increased waste delivery from ships. However, ports have interpreted the Directive in different ways leading to some confusion among stakeholders (ships, shipping agents, waste operators and environmental authorities). Most ports and ships have shown therefore a strong wish to have more detailed and clear and uniform guidelines, when these are not provided by central or regional government. Only in MSs with detailed and clear transposing measures and clear guidelines, in accordance with the principles of The Directive, is the waste delivery in ports shows to be significantly higher.¹⁵¹

Despite the study by EMSA described above it is difficult to identify an improvement in the situation with respect to port waste reception facilities as prior to implementation date of measures there was no reporting system in place and most waste operations

¹⁵¹ EMSA (2005) *A study on the availability and use of port reception facilities for ship-generated waste*, accessed 10 October 2013, <http://www.emsa.europa.eu/implementation-tasks/environment/port-waste-reception-facilities/download/445/235/23.html>

in ports are contracted out to private operators. These operators often do not report to port authorities and therefore only limited statistics are available.¹⁵²

In addition to the factors influencing effectiveness already discussed, the priority of marine debris for the government in question must be taken into account. In cases where countries have ratified Annex V, these countries need to have the financial and technical capacity to enforce necessary regulations. Countries are at different levels of development; ensuring implementation and compliance with international legislations could pose a particular challenge to developing countries.¹⁵³

It is clear from both the international and individual state experiences that regulations to prevent garbage from vessels of all sizes may not be a comprehensive solution to the problem. While regulation is essential, enforcement of regulations becomes extremely difficult when vessels are routinely out of sight of enforcement agencies and, in the case of smaller vessels, are not even required to keep records of garbage management practices on board.¹⁵⁴

4.3 Cost effectiveness

Information regarding the cost of rolling out different strategies is not widely available; where data is published the true cost of a strategy is likely to be hidden in wider budgets. The cost of compliance with strategies or measures is also not particularly well known, as relevant data will not be estimated unless an Impact Assessment has been carried out. In light of the lack of information about costs it is necessary to rely on anecdotal information and experience from stakeholders as to the strategies and measures that work in practice.

4.4 Summary

The key point raised by attempting to identify the effectiveness of measures, is that there is a significant lack of information regarding the volume and dispersion of marine debris. This must be addressed in order to have a better understanding of the measures that have the most potential to reduce the disposal of garbage from commercial vessels.

Once a better dataset has been established for the identified areas, it would be interesting to investigate whether the effectiveness of guidelines correlates with the extent to which the guidelines draw on the full waste hierarchy (i.e waste management steps from reduction, re-use, recycling, energy recovery and landfill, in

¹⁵² OSPAR Commission (2009) *Assessment of the impacts of shipping on the marine environment*, accessed 10 October 2013, http://qsr2010.ospar.org/media/assessments/p00440_Shipping_Assessment.pdf?zoom_highlight=clean%2Bship#search=%22clean%20ship%22

¹⁵³ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

¹⁵⁴ NOAA, and UNEP (2011) *Honolulu Strategy: Technical Proceedings of the Fifth International Marine Debris Conference (Honolulu Strategy)*, accessed 23 October 2013, <http://5imdc.files.wordpress.com/2011/03/5imdc-proceedings-final1.pdf>

order of the most preferred option to the least preferred), rather than simply waste segregation at sea. If the measures rely on segregation alone, this could be interpreted as a weakness, as the goal should be to ensure waste is disposed of on land. This would be guaranteed if the waste hierarchy had to be respected as the most of the final waste destinations in the hierarchy are generally implemented on land.

5.0 Regulatory Gaps

Despite the implementation of international legislation, gaps still remain in the regulatory framework, meaning that the disposal of garbage into the sea is not entirely eliminated.

5.1 MARPOL Annex V

Ratification

At a global level, there is still a need to ratify and implement existing international conventions which can assist in addressing the marine debris problem. For example, not all coastal or flag states have ratified or adhere to international instruments such as MARPOL Annex V.¹⁵⁵ According to the IMO status of conventions, a total of 145 nations have ratified MARPOL Annex V, as of 30th September 2013.¹⁵⁶ Whilst this may be the majority of nations, it leaves significant gaps where nations have not ratified. For instance, if a ship is registered with a non-ratified state under an open registry, the ship may continue to discharge garbage in international waters; there is no regulatory framework to prevent this activity, and the ship has no obligation to stop.

States that have not ratified Annex V are widespread globally, but there appear to be several 'clusters' of non-ratified states in coastal areas:

- The Caribbean (Costa Rica, Grenada, Haiti);
- South East Asia and Pacific Islands (Myanmar, Thailand, Vietnam, Nauru, Federal States of Micronesia, Timor-Leste, Fiji, Cook Islands); and
- Red Sea and Gulf of Aden (Eritrea, Djibouti, Yemen, Sudan, Somalia).

These clusters of non-ratified states may have an impact on the effectiveness of MARPOL Annex V, particularly in relation to port reception facilities and controlling ships with an open registry in these states.

Specific requirements

¹⁵⁵ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

¹⁵⁶ NOAA, and UNEP (2013) *IMO Status of Conventions*, accessed 15 October 2013, <http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx>

With regards to the specified requirements for ships under MARPOL Annex V, the IMO adopted amendments in 2011 (entry into force date of 1 January 2013) which require that:

1. Every ship of 100 gross tonnage and above, and every ship certified to carry 15 or more persons, and fixed or floating platforms shall carry a garbage management plan;
2. Every ship of 400 gross tonnage and above, and every ship certified to carry 15 or more persons engaged in voyages to ports or offshore terminals of another Party, and every fixed or floating platform shall be provided with a Garbage Record Book; and
3. Every ship of 12 metres or more in length overall, and fixed or floating platforms shall display placards which notify the crew and passengers of the ship's disposal requirements of regulations 3, 4, 5 and 6 of the Annex as applicable.¹⁵⁷

Consequently, these requirements present a gap in that vessels outside of the described scope do not have any obligation to comply. As less than 1% of vessels in the world fishing fleet have a gross tonnage of over 100 tonnes,¹⁵⁸ this means that the majority of the fleet do not have any obligations to have a garbage management plan or a Garbage Record Book maintained and in place. Whilst fishing vessels may not be considered as 'commercial' shipping vessels, they still contribute towards the problem of marine debris, particularly in terms of ADLFG which is understood to have a considerable impact on marine species (although this may be because ADLFG is easily recognisable compared to other types of marine debris)¹⁵⁹ ¹⁶⁰, therefore this gap in international regulation should be addressed.

In several circumstances the regulations do not provide clear definitions of terms, therefore creating potential loopholes. For example, the term "reasonable precaution" is used under regulation 7.2, in relation to the accidental loss of garbage resulting from damage to a ship or its equipment, and 7.3, which relates to the accidental loss of fishing gear. The lack of a proper definition here may lead to misuse of the term. Along a similar vein, regulation 10.3.2 only obliges a ship to report the "estimated" amount of discharged or incinerated garbage. This provision does not adequately address the need for robust monitoring of on-board waste and makes it difficult to check whether the regulations have been adhered to.

¹⁵⁷ MEPC (2012) *2012 Guidelines for the Development of Garbage Management Plans*. Resolution MEPC.220(63) Adopted on 2 March 2012 (Annex 25), accessed 15 October 2013, http://www.ukpandi.com/fileadmin/uploads/uk-pi/Documents/Conventions/Environmental_Compliance/MEPC.219%2863%29.pdf

¹⁵⁸ FAO (2013) *World Fishing Fleet*, accessed 15 November 2013, <http://www.fao.org/fishery/topic/1616/en>

¹⁵⁹ Butterworth, A., Clegg, I., and Bass, C. (2012) *Untangled - Marine Debris: a global picture of the impact on animal welfare and of animal-focused solutions*, Report for WSPA, 2012, http://www.wspa-international.org/Images/Untangled%20Report_tcm25-32499.pdf

¹⁶⁰ STAP/GEF (2012) *Impacts of marine debris on biodiversity: Current status and potential solutions*, Report for CBD, 2012

Port Waste Reception Facilities

Another gap identified in MARPOL Annex V relates to port waste reception facilities. MARPOL requires that the Government of each Party is to provide facilities for the reception of ship-generated residues and garbage that cannot be discharged into the sea. The reception facilities must be *adequate* to meet the needs of ships using the port, *without causing undue delay to ships*. In providing further clarification for what this requirement actually means, resolution MEPC 83 (44) in March 2000 concluded that adequate facilities can be defined as those which:

- Mariners use;
- Fully meet the needs of the ships regularly using them;
- Do not provide mariners with a disincentive to use them; and
- Contribute to the improvement of the marine environment.

Furthermore, resolution MEPC 83 (44) stated that facilities provided by the port must meet the needs of the ships normally using the port, and allow for the ultimate disposal of ships' waste to take place in an environmentally appropriate way.¹⁶¹

Closer scrutiny of these requirements indicates that MARPOL does not set any prescriptive standards for port reception facilities, other than requiring that these are 'adequate', which in itself is defined as a qualitative manner in an MEPC resolution (which is not a mandatory instrument). Furthermore, MARPOL does not set any certification requirements for port reception facilities, and does not set any requirements for the environmentally sound management of any residues or garbage delivered to a port reception facility. Resolution MEPC 83 (44) requires that facilities should allow for the ultimate disposal of ships' wastes to take place in an environmentally appropriate way, but as mentioned previously, the MEPC resolution is not a mandatory instrument.¹⁶²

Another problem with Port Waste Reception Facilities under MARPOL Annex V is that fishing vessels are required to offload all ship-generated waste (other than sewage) to shore reception facilities, but are not required to notify the harbour authority or terminal operator in advance or to pay the mandatory charge. This informal approach to fishing vessels may encourage them to offload garbage at ports; however it could be argued that fishing vessels should be subject to the same requirements as other vessels (i.e. make arrangements and payment for the landing of waste with the

¹⁶¹ Mikelis, N. (2010) IMO's Action Plan on tackling the inadequacy of port reception facilities, paper given at Ships' Waste: Time for action!, Brussels, 14 October 2010, <http://www.imo.org/OurWork/Environment/PollutionPrevention/PortReceptionFacilities/Documents/2010-10-14%20IMOs%20Action%20Plan%20on%20tackling%20the%20inadequacy%20of%20port%20reception%20facilities%20-%20FEBEM%20-%20EUROSHORE%20Conference%20Brussels.pdf>

¹⁶² Mikelis, N. (2010) IMO's Action Plan on tackling the inadequacy of port reception facilities, paper given at Ships' Waste: Time for action!, Brussels, 14 October 2010, <http://www.imo.org/OurWork/Environment/PollutionPrevention/PortReceptionFacilities/Documents/2010-10-14%20IMOs%20Action%20Plan%20on%20tackling%20the%20inadequacy%20of%20port%20reception%20facilities%20-%20FEBEM%20-%20EUROSHORE%20Conference%20Brussels.pdf>

harbour/terminal in question). Nevertheless, introducing such requirements for fishing vessels may act as a disincentive to dispose of garbage on land rather than at sea.

The port reception facilities database (GISIS) enables inadequate facilities to be reported, however it could be argued that introducing more specific requirements within MARPOL would speed up the process of improving waste reception facilities in all ports. On the other hand, some may disagree in that the introduction of a more detailed specification would be too prescriptive, and thus have a negative impact on the quality of port reception facilities. Despite the existence of the GISIS database, very few reports are actually made through this facility, compared to the number of port calls made by commercial ships across the globe. If used for its designed purpose, the GISIS database could be a useful tool for reporting inadequate port waste reception facilities. One potential method of increasing its usage could be to introduce mandatory reporting of facilities after each port of call a commercial ship makes.

Whilst it is generally conceived that good quality port reception facilities that meet the needs of visiting ships is important in encouraging ships to dispose of their garbage at ports rather than in the sea, MARPOL does not provide any requirements for how waste should be managed and treated on land. Responsible waste management on land, especially along the coast, is important in ensuring waste does not escape containment and find its way into the sea. However, under the Basel Convention, parties have the duty to take all appropriate measures to ensure the environmentally sound management of hazardous wastes (paragraphs b), c), e), f), g), and h) of Article 4.2).¹⁶³ Despite the notion of environmentally sound management being described in rather general terms by the Basel Convention,¹⁶⁴ the concept is a useful one that may be beneficial if applied to MARPOL.

To summarise, the current Annex V requirements of MARPOL do not support a closed system, in terms of what goes on board a ship and the resultant discharges, particularly solid garbage. In the present situation it is impossible to verify what a ship discharges and where; and whether this follows recommended best practice. Until this is achieved, it is impossible to know how much waste is discharged over board. Equally, this is difficult to regulate, but the unfortunate reality is that whatever prohibitive measures are agreed upon, whether they are abided by will remain unknown.

¹⁶³ UNEP (2013) Development of an assessment of how far the Basel Convention technical guidelines cover MARPOL wastes and of a guidance manual on how to improve the sea-land interface to ensure that MARPOL wastes, once offloaded a ship, are managed in an environmentally sound manner

¹⁶⁴ Abrams, D., J. (1990) Regulating the International Hazardous Waste Trade: A Proposed Global Solution, *Columbia Journal of Transnational Law*, Vol.28, p.828

5.2 London Convention and Protocol

According to the IMO status of conventions, 87 nations have ratified the London Convention, and 43 nations have ratified the London Protocol.¹⁶⁵ The lack of nations ratifying both the Convention and the Protocol represents a significant gap in the regulatory framework. Whilst encouraging land-locked nations to ratify may not be necessary, it is important to engage with coastal nations that are flag (or open registry) states for ships. It would be beneficial to encourage states to ratify the Protocol rather than the Convention, as the Protocol has a more precautionary approach to waste and the environment.

5.3 Cruise Ships

Cruise ships operate in every ocean worldwide, often in pristine coastal waters and sensitive marine ecosystems. Cruise ship operators provide amenities to their passengers that are similar to those of luxury resort hotels, including pools, hair salons, restaurants, and dry cleaners. As a result, cruise ships have the potential to generate wastes similar in volume and character to those generated by hotels. According to a 1999 Royal Caribbean Cruises Environmental Report, packaging materials from consumables and spare parts for a ship can generate up to 15 tons of waste in a single day.¹⁶⁶

Worldwide, the cruise industry has a compound annual passenger growth rate of 7% since 1990. Worldwide, the number of passengers carried is expected to increase from approximately 21 million in 2013 to 23.7 million in 2017.¹⁶⁷

The majority of current legislation regarding pollution and shipboard waste was developed prior to the rapid growth of the cruise market; as a consequence there exists no international legislation addressing the particular issues surrounding pollution and waste management on these vessels.¹⁶⁸

Passengers partaking of cruises are invariably attracted to those parts of the world that can be described as 'ecologically vulnerable' or as 'bio-diversity hot spots', which cannot, or struggle to, assimilate the added pressure that these vessels place on their fragile environments.¹⁶⁹

¹⁶⁵ NOAA, and UNEP (2013) *IMO Status of Conventions*, accessed 15 October 2013, <http://www.imo.org/About/Conventions/StatusOfConventions/Pages/Default.aspx>

¹⁶⁶ UNEP, and Caribbean Environment Programme (2007) *The Caribbean Environment Programme: Draft Cruise Ship Discharge Assessment Report*, accessed 19 November 2013, <http://www.cep.unep.org/publications-and-resources/databases/document-database/other/cruiseship-discharge-assessment-report.pdf/view>

¹⁶⁷ Cruise Market Watch (2013) *Growth of the Cruise Line Industry*, <http://www.cruisemarketwatch.com/growth/>

¹⁶⁸ Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591 – 598

¹⁶⁹ Johnson, D. (2002) Environmentally sustainable cruise tourism: a reality check, *Marine Policy*, Vol.26, No.4, pp.261–270

The Caribbean islands are a case in point, with an estimated 44% share of the total cruise market. Alaska, another ecologically sensitive area, accounts for 7.9% and the Mediterranean, a semi-enclosed sea, 12.7% of the market.¹⁷⁰ Both the Caribbean (Gulf of Mexico) and the Mediterranean sea have been designated 'special areas' under MARPOL Annex V, highlighting the need for protection in these areas.

Another key point to make in relation to cruise ships is not exactly a gap in legislation, but an issue related to the interpretation of MARPOL requirements for port waste reception facilities. This issue is demonstrated through the example in the box below.

Port waste reception facilities and cruise ships at Southampton

Associated British Ports (ABP) is responsible for the running of the Port of Southampton and has an environmental policy which supports "...sustainable development for both our business and the environment".¹ They advocate complying with all relevant legislation and call for the adoption and promotion of best practice through introducing 'robust' environmental management. This policy applies to all ports operated by ABP and is delivered through their 'Environmental Management Framework Waste Management Plan' which complies with MARPOL, the EU Directive on Port Reception Facilities, and other relevant legislation.

At the Port of Southampton there is a mandatory waste fee for all 'non-exempt' ships berthing at Southampton, which pays for the disposal of up to 4m³ of solid waste that falls under MARPOL Annex V, any amount greater than this or waste falling under other MARPOL Annexes must be dealt with by outside waste contractors, arranged for by ship's agents. Clearly the ABP waste allowance is inadequate for cruise vessels even though EU Directive 2000/59, Article 4(2), requires that "...the reception facilities shall be capable of receiving the types and quantities of ship generated waste...and take into account the operational needs of the users of the port". ABP address this issue by providing a list of outside waste contractors.¹

6.0 Recommendations

6.1 General Recommendations

Marine debris remains a global problem and challenge. In 2005, UNEP concluded that: "... marine litter is not a problem which can be solved only by means of legislation, law enforcement and technical solutions. It is a social problem which requires efforts to change behaviours, attitudes, management approaches and multi-sectoral involvement."¹⁷¹ The circumstances do not appear to have changed since

¹⁷⁰ UNEP (2002) *Industry as a partner for sustainable development: Tourism*, accessed 17 October 2013, <http://www.unep.fr/shared/publications/pdf/WEBx0012xPA-IndustryTourism.pdf>

¹⁷¹ UNEP (2005) *Marine Litter: An Analytical Overview*, 2005

2005, as such the recommendations provided in the following sections are wide ranging.

Prevention is generally more effective and efficient than remedial action. In many cases, preventive mechanisms and the authority to enforce them are already implicit in existing global or regional conventions and action plans, even when marine debris is not specifically mentioned. When political agreements address the need to protect coastal habitats, sustain the health and productivity of seas and coastal areas, pursue integrated coastal zone management and sustainable development of seas and coastal zones, and raise environmental awareness, the issue of marine debris is covered.¹⁷²

In order to achieve any improvement to the current situation with regards to marine debris, a collaborative approach between industry and governments will be required, with a focus on early facilitation of regional cooperation. However, challenges may arise in obtaining international agreement to change conventions, due to differences in priorities and ability to implement changes. For instance, developing countries and small island states may struggle with land-based infrastructure, adding to the challenge of managing ship-based waste.¹⁷³

6.2 Improvements to Existing Regulations

Current rules are lagging far behind the practices at the better performing end of the market. This means that responsible ship operators have no competitive advantage. Regulation and enforcement is a powerful driver for quality shipping.¹⁷⁴

Within the Clean Ship approach, established by Seas at Risk (see Section 2.3.2), it is suggested that regulators should close the gap between regulatory standards and existing best available technologies and practices. Quality operators will nearly always live by the rules, but only thorough and effective enforcement will ensure that everyone plays by the same rules.¹⁷⁵

Looking back to the regulatory gaps identified in Section 5.0, the two key gaps are associated with the lack of ratification of international legislation across the globe, and the specification of the requirements in MARPOL Annex V. The lack of ratification can be addressed through raising awareness of the legislation, and how ratifying

¹⁷² UNEP (2009) *Marine Litter - A Global Challenge*, accessed 11 October 2013, http://www.unep.org/pdf/unep_marine_litter-a_global_challenge.pdf

¹⁷³ NOAA, and UNEP (2011) *Honolulu Strategy: Technical Proceedings of the Fifth International Marine Debris Conference (Honolulu Strategy)*, accessed 23 October 2013, <http://5imdc.files.wordpress.com/2011/03/5imdc-proceedings-final1.pdf>

¹⁷⁴ Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Policy%20Analysis%20_V_W%20case%20study%201_.pdf

¹⁷⁵ Seas at Risk (2006) *Implementing the Clean Ship Approach: closing the gap between what is possible and what is required by law*, accessed 10 October 2013, <http://www.seas-at-risk.org/1images/SAR%20Mind%20the%20Gap%20seminar%20presentation.pdf>

helps to prevent the problem of marine debris. Recommendations for addressing the specification of the requirements are dealt with in Section 6.2.1 below.

6.2.1 MARPOL Annex V

Existing rules under MARPOL are the bottom line for shipping, therefore new rules should make it more difficult for offenders to stay in business. There is a connection with innovation to be made; environmental policy and legal standards should be at least as strict as that made possible by the best available technologies. Strengthened enforcement remains important; if polluters don't get caught or if the fines are too low, environmental offences will remain a minor business risk. New regulations should encourage innovation, not only setting a standard for now, but also a target for the short and long term.¹⁷⁶

Seas at Risk made the following recommendations for improving MARPOL Annex V:

1. **Clear Rules, clear compliance and strong enforcement:** Clear rules for on-board personnel and passengers regarding waste and marine debris creates awareness and improves behaviour;
2. **Zero discharge = zero confusion:** At the moment, certain types of waste are still allowed to be thrown overboard and others are not. Implementing a “zero discharge” (at sea) approach makes environmental sense and avoids confusion;
3. **Phase-out on-board waste incineration:** compliance with recommendations 1 and 2 is impossible to control or enforce as waste can be burnt at sea and regulators have to rely on logged estimated amounts incinerated.
4. **Deliver waste in ports:** improved and harmonised port reception facilities that are simple to use, accessible and affordable will decrease the amount of waste that ends up as marine debris; and
5. **Waste management as business practice:** waste management and recycling is all about volumes. If all ships deliver all their waste to ports the chances for the creation of serious markets in ship waste recycling increases.¹⁷⁷

These suggested recommendations are very similar to those provided by the Clean Shipping Coalition, who also emphasise the need to improve port reception facilities, and the need to prohibit discharge of waste at sea (except when the ship or crew safety is at risk and there are no other alternative means of handling the waste).

A further recommendation made by the Clean Shipping Coalition is to prohibit all discharges in the Polar area. The IMO is in the process of developing a draft mandatory international code of safety for ships operating in polar waters (the Polar

¹⁷⁶ Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Policy%20Analysis%20_V_W%20case%20study%201_.pdf

¹⁷⁷ Seas at Risk *No place for waste: let's end ship waste dumping at sea*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Marine%20litter%20brochure_2.pdf

Code). Friends of the Earth International (FOEI), Greenpeace International, International Fund for Animal Welfare (IFAW) and World Wildlife Fund (WWF) submitted a joint proposal to the IMO detailing their recommendations for a 'Mandatory Polar Code'. Within these recommendations it was suggested that the code must be applicable to all vessels, and must include comprehensive provisions for environmental protection for all vessels operating in polar water, such as more stringent provisions for garbage discharge, amongst other discharges.^{178 179}

The scope of vessels to which MARPOL Annex V applies is limited in that only certain vessels are required to have or maintain garbage management plans, a Garbage Record Book, and placards to notify the crew and passengers of the vessel of the ship's disposal requirements. The vessels that are not obligated to comply with these requirements represent a key gap in MARPOL Annex V. For instance, according to the European Commission's Fishing Fleet Register, only 4% of EU registered fishing vessels are covered by the requirement to have a garbage management plan. As the tonnage threshold for the carrying of a Garbage Record Book is even higher, it equates to just 0.4% of all EU-registered fishing vessels.^{180 181}

To properly cover waste from fishing vessels, Annex V should be amended to include a mandatory requirement for all commercial seagoing vessels to have a Garbage Management Plan and a Garbage Record Book.¹⁸² With regards to the definition of a 'commercial shipping vessel', perhaps this too should be more clearly defined within MARPOL to ensure that there is no misunderstanding. We would recommend that fishing vessels are included within this definition.

6.2.2 Port Waste Reception Facilities

The requirements for port waste reception facilities under MARPOL are not specific, simply requiring that ports are 'adequate' and do not cause undue delay to ships. Perhaps introducing specific requirements for port waste reception facilities, staggered through targets over time, may help ports improve the standards of their waste reception facilities. Another recommendation for improving port reception facilities and the way they handle waste could be to take the concept of

¹⁷⁸ MEPC (2009) *Mandatory Polar Code: Submitted by Friends of the Earth International (FOEI), Greenpeace International, IFAW and WWF (MEPC 59/20/5)*, accessed 19 November 2013, http://www.zeemail.nl/upload/actueel/2_MEPC_59-20-5_polar_code_FOEI_ifaw.pdf

¹⁷⁹ Clean Shipping Coalition (2010) *Interpretations of, and amendments to, MARPOL and related instruments*, accessed 11 October 2013, <http://www.seas-at-risk.org/1images/MEPC%2061-7-12csc.pdf>

¹⁸⁰ European Commission (2013) *Community Fishing Fleet Register*, accessed 19 November 2013, <http://ec.europa.eu/fisheries/fleet/index.cfm>

¹⁸¹ Clean Shipping Coalition (2010) *Interpretations of, and amendments to, MARPOL and related instruments*, accessed 11 October 2013, <http://www.seas-at-risk.org/1images/MEPC%2061-7-12csc.pdf>

¹⁸² Clean Shipping Coalition (2010) *Interpretations of, and amendments to, MARPOL and related instruments*, accessed 11 October 2013, <http://www.seas-at-risk.org/1images/MEPC%2061-7-12csc.pdf>

environmentally sound management from the Basel Convention, and apply it to MARPOL Annex V waste arriving in the port reception facility to the final disposal destination.

As indicated in the previous Section (6.2.1), it is generally agreed that port waste reception facilities should be improved to encourage waste disposal in ports rather than illegal dumping at sea. An indirect fee system of charging for waste disposal in ports was discussed in Section 2.2.5. However, if this approach is to be expanded to more ports both regionally and internationally, careful steps must be taken to ensure a level playing field is achieved to maintain competition between ports. Options for ensuring this were discussed in Section 2.2.5.2. Undertaking further research into the expansion of the indirect fee system using these options could be a task for CMS.

IMO has developed a number of guidelines, the most recent of which have been published as a Comprehensive Manual on Port Reception Facilities. It is possible that a review may be required to understand whether these guidance documents fulfil the needs of the relevant stakeholders, and whether amendments or further guidance needs to be written to enable successful compliance and enforcement of MARPOL Annex V and port waste reception facilities.

6.3 Gaps to Address

6.3.1 Lack of data

While there are governmental and national efforts to survey, monitor and quantify marine debris from land-based sources, information about debris from ocean-based sources in most cases is non-existent or not collected on a regular basis. In some instances the collection of such information is largely dependent on funding from international organisations such as UNEP and the Intergovernmental Oceanographic Commission (IOC).¹⁸³

A lack of data regarding the level of marine debris, both past and present, and on different geographical scales has an impact on the decision making process, as well as affecting the ability to assess the effectiveness of existing or proposed measures.

Monitoring and evaluation are critical components of determining whether strategies are achieving expected results. The following are potential evaluation questions and indicators, proposed within the Honolulu Strategy, to be considered in developing an evaluation approach for strategies focused on shipping, boating, and transport:

1. What is the level of awareness of specific groups of ocean users regarding Best Management Practices (BMPs), storage and disposal options, and legislation and policies?
 - Percentage of ocean users by specific industry or group
 - Percentage of ocean users briefed by specific industry or group

¹⁸³ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

- Percentage of ocean users adopting best practices by specific industry or group
 - Tonnage of lost cargo
 - Cost of lost cargo
2. What percentage of specific groups of ocean users are using proper waste storage and disposal options?
 - Percentage of ocean users using proper waste storage on board and disposal at port reception facilities
 - Tonnage of waste collected at port reception facilities
 3. What is the level of awareness of fishermen regarding BMPs, legislation and policies?
 - Percentage of fishermen who think current practices and methods to prevent abandoned, lost, or otherwise discarded fishing gear (ALDFG) sources are adequate by fishing fleet or area
 - Percentage of fishers aware of BMPs, practices, and legislation by fishing fleet or area
 - Percentage of fishers briefed by fishing fleet or area
 4. What percentage of fishermen are adopting best practices and modified or alternative fishing gear?
 - Percentage of fishermen adopting best practices by fishing fleet or area
 - Percentage of fishermen using alternative/modified fishing gear by fishing fleet or area
 - Number of gear items lost
 - Tonnage of gear lost
 - Cost of lost gear¹⁸⁴

Whilst this information will contribute to the knowledge base on marine debris, it is important to also undertake research investigating the cost and cost effectiveness of measures to prevent the disposal of garbage at sea. At present there is a significant lack of data of this sort, but combined with information about the effectiveness of measures it is possible to estimate the level of funding and investment required to make a difference. Furthermore, whilst a number of best practice measures have been identified in Section 2.0, the extent to which these measures are implemented is not widely known; addressing this gap would be very useful in understanding the types of measures that industry does or does not favour.

¹⁸⁴ UNEP, and NOAA (2011) The Honolulu Strategy

6.3.2 Education for seafarers

Much of the pollution from shipping is caused by a lack of knowledge about the marine environment. Raising awareness and training on the issues of marine debris is essential to achieving success.¹⁸⁵ It is important to ensure education is delivered on all levels; from seafarers and fishermen to the top level of management in large shipping firms. There has been a distinct lack of campaigns to raise awareness or education programmes within the commercial shipping industry, an issue discussed in Report III.

At the end of the day it is people who build, maintain and operate the ships and take decisions which can have far-reaching consequences. Providing training for seafarers, both before they start working on a ship and when they have become part of the crew, is a keystone to achieving better compliance with international legislation. At present knowledge of the marine ecosystem is not a part of the curriculum.¹⁸⁶ The ProSea Foundation provides sustainability courses for the maritime and fishing sectors, schools, governmental agencies and businesses. The courses are for both those who work at sea, as well as land based decision makers. ProSea has been providing marine awareness courses since 1999 and has developed the IMO model course Marine Environmental Awareness.¹⁸⁷ As such, ProSea is a well-placed organisation for CMS to work with in terms of delivering the appropriate training and education for users of the marine environment, with particular regard to marine debris.

6.3.3 Cruise Ships

Generally speaking, it is sensible to assume that the volume of solid waste produced by a vessel at sea is proportionate to the number of crew and passengers on board. On this basis, combined with the fact that the cruise industry is rapidly expanding, cruise ships are a significant source of garbage, and could potentially be a large source of marine debris if not carefully regulated and monitored. As mentioned in Section 5.3, cruises often visit ecologically vulnerable or sensitive areas, yet the majority of current legislation regarding pollution and shipboard waste was developed prior to the rapid growth of the cruise market. Consequently there exists no international legislation addressing the particular issues surrounding pollution and waste management on these vessels.¹⁸⁸

If such legislation were to be established, the possible criteria to address could be:

¹⁸⁵ Seas at Risk (2006) *Implementing the Clean Ship Approach: closing the gap between what is possible and what is required by law*, accessed 10 October 2013, <http://www.seas-at-risk.org/1images/SAR%20Mind%20the%20Gap%20seminar%20presentation.pdf>

¹⁸⁶ Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, <http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Policy%20Analysis%20 V W%20case%20study%201 .pdf>

¹⁸⁷ ProSea (2014) *ProSea - About ProSea*, accessed 24 January 2014, http://www.prosea.info/?page_id=2

¹⁸⁸ Butt, N. (2007) The impact of cruise ship generated waste on home ports and ports of call: A study of Southampton, *Marine Policy*, Vol.31, pp.591 – 598

- Implementing zero disposal of solid waste at sea; and
- Ensuring that cruise ships only call at ports that have adequate port waste reception facilities to handle the volume of waste produced.

6.4 Market-based Instruments (MBIs)

When properly harnessed, the market can be a powerful driver for change. The use of economic incentives to discourage the disposal of garbage at sea has already been recommended by Seas at Risk, and UNEP commissioned a guidance document on the use of market-based instruments to address the problem of marine debris in April 2009.^{189 190}

The costs associated with marine debris are largely borne by those that are not causing the problem, with the result that there is insufficient liability to the entities responsible for the source of the problem. In other words, the polluter does not pay at present. As discussed in Report I, the impacts of marine debris can have high economic and ecological costs.¹⁹¹ The direct and indirect benefits of reducing and preventing marine debris merit the investment of time, effort and money. However, there must be political will to address this issue; the cooperation and support of government, the private sector and the general population, are essential for a long-term and effective approach to handling marine debris.¹⁹²

The aim of using economic incentives and disincentives is to change people's behaviour regarding the correct handling of their waste. Market forces can be influenced by communities, governments, industry and nongovernmental organisations. When used in parallel with public education, adequate waste management infrastructure and other related efforts, market based instruments (MBIs) can be extremely effective.¹⁹³

MBIs addressing the inland sources of marine debris are discussed in Report I; an integrated approach must be adopted to ensure the different incentives address different target audiences and can be feasibly used in parallel. MBIs for ocean based sources of marine debris are not yet widespread.

¹⁸⁹ Seas at Risk (2006) *Implementing the Clean Ship Approach: closing the gap between what is possible and what is required by law*, accessed 10 October 2013, <http://www.seas-at-risk.org/1images/SAR%20Mind%20the%20Gap%20seminar%20presentation.pdf>

¹⁹⁰ UNEP, and IEEP (2009) *Guidelines on the Use of Market Based Instruments to Address the Problem of Marine Litter*, accessed 11 October 2013, http://www.unep.org/regionalseas/marinelitter/publications/docs/Economic_Instruments_and_Marine_Litter.pdf

¹⁹¹ For example: loss of biodiversity, loss of ecosystem functions, loss of revenue, loss of livelihood of population groups, and increased maintenance costs.

¹⁹² UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

¹⁹³ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

An instrument that actively encourages relevant operators to adopt best practice may be more effective where enforcement is particularly challenging. For example, offering appropriate tax relief or a reduction in port fees to ships or fleets that operate a zero waste discharge at sea policy, would give significant advantages to commercial shipping operators that employ best practice, therefore encouraging the industry to adopt best practice. In theory, port operators that support this scenario would in turn receive benefits through a greater number of ships calling into the port in question.

However, it is important to remember that nations vary in their stages of economic, social and political development, all of which affect their ability to respond to environmental problems such as marine debris. Measures are more likely to be effective if the regulatory framework and institutional infrastructures are in place. Nations also differ in their ability to afford some of the expenses associated with strategies and programmes. The relevance and effectiveness of any instrument will need to be assessed on a case-by-case basis to determine its potential for success.¹⁹⁴

6.5 Role for CMS

The maritime industry is a complex sector with stakeholders engaging at all levels. These interdependencies between fuel suppliers, ship owners, cargo owners and financing and insurance companies mean that the implementation of best practice requires not only technological, but also social and organisational changes. Ensuring success calls for a multi-stakeholder approach; the crew and ship owner are important, but a number of other players in the maritime industry must also be involved. When thinking about incentives or possible actions that are to be included it is essential to ensure they are well targeted to actors that can and are willing to make a difference.¹⁹⁵

As in other spheres there is always a tendency to try and shift the responsibilities to others. An example is waste collection and treatment. Ship operators complain that ports do not offer reception facilities while ports claim that the crew of visiting ships do not deliver their waste in port. Without clear directions, problems – and associated solutions – will be put on the shoulders of others.¹⁹⁶

UNEP, perhaps through the Regional Seas Programme, can facilitate coordination between all of the different stakeholders to enable best practice measures to be implemented. International forums such as the IMO take decisions on the basis of a consensus, which invariably means that large flag-States (particularly those acting as

¹⁹⁴ UNEP (2009) *Guidelines on the Use of Market-based Instruments to Address the Problem of Marine Litter*, 2009

¹⁹⁵ Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Policy%20Analysis%20_V_W%20case%20study%201_.pdf

¹⁹⁶ Seas at Risk (2007) *The Clean Ship Concept: A strategy for uncoupling growth in shipping from environmental harm*, accessed 10 October 2013, http://www.seas-at-risk.org/1images/Seas%20At%20Risk%20Policy%20Analysis%20_V_W%20case%20study%201_.pdf

“open registry” for a large proportion of ships) have a loud voice and considerable influence. Therefore, the outcome of IMO deliberations may be somewhat lacking in ambition at times. It is important that key players are supported in promoting best practice and addressing the gaps identified to ensure improvements in international legislation and the global situation do not get overlooked, and UNEP, supported by CMS, can help provide this support.

To this end, CMS can encourage Parties to the Convention on Migratory Species to:

- Ratify key international legislation such as MARPOL Annex V (where CMS Parties have not yet done so);
- Initiate and support the improvement of MARPOL Annex V so that exemptions are tightened, in order to include most fishing vessels.
- Encourage ships and shipping operators from CMS Parties to sign up to measures such as the Clean Shipping Index;
- Encourage and support every seafarer to attend a marine environmental awareness course provided by ProSea or another similar organisation;
- Encourage shipping operators and other key industries from CMS Parties involved with the international transport of goods to drive environmental demands;
- Promote the wider rollout of the indirect fees system in ports, and support the improvement of port waste reception facilities in general; and
- Support and encourage CMS Parties to implement and achieve relevant ISO standards.

Many of the activities suggested here may involve approaching governments, industries and international organisations to facilitate research and explore funding potential for investigating how such actions could be best implemented. CMS may not be able to undertake all these activities alone, and so should support UNEP and the Regional Seas Programme to do so. Developing research questions around these topics and co-ordinating research to address information gaps is a good approach. For instance, initiating further research to investigate whether market based instruments are appropriate measures for preventing commercial shipping from disposing of garbage at sea. Additionally, identifying a strategy to target specific audiences and work with key industries in order to improve awareness, knowledge and behaviour with regards to marine debris would be beneficial. We recommend that one of the first industries to target would be the cruise ship industry, as they produce a significant amount of garbage at sea, therefore improving waste management and performance in this global industry would potentially have a large and beneficial impact.

Encouraging ratification of international legislation such as MARPOL is all well and good, but this report clearly shows that there are significant gaps that need to be addressed if the legislation is to become more effective. Therefore one of the key recommendations for CMS Parties and the Secretariat is to focus on the gaps identified in this report and explore the possible means to address them.



CMS



CONVENTION ON MIGRATORY SPECIES

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REPORT III: MARINE DEBRIS PUBLIC AWARENESS AND EDUCATION CAMPAIGNS

Review required under CMS Resolution 10.4 on Marine Debris

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Debris

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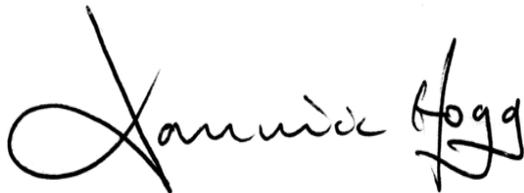
Report for:

The Secretariat of the Convention on Migratory Species

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03/03/2014

EXECUTIVE SUMMARY

Eunomia Research & Consulting (Eunomia) has worked in partnership with the International Union for the Conservation of Nature (IUCN) and the Marine Conservation Society (MCS) to prepare three reports for the Convention on the Conservation of Migratory Species of Wild Animals (CMS) for 'Reviews required under Resolution 10.4 on Marine Debris'. The three reports are as follows:

- Report I: Migratory Species, Marine Debris and its Management;
- Report II: Marine Debris and Commercial Marine Vessel Best Practice; and
- Report III: Marine Debris Public Awareness and Education Campaigns.

The approach to gathering information for this report was based on a mind mapping of target audiences for public awareness and education campaigns, in relation to potential sources of marine debris. The target audiences and potential sources of marine litter were grouped into categories. An internet search was conducted using relevant key terms to identify at least one campaign for each of the target audience types, debris types and regional seas areas defined by the Regional Seas Programme. Selected case studies that demonstrate a focus on migratory species, multi-faceted approaches, and specific targeted campaigns are presented in Section 2.3.

Through undertaking an extensive search for a wide variety of campaigns targeting different audiences, four key gaps were identified:

1. Audience gaps;
2. Geographic gaps;
3. Species gaps; and
4. Debris type gaps.

Further information on each of these gaps is discussed in Section 2.4.

Having identified a wide range of different campaigns targeting different audiences and types of marine debris across the world, naturally the next step would be to establish their effectiveness. From the information available it appears that campaigns targeting a specific audience and specific type of marine debris tend to have more success. However, information on the efficacy of the public awareness campaigns is sparse, and where it is available the analysis is in almost all cases conducted by the campaign organisers and therefore lacks independent and impartial authority. Our review of campaigns found that factors contributing to failure of campaigns are more difficult to identify.

We note, in this regard, that economic instruments described in Report I such as levies on single-use carrier bags and deposit-refunds for beverage containers, show strong debris-prevention impacts, drawing from a more robust evidence base. Accordingly, while we note the role that behavioural change campaigns can play, either in isolation or in tandem with regulatory measures or economic instruments, they are not a substitute for regulatory action. Behavioural change campaigns can, however, be useful in aiding the introduction of economic instruments and/or regulatory measures, by making sure that the public is aware of the rationale for introducing the measure, and therefore increasing the likelihood of support.

Bearing in mind the preference for economic incentives and/or regulatory measures, our key recommendation for CMS is to provide support for the successful campaigns identified within this report. We have identified a number of successful campaigns that target a specific type of marine debris and can easily be applied to different countries and locations. Campaigns

such as the Operation Clean Sweep program, the monofilament and fishing tackle capture and recycling campaigns, and the Beat the Microbead campaign are easily adapted to local requirements and have already been implemented in different locations. Support for these campaigns can be promoted to CMS Party and Signatory States through National Focal Points, the Conference of the Parties and the Standing Committee as well as through external networks. The CMS could also invite applications to the CMS small grants programme for funding for campaigns.

Promotion of the practices and achievements of site or industry specific measures, such as those undertaken by Maryland Port Administration and The Port of Oakland, may encourage other facilities to take steps of their own to minimise marine debris. Engaging industry bodies, such as the International Association of Ports and Harbours, the American Association of Port Authorities, the European Seaports Organization, the Association of Australian Ports and Maritime Authorities, and the Association of Canadian Port Authorities, may be a good way to promote measures across an industry, as has been seen in the plastics industry with Operation Clean Sweep.

It is logical to build upon existing networks and resources by working with organisations currently campaigning around marine debris and others who are stakeholders in the marine environment. CMS can seek to engage organisations invested in migratory species to promote campaigns and raise awareness of marine debris amongst their members.

There may also be opportunities to address the audience gaps identified in Section 2.4. However more research is needed to understand the relative importance of these sources of marine debris, the means of reducing marine debris and the potential for impact upon levels of marine debris in these areas.

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1.0 Introduction

A wide variety of different approaches to raising awareness of the scale and impact of the marine debris problem exist throughout the world. The aim of this report is to assess the effectiveness of current public awareness tools and education campaigns, identifying regional distinctions where possible.

1.1 Approach

Potential target audiences for public awareness and education campaigns and potential sources of marine debris were mapped out in order to create a list by which campaigns could be classified and any gaps identified. These lists were then used as search terms to find relevant campaigns on the internet, with the areas of the regional seas program used to check the geographical coverage of campaigns. An exhaustive search of marine debris campaigns was not possible in this study; instead the aim was to find a campaign for each of the audience types, debris types and regional seas areas and in doing so highlight any gaps where no campaign could be found.

2.0 Overview and Case Studies of Marine Debris Awareness-Raising Initiatives

2.1 Target Audiences

The list of potential target audiences shown in Table 1 was generated in a mind mapping session, and is largely based on the sources of marine debris indicated in the second column.

Table 1: Target audience groups for marine debris awareness-raising initiatives

Target audience	Examples / source of marine litter
Members of the general public engaged in marine activities	Beach and coastal visitors, with debris arising from overflowing bins, beach parties and golfing activities
	Those engaged in recreational boating activities, including yachting, diving, and recreational angling
	Passengers on ferries and cruise ships
Members of the general public engaged in land based activities	General littering
	Domestic disposal of solid waste to the sewage system
	Smoking
	Hunting

Target audience	Examples / source of marine litter
Private firms and employees	Commercial marine activities, including freight and commercial fishing
	Port and harbour authorities
	Agriculture and aquaculture
	Formal waste management, including ship breakers, municipal solid waste management, commercial and industrial waste, landfill sites, scrapyards, sewage system management, informal / unregulated waste management, historic government dumping
	Plastics manufacturing and other manufacturing
	Construction industry
	Healthcare
	Retail, including fast food outlets, beach establishments, retail outlets
	Hospitality industry, including coastal hotels
Public bodies and employees	Central and local government
	The armed forces
	Storm water drainage planners and management firms

2.2 Organisations and Instruments

A total of 58 public awareness and education campaigns were selected for use as case studies following the internet search described in Section 1.1. Details of all the case studies are available in Appendix A.1.0. An exhaustive review of awareness-raising initiatives has not been conducted in this study and so we do not intend the list of organisations to be complete, but rather to include the larger, more prevalent or better networked organisations reporting awareness-raising campaigns on the internet, found with the search criteria used.

The list of organisations in Appendix A.1.0 does not indicate the number or scope of the campaigns launched by each organisation. Some of the organisations will be instrumental in education and campaigning on marine debris issues whereas others will have been identified when researching campaigns for a specific region, type of debris, or audience.

The instruments used by campaigns include:

- Beach and coastal clean-up events;
- Public art works;
- Government lobbying and reports to government ministries;
- Best practice guidance;
- Data collection and reporting;
- Industry pledges;
- Petitions;
- Signage and posters;
- Conferences and summits;
- Classroom and educational material;
- Smartphone apps;
- Press releases;
- Direct engagement of companies, individuals and interest groups;
- TV, radio, film and social media notices;
- Environmental rating, ranking and reporting of businesses;
- Innovative infrastructure;
- Cessation of cleaning to highlight beach litter; and
- Games and competitions.

The majority of campaigns combined several instruments as a means to reach different audiences.

2.3 Case Studies

Several case studies have been presented in more detail due to their relevance to migratory species or in order to highlight different campaign approaches.

2.3.1 Migratory Species

Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) – Education and Regulation in the Antarctic

CCAMLR was established in 1982 and its activities include writing conservation measures and resolutions for its members to follow, as well as producing educational material for commercial fishing vessels designed to reduce marine litter and the entanglement of marine species in discarded fishing equipment. Over the course of a five year study from 1989 to 1994 in South Georgia, a marked decrease was recorded in the incidence of fur seal entanglement, which is traditionally caused by

the packing bands of bait boxes used by long line fishing vessels. Furthermore, all packing bands washed ashore in the last two years of the study had been cut to prevent entanglement. ¹ The observed behavioural change—the cutting of the packing bands—and its subsequent effect on fur seal entanglement was attributed to the educational and regulatory efforts of CCAMLR. ²

Since November 2011 the Code of Federal Regulations of the United States has prohibited the disposal of items that may interfere with other ships, gear or wildlife and placed a legal requirement upon fishing vessels operating in the Antarctic region to display CCAMLR educational material. The regulations state that:

(a) The operator of a harvesting vessel may not dump overboard, jettison or otherwise discard any article or substance that may interfere with other fishing vessels or gear, or that may catch fish or cause damage to any marine resource, including marine mammals and birds, except in cases of emergency involving the safety of the ship or crew, or as specifically authorized by communication from the appropriate USCG commander or authorized officer. These articles and substances include, but are not limited to, fishing gear, net scraps, bale straps, plastic bags, oil drums, petroleum containers, oil, toxic chemicals or any manmade items retrieved in a harvesting vessel's gear.

(b) The operator of a harvesting vessel may not abandon fishing gear in Convention waters.

(c) The operator of a harvesting vessel must provide a copy of the CCAMLR information brochure “Marine Debris—A Potential Threat to Antarctic Marine Mammals” to each member of the crew of the harvesting vessel and must display copies of the CCAMLR placard “Avoidance of Incidental Mortality of Antarctic Marine Mammals” in the wheelhouse and crew quarters of the harvesting vessels. Copies of the brochure and placard will be provided to each holder of a harvesting permit by NMFS when issuing the permit. ³

The brochure mentioned outlines practices to reduce the numbers of lost nets and fishing gear, render any lost items incapable of entrapping fish or other marine organisms, reduce the number of non-degradable products carried on-board, and reduce the number of food and drinks containers. ⁴

¹ Arnould, J.P.Y., and Croxall, J.P. (1995) Trends in entanglement of Antarctic fur seals (*Arctocephalus gazella*) in man-made debris at South Georgia, *Marine Pollution Bulletin*, Vol.30, pp. 707–712

² Zavadil, P.A., B.W. Robson, A.D. Lestenkof, R. Holser, and A. Malavansky *Northern Fur Seal Entanglement Studies on the Pribilof Islands in 2006*,

³ 50 CFR 300.109 - Gear disposal. | Title 50 - Wildlife and Fisheries | Code of Federal Regulations | LII / Legal Information Institute, accessed 29/11/2013, <http://www.law.cornell.edu/cfr/text/50/300.109>

⁴ *Marine Debris-A Potential Threat to Antarctic Marine Mammals*, accessed 29/11/2013, http://archive.ccamlr.org/pu/E/e_pubs/brochure.pdf

The Federal Regulation came into effect in 2011 and so the earlier behavioural change seen in the fur seal study cannot be attributed to it, nor is there evidence of its effect on quantities of marine litter or incidents of entanglement. However, the approach of combining within the same legal document the regulation of gear disposal and a requirement on fishing vessel operators to provide education material to their crew will ensure a wider audience for the information disseminated and places the onus on the operator to ensure understanding of and compliance with the law.

Antarctic fur seals are a migratory species but are not listed in the appendices of the Convention on the Conservation of Migratory Species of Wild Animals and are classified by the IUCN Red List as a species of least concern due to their large and apparently increasing population size.⁵ Although not considered an endangered species, any reduction in observed cases of entanglement is a great success.

Sea Turtle Conservancy - Tour de Turtles

The Sea Turtle Conservancy operates an annual awareness raising campaign, now in its sixth year, in which turtles are fitted with satellite transmitters and released from the Caribbean coastline. The course of the turtles is tracked as they compete in a “marathon” to travel the furthest distance in three months. In the marathon, each turtle is assigned a threat to turtles as an awareness raising cause, one of which is plastic debris.⁶ The website provides information on each cause, highlighting its origin, the impact upon turtles, and steps that the public can take to counter the problem. Each turtle has a corporate sponsor and may also be sponsored by the public, raising funds for the Sea Turtle Conservancy.

This innovative approach raises awareness of marine debris and its impact upon turtles at the same time as raising funds for the Sea Turtle Conservancy. The public is engaged first in the beach launch of the turtles, and subsequently through material on the website showing the path of the released turtles, their progress in the marathon and how much money each turtle has raised. Additional educational material for teachers and an on-line tool to create and share turtle animations provide further engagement and increase the campaign audience.

All seven species of sea turtle are known to be migratory and are listed in Appendix II (species that need or would significantly benefit from international co-operation) of the Convention on the Conservation of Migratory Species of Wild Animals. Two species of sea turtle are classified as vulnerable and one species is classified as critically endangered by the IUCN Red List.

⁵ Auriolos, D. & Trillmich, F. (IUCN SSC Pinniped Specialist Group) 2008. *Arctocephalus gazella*. In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 17 December 2013

⁶ Tour de Turtles – Plastic Debris, accessed 29/11/2013, <http://www.tourdeturtles.org/2013/Claire.php?page=cause>

SumOfUs - Tesco: Stop dumping plastic waste into our oceans!

SumOfUs is a non-profit organisation based in the United States which puts pressure on corporations through awareness raising campaigns and petitions. The organisation is currently petitioning UK supermarkets to ensure that their grocery suppliers dispose of their waste safely.⁷ The campaign follows an article in a British Newspaper linking the supermarket suppliers to 17kg of plastic found in a sperm whale's stomach, including sections of transparent sheeting thought to originate in greenhouses on the southern Mediterranean coast of Spain.⁸ The campaign has not produced an official response from the supermarkets but has generated a lot of support and comment especially from social networking websites.

The campaign is focused around protecting sperm whales from marine debris in the Mediterranean. Population estimates vary but there are generally thought to be fewer than 2,500 sperm whales in the Mediterranean, and their numbers are currently declining, which has led the species to be classified as endangered on the IUCN Red List.⁹ The species is listed in Appendix I (species threatened with extinction), and Appendix II (species that need or would significantly benefit from international co-operation) of the Convention on the Conservation of Migratory Species of Wild Animals, and is also covered by the Agreement on the Conservation of Cetaceans in the Black Sea, Mediterranean Sea and Contiguous Atlantic Area.

2.3.2 Multi-Faceted Approach

In addition to the CCAMLR case study in Section 2.3.1, there are a number of instances in which public awareness campaigns have been conducted in combination with legislative change, financial incentives or new infrastructure.

Raising Support for Legislative Change through Awareness and Education

The Director General of the Rwanda Environment Management Authority largely attributes the success of the plastic ban in Rwanda to public support for the ban – a result of the public awareness and education campaign that preceded the change in legislation.¹⁰ During Rwanda's mandatory monthly community work day the reasons for the ban were discussed during talks including testimonies from farmers whose livestock had died from ingesting littered plastic bags. TV, radio and social

⁷ Tesco: Stop dumping plastic waste into our oceans! | SumOfUs, accessed 29/11/2013, <http://action.sumofus.org/a/sperm-whale-plastic-tesco/>

⁸ Spanish sperm whale death linked to UK supermarket supplier's plastic | World news | theguardian.com, accessed 29/11/2013, <http://www.theguardian.com/world/2013/mar/08/spain-sperm-whale-death-swallowed-plastic>

⁹ Notarbartolo di Sciarra, G., Frantzis, A., Bearzi, G. & Reeves, R. 2012. *Physeter macrocephalus* (Mediterranean subpopulation). In: IUCN 2013. IUCN Red List of Threatened Species. Version 2013.2. <www.iucnredlist.org>. Downloaded on 11 December 2013.

¹⁰ Rwanda's Plastic Bag Ban | The Story of Banning the Plastic Bag in Rwanda, accessed 4/12/2013, <http://thedeliciousday.com/environment/rwanda-plastic-bag-ban/>

media campaigns explaining the negative impact of plastic bag usage further strengthened the message, and strong partnerships were fostered with all public sectors. Short videos informed travellers to Rwanda of the plastic bag ban at airports and on buses. Tax incentives were given to support plastic recycling and the manufacturing of environmentally friendly bags in order to lessen the immediate economic impact of the ban and to support industry and retail in finding viable alternatives.

The factors thought to contribute to Rwanda's success in the plastic bag ban were missing or poorly managed when Somaliland attempted but failed in implementing a similar ban, and have even been cited as contributing to the failure. A lack of public support and an unwillingness to find an alternative product meant that the ban had little effect.¹¹ Although a public education campaign had been planned no further information could be found on its delivery or success.

Financial Incentives

The Boomerang Alliance is one of several organisations campaigning for a container deposit system in Australia.¹² Whilst such a system has been operating in South Australia for several years with notable success, the adoption of container deposit schemes in other states has been fiercely opposed by the beverage industry resulting in legal action in the Northern Territory. Coca Cola Amatil successfully challenged the container deposit scheme in the Federal Court in 2013 until an exemption was made to the law allowing the Northern Territory Government to continue the scheme. Petitions, reports targeted at specific states and stakeholders, opinion polls and media coverage have all raised public awareness of the issue and put pressure on federal government to support the schemes. Much of the public awareness material emphasises the impact a container deposit system would have upon litter in the marine environment.^{13, 14}

Campaigns Supported by Additional Infrastructure

Supporting campaigns designed to produce behavioural change with additional infrastructure have been a successful approach for the Victorian Government's Don't

¹¹ Somalis ignore plastic bag ban, accessed 4/12/2013, <http://www.panapress.com/Somalis-ignore-plastic-bag-ban--12-564930-40-lang2-index.html>

¹² Cash for Containers - Boomerang Alliance - Campaigning for recycling, accessed 5/12/2013, <http://www.boomerangalliance.org.au/cash-for-containers.html>

¹³ Key Points for Lobbying - Boomerang Alliance - Campaigning for recycling , accessed 5/12/2013, <http://www.boomerangalliance.org.au/cash-for-containers/cash-media/125-key-points-for-lobbying.html>

¹⁴ Time for the Drinks Industry to Do the Right Thing - Boomerang Alliance - Campaigning for recycling , accessed 5/12/2013, <http://www.boomerangalliance.org.au/cash-for-containers/cash-media/141-time-for-the-drinks-industry-to-do-the-right-thing.html>

be a Tosser - Bin Your Butts campaign.¹⁵ Cigarette butt littering rates were forecast to increase from 58% to 80% as a result of the 2007 ban on indoor smoking at licensed venues. The campaign targeted smokers and venue operators through a range of media channels and was supported by the distribution of free personal ashtrays to smokers and financial support for venue operators to install butt bins and signs. As a result butt littering fell to 33% at the peak of the campaign, with 73% of venues supporting the campaign. The campaign's success was attributed to the strong partnerships developed with the hospitality industry, local and state governments, the infrastructure created for disposing of the butts, the public awareness campaign and the approach taken of positively engaging those littering rather than making them feel guilty.

The Monofilament Recovery and Recycling Program in the USA takes a similar approach by engaging anglers with promotional material and providing infrastructure by which they can recycling monofilament fishing line.¹⁶ An on-line pack is available to facilitate starting a local fishing line recycling program, including how to tailor campaign material to the target audience, guidance on how to use local media and distribute campaign material, and how to evaluate the effectiveness of the campaign. This packaged approach increases the reach of the campaign and allows it to be tailored to the target location in order to be most effective. The program has been taken up at locations within 47 Counties in Florida and within 32 Counties in Texas.¹⁷ A similar campaign, combining recycling points with awareness raising material, has been undertaken by the Marine Conservation Society in the UK.¹⁸

2.3.3 Targeted Campaigns

Audience Targeted Campaigns

Most campaigns target a specific audience, either based on the source of the marine debris, specific stakeholders in the marine environment, or by targeting those with the power to influence behavioural change in others.

In January 2013, Tangaroa Blue released a report to all federal and state environmental ministers, the directors of the Bureau of Meteorology (BoM) and the Great Barrier Reef Marine Park Authority regarding the marine pollution caused by

¹⁵ VLAA - Don't be a Tosser, accessed 5/12/2013, <http://www.litter.vic.gov.au/www/html/3370-dont-be-a-tosser.asp?intSiteID=2>

¹⁶ Monofilament Recovery & Recycling Program, accessed 5/12/2013, <http://mrrp.myfwc.com/getting-started/implementing.aspx>

¹⁷ Texas Monofilament Recovery & Recycling , accessed 5/12/2013, <http://mrrp.tamu.edu/binlocations.html>

¹⁸ Hang on to your tackle | Marine Conservation Society, accessed 9/12/2013 http://www.mcsuk.org/what_we_do/Clean+seas+and+beaches/Campaigns+and+policy/Hang+on+to+your+tackle

weather balloon targets released daily around Australia by BoM. ¹⁹ A weather balloon target consists of a polystyrene target wrapped in silver foil attached to a large balloon, and a torch and batteries when released at night, and is used to track the balloons position using radar. The report sparked an investigation, and by the following June one of the 44 BoM offices had already switched to a non-polluting alternative. The report appears to have been effective in educating its target audience—who were described as being “*very surprised to hear about this daily pollution into the Great Barrier Reef*”—and in causing a subsequent behavioural change.

The Operation Clean Sweep program aims to reduce plastic pellet loss through product stewardship and provides guidance and tools for putting a pledge into effect. The program was created by the Society of the Plastics Industry trade association, and the American Chemistry Council's Plastics Division and 138 companies from the USA, Canada, and Mexico have signed the pledge, including producers, transporters and terminals. ²⁰ Surfers Against Sewage successfully put pressure on the British Plastics Federation to adopt the program and has since taken the campaign directly to factories to ensure compliance. ²¹ The program has now been launched in India, Nepal, France, New Zealand and South Africa and organisations are campaigning for its adoption by the plastics industry in Australia. ^{22, 23} Where pollution comes from a relatively small number of point sources controlled by companies it can be a simple exercise to implement additional procedures to limit that pollution. Program testimonials praise the ease of implementation and highlight the added value in being able to demonstrate environment stewardship to customers. ²⁴

Several other campaigns have targeted specific audience groups:

- The Maryland Port Administration's Clean Port Initiative in Baltimore introduced permits to control the discharge of storm water associated with industrial activities—a pathway often cited as significant in marine litter and

¹⁹ Reports to Minister Released - Tangaroa Blue Foundation, accessed 18/12/2013, <http://www.tangaroablue.org/amdi/campaigns/60-bom-weather-balloons/349-reports-to-minister-released.html>

²⁰ Operation Clean Sweep, accessed 5/12/2013, <http://www.opcleansweep.org/default.aspx>

²¹ Mermaid's tears | Surfers Against Sewage, accessed 5/12/2013, <http://www.sas.org.uk/campaign/mermaids-tears/>

²² Fighting plastic litter in our oceans: a report by The Plastics Division of the American Chemistry Council, SPI: The Plastics Industry Trade Association, and The Canadian Plastics Industry Association. - Free Online Library, accessed 18/12/2013, <http://www.thefreelibrary.com/Fighting+plastic+litter+in+our+oceans%3A+a+report+by+The+Plastics...-a0323143719>

²³ Campaigns - Tangaroa Blue Foundation, accessed 18/12/2013, <http://www.tangaroablue.org/amdi/campaigns/59-pellet-alert-project.html>

²⁴ Operation Clean Sweep Testimonials, accessed 5/12/2013, <http://www.opcleansweep.org/Pledge/Testimonials.html>

- yet rarely the subject of educational campaigns.²⁵ The initiative also included compliance workshops, educational outreach and community clean-ups.
- Friends of the Earth enlist cruise customers to put pressure on cruise lines to manage their waste responsibly by grading and ranking their performance with the Cruise Report Card.²⁶ The results are intended to help customers choose a cruise based on the resultant environmental performance ratings.
 - Project Aware engages divers as stakeholders in the marine environment through debris survey and clean-up events, and the Virginia Department of Environmental Quality's Virginia Eastern Shorekeeper program effectively targets Clam and Oyster aquaculture firms in the area, producing a 41% reduction in clam nets found on barrier island beaches in 2 years.^{27,28}
 - Surfers Against Sewage targets people flushing plastics down the toilet with their Think Before You Flush campaign.²⁹

Regional and Debris Type Targeted Campaigns

Country specific 'Clean-up' organisations—such as Clean-up South Africa—and coastline clean-up events organised by a wide range of organisations were the most common regional campaigns found.³⁰ Indeed, public awareness-raising campaigns were identified in each of the Regional Seas areas. On an even smaller scale, litter cleaning vessels and an Italian seabed cleaning campaign target very specific debris sites whilst raising awareness.^{31, 32}

The majority of the case studies target a specific type of marine debris. The Beat the Micro Bead campaign targets producers of cosmetic exfoliants that use plastic microbeads. The organisation provides a smartphone barcode scanner app to identify

²⁵ Maryland Port Administration Green Port of Baltimore - Environmental Management Plan for Clean Port Initiative, accessed 9/12/2013, <http://mpa.maryland.gov/greenport/images/CleanPortInitiative.pdf>

²⁶ 2013 Cruise Report Card, accessed 9/12/2013, <http://www.foe.org/cruise-report-card>

²⁷ Dive Against Debris | Project AWARE, accessed 9/12/2013, <http://www.projectaware.org/project/dive-against-debris>

²⁸ Virginia DEQ - Virginia CZM Program: Virginia Seaside Heritage Program Goals , accessed 9/12/2013, <http://www.deq.state.va.us/Programs/CoastalZoneManagement/CZMIssuesInitiatives/VirginiaSeasideHeritageProgram/SeasideHeritageProgramGoals.aspx>

²⁹ Think Before You Flush | Surfers Against Sewage, accessed 9/12/2013, <http://www.sas.org.uk/campaign/think-before-you-flush/>

³⁰ Clean-Up South Africa , accessed 9/12/2013, <http://www.cleanup-sa.co.za/underwater.htm>

³¹ LOW-TECH MAGAZINE: Fighting marine debris: the dustcarts of the sea, accessed 9/12/2013, <http://www.lowtechmagazine.com/2009/06/fighting-marine-debris-the-dustcarts-of-the-sea.html>

³² Seabed cleaning - Collection and disposal of litter at depth less than 50 m - MARLISCO, accessed 9/12/2013, <http://www.marlisco.eu/seabed-cleaning-collection-and-disposal-of-litter-at-depth-less-than-50-m-bp5-e.en.html>

products that contain plastic microbeads and rates them as red (contains microbeads), orange (contains microbeads but the producer has indicated it will stop within a given timeframe) or green (free from microbeads). In doing so, targeted information is readily available before the point of purchase to allow the consumer to boycott brands and products using microbeads. The potential purchasing power pressure combined with the bad publicity of having products listed in the campaign has proved to be strong motivation for some companies, with many having made commitments to remove microbeads from their products, including The Body Shop, Johnson & Johnson, Unilever, L'Oreal, Colgate-Palmolive, Beiersdorf (Nivea) and Procter & Gamble.

The Marine Conservation Society's Don't Let Go Campaign aims to stop releases of balloons and sky lanterns due to the litter they create and the impact upon marine species.³³ The campaign provides an action pack so that individuals may take action to stop a balloon or sky lantern release in their area and directly engages groups planning balloon and sky lantern launches. A petition to the Welsh Government led to an investigation to gather and review evidence to inform future Government responses to any call for action.

Campaigns such as GhostNets Australia, CCAMLR Antarctic Marine Debris, Don't be a Tosser - Bin Your Butts, Monofilament Recovery and Recycling Program, Tangaroa Blue Weather Balloon, Operation Clean Sweep and Virginia Eastern Shorekeeper detailed above also target specific types of marine debris.³⁴

2.4 Campaign Gaps

2.4.1 Audience Gaps

The majority of audiences identified in Section 2.1 have been found in the case studies outlined in Section 2.3. The main audience gaps were around waste management firms, storm water drainage and the military.

Improving waste management infrastructure and practice as well as public education around waste management has been identified as a key strategy to achieving many of the goals set out in The Honolulu Strategy.³⁵ Whilst most of the case studies in Section 2.3 relate to waste reduction and improving public use of waste infrastructure, none have targeted waste management firms or their employees. Such an approach could be expected to be effective, given the outcomes of targeting employees of harvesting vessels (CCAMLR campaign, Section 2.3.1) and educational

³³ Don't Let Go - balloons and sky lanterns | Marine Conservation Society, accessed 18/12/2013, http://www.mcsuk.org/what_we_do/Clean+seas+and+beaches/Campaigns+and+policy/Don't+let+go+-+balloons+and+sky+lanterns

³⁴ Ghost Nets Australia, accessed 9/12/2013, <http://www.ghostnets.com.au/>

³⁵ NOAA, and UNEP (2011) *The Honolulu Strategy: A Global Framework for Prevention and Management of Marine Debris*, Accessed 23 October 2013, <http://5imdc.wordpress.com/about/honolulustrategy/>

measures for plastics industry employees to support procedures to control the loss of plastic pellets (Operation Clean Sweep, Section 2.3.3).

Where storm water drainage infrastructure is regulated it tends to be done so through government legislation, and specific guidance documents rather than broad educational campaigns appear to be the tool most commonly used to promote best practice.^{36,37} It is crucial to plan storm water drainage to limit the transmission of land based litter to the marine environment. Once the drainage has been planned and built there may be limited opportunity to further reduce litter passing through the system by way of maintenance and upgrades. As such, working with governments to ensure that planning guidance and best practice documents are relevant to the reduction of marine debris may be a more effective strategy in this area. However, the amount of litter that enters a storm water drain can be affected by educational campaigns as it is largely dependent on public behaviour. None of the campaigns found in this study have targeted sites where litter is likely to be washed into storm drains or temporal periods of increased rainfall where a greater flow of water into storm drains is likely to carry more debris. Material entering storm drains from private industry can be reduced using local policy and training such as the Maryland Port Administration's Clean Port Initiative in which discharge to storm water permits are used to regulate industrial activities, see Section 2.3.3.

The world's Navies are stakeholders in the marine environment and account for many of the larger vessels in the oceans. Whilst vessels are exempt from MARPOL Annex V when "*securing the safety of a ship and those on board or saving life at sea*"—which may apply more frequently to naval ships than other vessels—the fleet remains subject to Annex V regulations in all other non-exempt situations.³⁸ Apart from participating in occasional clean-up events, the only other information regarding marine debris actions relate to an outdated reference to the U.S. Navy's plans to fit compactors for plastic waste on all Navy ships by 1999.^{39, 40} It is unclear what training methods and educational materials are used by Navies to communicate the requirements of MARPOL Annex V to their personnel, nor what infrastructure and procedures are implemented to support its compliance. Without any data on the

³⁶ Federal Stormwater Management Requirements | Greening EPA | US EPA, accessed 9/12/2013, <http://www.epa.gov/greeningepa/stormwater/requirements.htm>

³⁷ Managing Stormwater - A Strategy for Promoting the Use of Sustainable Drainage Systems (SuDS) within Northern Ireland, http://www.doeni.gov.uk/niea/managing_stormwater_a_strategy_for_promoting_the_use_of_sustainable_drainage_systems_within_ni_september_2011.pdf

³⁸ IMO (2011) MARPOL Annex V, Accessed 10 October 2013, <http://www.imo.org/OurWork/Environment/PollutionPrevention/Garbage/Documents/201%2862%29.pdf>

³⁹ Naval trainees take to the beaches in big Cornwall clean up | Royal Navy, accessed 10/12/2013, <http://www.royalnavy.mod.uk/News-and-Events/Latest-News/2013/October/23/131023-Naval-trainees-take-to-the-beach>

⁴⁰ Global Marine Litter Information Gateway][Good examples (cases and practices), accessed 10/12/2013, <http://marine-litter.gpa.unep.org/cases/technical.htm>

quantity of marine debris produced by Navy vessels it is impossible to ascertain whether current systems are sufficient, although it is likely that improvements can be made. The size of naval fleets and the hierarchical and directive nature of the organisational structures provide an opportunity to engage them as major stakeholders in the minimisation of marine debris and potentially effect significant change. Indeed, the Navy could play a role in the enforcement of MARPOL by monitoring ship activities and checking log books during routine stop-checks and inspections.

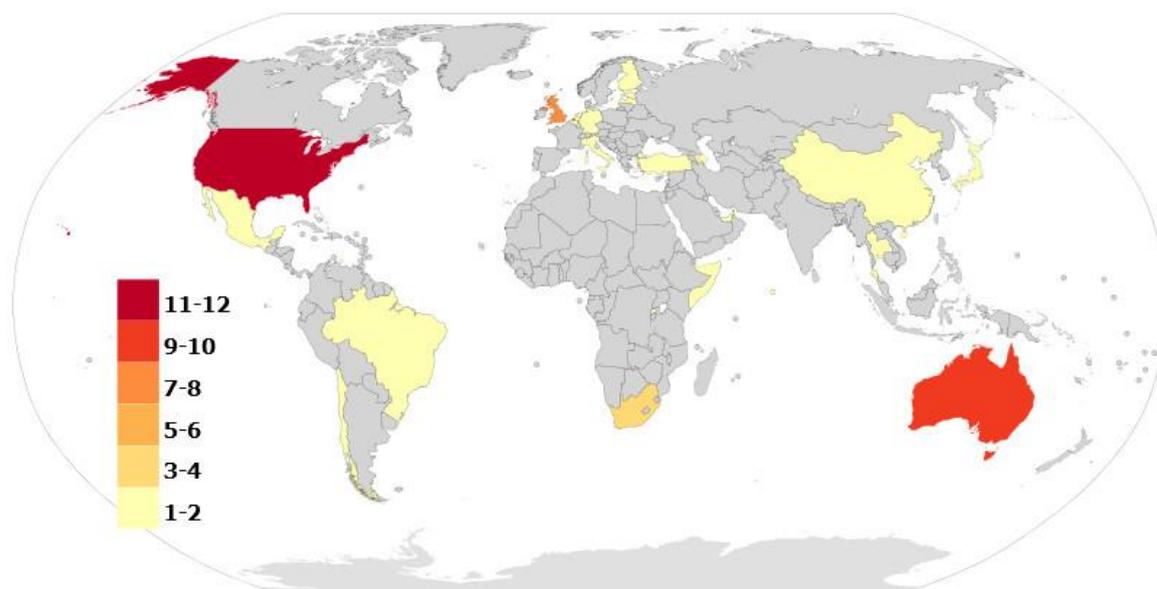
2.4.2 Geographic Gaps

The distribution of the case study campaigns is shown in Figure 1. Due to the research approach taken of a non-exhaustive internet search for public awareness campaigns, the distribution of the case studies is unsurprisingly biased towards certain locations. The number and size of campaigns undertaken will largely rely upon factors such as:

- the length of the country's coastline (where the anti-debris campaigns are marine specific),
- the population of the country;
- public attitudes towards environmental issues; and
- the resources available for such work.

The number of these campaigns then published on the internet will largely depend upon the number of internet users in the country, assuming that internet publication approximately follows readership. The number of the published campaigns that were found in this study will be biased by language, as for the most part English search terms were used. It is not surprising therefore that the country with the greatest number of campaigns covered in this study is the USA, followed by Australia and the UK, as all are English speaking nations with a very high number of internet users and large coastlines relative to their total territory. No campaigns were found in Russia and only one in China, which is unlikely to be representative given the coastline, population and internet penetration of those countries and is most likely due to language search bias and differences in media and reporting in those countries.

Figure 1: Distribution of campaign organisations used in the case studies



Public awareness campaigns were found in each of the Regional Seas areas but more extensive research would be required to estimate general distribution of all major campaigns.

2.4.3 Species Gaps

Very few of the public awareness campaigns identified have targeted specific migratory species. Only Antarctic fur seals, sea turtles and Mediterranean sperm whales have been used as the focus of campaigns in the case studies found. Arguably all campaigns that affect marine debris potentially have an impact upon migratory species, but more may be done to target those most at risk. Of course a migratory species may be used as the ‘face’ of a campaign, even if the focus of the campaign itself is a more generic one.

2.4.4 Debris Type Gaps

Campaigns were found to have good coverage of different types of marine debris, specifically targeting the most common debris types as well as those with the highest impact. The occurrence of debris type targeted campaigns within the case studies in Appendix A.1.0 is shown in Figure 2.

The top five most common items by count reported by the ICC in coastal clean-up exercises are cigarette butts, food wrappers/containers, beverage bottles, plastic bags and caps/lids. These debris items collectively account for over 56% of litter items found in surveys undertaken by the International Coastal Cleanup (see Report I). Public awareness campaigns targeting all five items have been identified in this study.

Several major campaigns—such as GhostNets Australia—target abandoned, lost or discarded fishing gear, which can have a lethal impact upon migratory species as a result of entanglement, (see Report I). Microplastics are potentially overlooked by the ICC and other marine debris surveys due to their small size, and are considered to

have a high impact due to absorption of toxic chemicals and ingestion (see Report I). Campaigns have targeted preventing microplastics from entering the marine environment in the form of manufacturing nurdles (Operation Clean Sweep) and cosmetic exfoliants (Beat the Microbead).

Figure 2: Targeted campaigns in the case studies by debris type



No specific debris types have been identified as gaps in campaigning, although changes in product design, packaging and the use of new materials mean that campaign organisations must react quickly if they are to keep pace with new types of marine debris.

3.0 Effectiveness

3.1 Effectiveness of Campaigns and Knowledge Gaps Relevant to their Evaluation

Information on the efficacy of the public awareness campaigns is sparse, and where it is available the analysis is in almost all cases conducted by the campaign organisers and therefore lacks independent and impartial authority. Campaigns rarely used the same metrics to measure success, and as financial information was not found for any

of the campaigns an evaluation of value for money could not be performed. These factors make the task of comparing case studies extremely difficult, although there are a number of other factors from which we can infer success.

138 companies from the USA, Canada, and Mexico have signed the Operation Clean Sweep pledge and it has now been adopted in six other countries. The campaign boasts positive testimonies praising the ease and low cost of implementing the program, and when an NGO identified plastic pellets as a problem in the UK they petitioned the British Plastics Federation to adopt the program. Continued campaign expansion can be attributed to the 'packaged' campaign format, where campaign material and guidance are readily available to be tailored and applied in other areas. This type of campaign is also seen in the Monofilament Recovery and Recycling Program, which has considerable penetration in two states in the USA and has been mirrored in the UK, see Section 2.3.3 above. Similarly the Beat the Microbead campaign has been successfully launched in several countries using the same base technology and campaign material with a country specific list of products containing plastic microbeads. When successful, this type of campaign can provide high value for money as materials and resources only have to be developed once with subsequent slight modifications to suit the target location. Furthermore, subsequent implementations can draw on directly relevant experience from an expanding knowledge base.

Directly engaging government ministries has proven effective in the weather balloon target campaign led by the Tangaroa Blue Foundation. The Australian government has launched its own investigation into the issue and one office of the Bureau of Meteorology has changed the type of weather balloon target used. Negative publicity and consumer pressure are effective when targeting manufacturers, and have led to major cosmetics firms promising to remove plastic microbeads from their products following the Beat the Microbead campaign.

The tone in which campaigns engage the public is also important. Alongside the humorous title, the message of the Victorian Government's Don't be a Tossler - Bin Your Butts campaign was carefully planned so that it "*pointed no fingers nor placed blame*" as "*telling people their behaviours are intrinsically bad seldom works for behaviour change*".⁴¹ The website of the Marine Conservation Society's Hang on to your Tackle campaign takes a different tack when it tells the reader that:⁴²

Most anglers take their litter home, but underwater clean-ups and regular beach cleans all too often reveal that some anglers are leaving behind snagged lines, fishing weights and hooks.

The message is reminiscent of reminder letters sent in Britain for unpaid taxes that elicit compliance to social norms by indicating that most other people in the

⁴¹ VLAA - Don't be a Tossler, accessed 5/12/2013, <http://www.litter.vic.gov.au/www/html/3370-dont-be-a-tossler.asp?intSiteID=2>

⁴² Hang on to your tackle | Marine Conservation Society, accessed 7/1/2014, http://www.mcsuk.org/what_we_do/Clean+seas+and+beaches/Campaigns+and+policy/Hang+on+to+your+tackle

customer's community or those owing a similar amount have already paid. The tax letters are worded based on nudge theory, and have effected behavioural change leading to savings of £210 million in one year alone.⁴³

It is clear from the case studies that generally the more targeted the campaign the easier it is to set out quantifiable objectives which in turn make it easier to directly measure success. A good example of such a campaign is the Don't be a Tossler - Bin Your Butts campaign which targets a specific marine debris type from a specific audience in a relatively small area. The campaign set out specific behavioural targets in terms of the number of premises implementing the campaign's actions and the littering rate at participating locations, and was able to evaluate its success against these objectives using data collected. Petitioning government about specific debris types has further reaching potential as well as easily observable outcomes as any reaction by government is likely to be public in nature. The Tangaroa Blue Weather Balloon Targets and the Marine Conservation Society Don't Let Go campaigns can both report positive outcomes in the government response to lobbying.

Factors contributing to failure of campaigns are more difficult to identify. The case studies presented here suffer from reporting and author bias in that the less successful campaigns are unlikely to be reported and campaign organisers are unlikely to risk negative reactions from the public or funding bodies by reporting any failures of a campaign. Of the campaigns that do report successful measures the majority make efforts to engage the public at the point of debris creation, for example posters and bins for anglers at popular fishing locations. No data was found on the short-term vs. long-term behavioural change resulting from the campaigns, but industry adoption of best practice guidance, such as Operation Clean Sweep, changes in legislation, such as the Rwandan plastic bag ban, and economic instruments, such as container deposit schemes, are likely to maintain a lasting effect as the behavioural change comes about through a constant and lasting driver largely independent of personal habit.

4.0 Recommendations for CMS

4.1 Support, Promote and Replicate Current Campaigns

In this study we have identified a number of successful campaigns that target a specific type of marine debris and can easily be applied to different countries and locations. Campaigns such as the Operation Clean Sweep program, the monofilament and fishing tackle capture and recycling campaigns, and the Beat the Microbead campaign are easily adapted to local requirements and have already been implemented in different locations. Support for these campaigns can be promoted to CMS Party and Signatory States through National Focal Points, the Conference of the Parties and the Standing Committee as well as through external networks. The CMS

⁴³ Britain's Ministry of Nudges - NYTimes.com, accessed 16/12/2013, http://www.nytimes.com/2013/12/08/business/international/britains-ministry-of-nudges.html?pagewanted=2&_r=0

could also invite applications to the CMS small grants programme for funding for campaigns.

Promotion of the practices and achievements of site or industry specific measures, such as those undertaken by Maryland Port Administration and The Port of Oakland, may encourage other facilities to take steps of their own to minimise marine debris. Engaging industry bodies, such as the International Association of Ports and Harbours, the American Association of Port Authorities, the European Seaports Organization, the Association of Australian Ports and Maritime Authorities, and the Association of Canadian Port Authorities, may be a good way to promote measures across an industry, as has been seen in the plastics industry with Operation Clean Sweep.

It is logical to build upon existing networks and resources by working with organisations currently campaigning around marine debris and others who are stakeholders in the marine environment. CMS can seek to engage organisations invested in migratory species to promote campaigns and raise awareness of marine debris amongst their members.

4.2 Gaps to Address

There may be opportunities to address the audience gaps identified in Section 2.4.1 by targeting campaigns around waste management firms, storm water drainage and the military. It would be useful if there was more data on the relative importance of these sources of marine debris, however this should not preclude investigation of the means of reducing marine debris and the development of communications strategies and materials.

4.3 Promote Best Practice within Campaigns

There is a general lack of data concerning the efficacy of campaigns. To overcome this CMS can promote campaign data collection and reporting by providing general guidance and could highlight the benefits of being able to evaluate the success of a campaign and report it to funders and the public. Providing data input templates and guidance to survey the campaign reach, message recognition and impact upon the target behaviour or levels of marine debris may be of help to campaign organisers.

When introducing legal and economic measures to produce behavioural change, public support can be improved by planning supporting campaigns to engage the public well before the changes come into effect. Public support is crucial if the measures are to be effective, especially if enforcing the measure and policing violations is difficult. Once in place, it is recommended that efforts continue to raise awareness of the measures and how to comply with them through targeted campaigns.

Some campaigns emphasise the need for a positive message, to encourage rather than chastise the audience. There may perhaps be lessons to be learned in this area from other behavioural change campaigns (stop smoking campaigns, general anti-littering campaigns, stop bullying campaigns) as well as lessons from behavioural science that can be used in the campaigns. One system, called nudge theory, has been applied to tax collection letters in the UK with significant success and could help

illicit public behaviour change through marine debris campaigns, see Section 3.1. Key tools may include raising awareness of and conformity to social norms, for example highlighting that people in the same group or demographic or engaged in the same activity find littering unacceptable. Campaigns can also employ a range of tones for different materials, approaches and audiences in order to affect a wider demographic of people and mind-sets.

The case studies show that many successful campaigns have targeted audiences and debris types. They are also often remarked upon for their ease of compliance, which can be facilitated through supportive infrastructure such as bins and recycling points and supporting alternative products when banning a certain material. Such lessons should prove useful when planning future campaigns.

APPENDICES

A.1.0 Public Awareness and Education Campaign Case Studies

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
Benguela Current Large Marine Ecosystem	NGO	Angola, Namibia, South Africa	General public	Angola, Namibia, South Africa	Various	The Marine Litter Project - including beach clean-ups in Angola, Namibia and South Africa	http://www.dlist.org/burnin-g-issues/the-ground-angola-pilot-activities-the-bclme-programme
A Campaign Consultative Committee of key organisations in Victoria	NGO	Australia	Smokers and venue operators	Australia	Cigarette butts	Don't be a tosser, bin your butts campaign - cigarette butt littering. Media launches, advertising, free personal ashtrays, rebates (incentive) to help premises install butt bins, direct engagement.	http://www.litter.vic.gov.au/www/html/3370-dont-be-a-tosser.asp?intSiteID=2
Australian Food & Grocery Council	Trade Association	Australia	General public	Australia	Land based litter and public recycling	The Packaging Stewardship Forum's Do the Right Thing Use the Right Bin litter and recycling campaign.	http://www.afgc.org.au/psf/do-the-right-thing.html
Australian Maritime Safety Authority	Government	Australia	Commercial shipping	Australia	Ship waste and litter	Stow it don't throw it pamphlet. Also notifies vessels of MARPOL law and that vessels of 12m length or more are required to display a placard stating disposal of plastics into the sea is prohibited.	http://www.amsa.gov.au/forms-and-publications/Publications/Stow-it.pdf
Boomerang Alliance	NPO Umbrella Group	Australia	General public	Australia	Drinks containers	Cash for Containers - Container Deposit Scheme	http://www.boomerangalliance.org.au/cash-for-containers.html
Clean Up Australia	NPO	Australia	General public	Australia	Drinks containers	Container Deposit Scheme	http://www.cleanup.org.au/Whateleswesupport/container-deposit-legislation.html
Clean Up Australia	NPO	Australia	General public	Australia	Land based litter	Clean Up Australia Day	http://www.cleanup.org.au/CleanUpEvents/about-the-campaign.html

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
GhostNets Australia	NPO	Australia	General public, coastal visitors	Australia	Abandoned, lost or discarded fishing gear	Data Summary Report of ghost nets collected in North Australia	http://www.ghostnets.com.au/index.html
GhostNets Australia	NPO	Australia	General public, coastal visitors	Australia	Abandoned, lost or discarded fishing gear	Public art exhibitions and workshops undertaken as public engagement	http://www.ghostnets.com.au/projects.html?cat=Art
Tangaroa Blue Foundation	NPO	Australia	Environment Ministers	Australia	Weather balloon targets	Report on debris from the Bureau of Meteorology's weather balloon targets	http://www.tangaroablue.org/amdi/campaigns/60-bom-weather-balloons/349-reports-to-minister-released.html
Tangaroa Blue Foundation	NPO	Australia	Government Agencies	Australia	Plastic manufacturing pellets (nurdles)	Report to Government Agencies on plastic pellets with recommendation to implement the Operation Clean Sweep program	http://www.tangaroablue.org/amdi/campaigns/59-pellet-alert-project.html
Ecology and Natural Resources Ministry Azerbaijan	Government	Azerbaijan	General public	Azerbaijan	Various	Week of the Caspian Sea. Cultural and educational activities including a 10km coastline clean, household and industrial waste cleared from 25 hectares in other coastal town and coastal zone areas. The Ecology and Natural Resources Ministry's specialists gave lectures on the importance of protecting biological resources of the Caspian Sea.	http://en.trend.az/news/society/1759878.html
Comlurb - municipal cleaning company	Private	Brazil	General public	Brazil	Various	To raise awareness of beach litter, in the build up to a Zero Waste program and cigarette littering fine in Rio, Comlurb didn't clean Ipanema beach to show the amount of litter deposited in one weekend.	http://oglobo.globo.com/rio/multas-do-programa-lixo-zero-comecam-ser-aplicadas-partir-do-proximo-dia-20-9354122

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
The "Miladinov Brothers" school in Burgas	Public	Bulgaria	General public	Bulgaria	Various	School activities to reduce waste in the Black Sea including direct teaching and discussion, an exhibition dedicated to the Black Sea and commenting on environmental issues related to its pollution, posters and a concert.	http://www.marlisco.eu/School_activities_to_reduce_waste_in_the_Black_Sea.en.html
The Green Burgas Foundation	NPO	Bulgaria	Government, general public	Bulgaria	Various	My Black Sea campaign in Burgas. Beach clean-up, petitioning the President of the Republic of Bulgaria, National Assembly, Ministry of Environment and Water and the Council of Ministers, leaflet distributed to citizens of Burgas, art works.	http://www.marlisco.eu/Campaign_in_Burgas.en.html
Universidad Católica del Norte	Private	Chile	General public	Chile	Various	Científicos de la basura - various activities for schools to monitor and clean up litter, mostly in river environments.	http://www.cientificosdela_basura.cl/index_.php
Shanghai Roots and Shoots	NPO	China	School Children	China	Plastic bags	No plastic bags campaign. Lectures on reusable bags versus plastic bags and free reusable bags given to children at schools in Shanghai.	http://www.jgi-shanghai.org/index.php/english/projects/no-plastic-bags-campaign/
Seas At Risk	NGO	Europe	School Children	International	Various	Learn2sea website and educational material	http://www.learn2sea.org/index.php
BUND Friends of the Earth Germany	NGO	Germany	School Children	International	Ship waste and litter	Nothing Overboard - Cartoon Competition	http://www.bund.net/fileadmin/bundnet/publikation/en/meere/130207_bund_meeresschutz_comicwettbewerb_broschuere.pdf
CCAMLR	IGO	International	Commercial fishing	International	Abandoned, lost or discarded fishing gear, and ship	The operator of a harvesting vessel must provide a copy of the CCAMLR information brochure "Marine Debris—A Potential Threat to Antarctic Marine Mammals" to each member of the crew	http://federal.eregulations.us/cfr/section/title50/chaapteriii/part300/sect300.109?selectdate=11/1/2011

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
					waste and litter	of the harvesting vessel and must display copies of the CCAMLR placard "Avoidance of Incidental Mortality of Antarctic Marine Mammals" in the wheelhouse and crew quarters of the harvesting vessels.	
Friends of the Earth	NGO	International	Cruise line operators and customers	International	Cruise ship waste	Cruise Report Card - rating and ranking cruise lines and ships on several environmental factors	http://www.foe.org/cruise-report-card
Project Aware	NGO	International	Divers	International	Various	Dive Against Debris - organised local events to remove debris, tools to plot and centrally store a record of marine debris found on dives.	http://www.projectaware.org/project/dive-against-debris
Regional Agency for Environmental Protection of Tuscany (ARPAT), Liguria Regional Authority, Environmental Office of Corsica, Sardinia Regional Authority, Livorno Province.	Government	Italy	Local Authorities, local Port Authorities, local diving schools, local fishermen	Italy	Various	Seabed cleaning - Collection and disposal of litter at depth less than 50m (Italy), with public stands and engagement.	http://www.marlisco.eu/seabed-cleaning-collection-and-disposal-of-litter-at-depth-less-than-50-m-bp5-e.en.html
Japan Environmental Action Network (JEAN), the Ocean Conservancy's	Public	Japan	Public	Japan	Various	Artwork to mark the International Coastal Cleanup (ICC) day	http://japan.usembassy.gov/e/p/tp-20130925-01.html

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
Japan partner and International Coastal Cleanup organizer							
Como Hotels	Hospitality	Maldives	General public	International	Various	Promoting marine conservation, including Project Aware, to their hotel guests via the webpage	http://www.comohotels.com/cocoaisland/destination-guide/natural-world/marine-conservation
MIO-ECSDE, the Hellenic Marine Environment Protection Association (HELMEPA) and Clean-up Greece with the support of MED/POL and the Mediterranean Pollution Assessment and Control Programme of UNEP/MAP	Group various	Mediterranean Countries	Agriculture, industry, tourists, maritime sector, local authorities and port authorities.	Mediterranean Countries	Various	Keep the Mediterranean Litter-free Campaign. Poster/brochure in 11 languages,	http://www.mio-ecsde.org/articles.asp?cMC=&cID=6&aID=36
Ocean conservancy Mexico blog	NGO	Mexico	General public	Mexico	Various	La limpieza internacional de costas 2011 - coastal cleanup in la Playa Miramar (Tampico-Madero), and the Parque Metropolitano and in Altamira.	http://ocean-conservancy-mexico.blogspot.co.uk/
Plastic Soup Foundation & Stichting De Noordzee	NGO	Netherlands	General public	International	Microplastics used in cosmetics	Beat the micro bead Mobile App - scan products to see if contain plastic microbeads	http://beatthemicrobead.org/en/
Sea First Foundation	NPO	Netherlands and	General public	Pacific Ocean	Various	Oceans of Garbage - Infographics Poster	http://seafirst.be/en/oceans-of-garbage

Organisation	Organisati on Sector	Organisat ion country	Audience Group	Audience Country	Debris type	Campaign	Website
		Belgium		focused			
Rwanda Government	Government	Rwanda	General public	Rwanda	Plastic bags	Education for the plastic ban bag. Talks by people and leaders and discussion during the mandatory monthly community work day, TV and radio campaigns, and short videos for foreign visitors.	http://thedeliciousday.com/environment/rwanda-plastic-bag-ban/
Stornoway Port Authority	NGO	Scotland	Commercial fishing and general public	Scotland	Abandoned, lost or discarded fishing gear, various.	Beach Litter Clearance	http://www.stornoway-portauthority.com/archive/154-beachlitterclearance.html
Somaliland Government	Government	Somaliland	General public	Somaliland	Plastic bags	Plastic bag ban failed due to lack of support and lack of accepted alternatives	http://www.allaboutbags.ca/bansdontwork.html
Clean-up South Africa	NGO	South Africa	General public	South Africa	Various	Clean up events, promotion of artwork, educational material	http://www.cleanup-sa.co.za/underwater.htm
Plastics SA, Department of Environmental Affairs SA, South African National Biodiversity Institute and the United Nations Environment Programme	Various	South Africa	Government, industry and NGO	African countries	Various	First African Marine Litter Summit held in South Africa	http://www.projectaware.org/update/marine-debris-summit-focus-africa
Baltic Sea 2020 foundation	NGO	Sweden	Public	International	Abandoned, lost or discarded fishing gear	Ghost in the Baltic Sea - ghost fishing documentary	http://marinedebris.info/videos/ghosts-baltic-sea
Keep Sweden Tidy Foundation	NPO	Sweden, Estonia,	Public	Sweden, Estonia,	Various	The Baltic Marine Litter (MARLIN) project. Examples of activities carried	http://www.projectmarlin.eu/sa/node.asp?node=311

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
(Lead Partner)		Latvia, and Finland		Latvia, and Finland		out in the MARLIN project is a litter exhibition contest for children (Estonia), beach walk in the Riga bay (Latvia), collect sea-bed litter in marinas (Sweden) and educational material for children (Finland).	9
Phuket Marine Biological Centre under COBSEA's Green Fins activity	Private	Thailand	General public	Thailand	Various	Coastal Clean-Up Day in Thailand	http://www.cobsea.org/activities/activities_coralreef_coastal%20cleanup.html
The Spinal Cord Paralytics Association of Turkey	NGO	Turkey	Recycling companies, supermarkets, municipalities, private corporations, post office, schools, malls, general public.	Turkey	Plastic lids	Blue Lid Campaign - save bottle caps to buy wheelchairs. Remote link to marine litter?	http://www.marisco.eu/blue-lid-campaign-turkey.en.html
Emirates Diving Association	NPO	UAE	General public	UAE	Various	Clean Up Arabia campaign and beach clean	http://caravandaily.com/portal/clean-up-arabia-campaign-across-uae-saudi-arabia-and-oman/
Gumdrop Ltd	Private	UK	General public	UK	Chewing gum	Online game to reduce gum litter, lesson plans and educational downloads. Gumdrop makes plastic products out of used chewing gum,	http://gumdropltd.com/education/

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
						including gum bins for streets and a keyring version.	
Marine Conservation Society	NGO	UK	General public	UK	Balloons and sky lanterns	Don't Let Go campaign - petitions to national government to ban international outdoor balloon and lantern releases, directly engages groups and provides an action pack for individuals to stop balloon and sky lantern releases in their area.	http://www.mcsuk.org/what_we_do/Clean+seas+and+beaches/Campaigns+and+policy/Don't+let+go+-+balloons+and+sky+lanterns
Marine Conservation Society	NGO	UK	Recreational anglers	UK	Abandoned, lost or discarded fishing gear	Hang on to your tackle - campaign working with a local authority and the Angling Trust, poster, and guidance for encouraging anglers to not leave their tackle behind.	http://www.mcsuk.org/what_we_do/Clean+seas+and+beaches/Campaigns+and+policy/Hang+on+to+your+tackle
Peppersmith	Private	UK	General public	UK	Chewing gum	Plastic free chewing gum with papers included to wrap it in	http://myplasticfreelife.com/2012/05/peppersmith-makes-chewing-gum-without-plastic/
Royal Navy	Military	UK	General public	UK	Various	Students from 750 Naval Air Squadron beach clean in Cornwall	http://www.royalnavy.mod.uk/News-and-Events/Latest-News/2013/October/23/131023-Naval-trainees-take-to-the-beach
Surfers Against Sewage	NGO / Marine Leisure Users (Surfers)	UK	General public	UK	Domestic disposal of solid waste to the sewage system	Think before you flush campaign - posters and stickers to advertise, 1 town in Cornwall made a Think before you flush town for use of promo material	http://www.sas.org.uk/campaign/think-before-you-flush/
Surfers Against Sewage	NGO / Marine Leisure Users	UK	Plastics industry	UK	Plastic manufacturing pellets (nurdles)	Mermaid's Tears - campaign for the British Plastic Federation (BPF) to adopt the Operation Clean Sweep program.	http://www.sas.org.uk/campaign/mermaids-tears/

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
	(Surfers)						
Californians Against Waste	NPO	USA	General public	USA	Polystyrene Takeout Food Packaging	Polystyrene Takeout Food Packaging Pollution - raising awareness of polystyrene as marine debris, lists local polystyrene bans, raises support for and legally sponsors a bill in California that requires fast food chains to use packaging materials that can be locally recycled or composted.	http://www.cawrecycles.org/issues/plastic_campaign/polystyrene
Maryland Port Administration	Government	USA	Commercial tenants	USA	Stormwater carried debris, various	Clean Port Initiative - Permits for discharge of storm water, surveys of tenants waste, additional waste facilities, education, installed storm drain filters	http://mpa.maryland.gov/greenport/images/CleanPortInitiative.pdf
National Oceanic and Atmospheric Administration (NOAA), USA	Government	USA	Commercial line fishing boats, recreational anglers and general public	USA	Abandoned, lost or discarded fishing gear	Monofilament Recovery & Recycling Program. Supporting brochures, flyers and instillation of fishing line recycling bins. Also guidance and contact info for the recycling processors.	http://mrrp.myfwc.com/about.aspx
Ocean Conservancy	NPO	USA	General public	International	Drinks containers, various	Rippl iPhone App - gives environmental tips to reduce marine litter and helps set reminders for favourite tips (like taking a reusable mug when you leave the house). It also tracks your progress and allows you to share it via social media.	http://www.oceanconservancy.org/do-your-part/rippl.html
Sea Turtle Conservancy	NPO	USA	General public	International	Various	Tour de Turtles - several turtles released with tracking devices to see which	http://www.tourdeturtles.org/2013/Claire.php

Organisation	Organisation Sector	Organisation country	Audience Group	Audience Country	Debris type	Campaign	Website
						swims furthest. Each raises awareness and money for different causes threatening turtles, one of which is marine debris. Lesson plans and educational material available.	
Society of the Plastics Industry (SPI) trade association, and the American Chemistry Council (ACC)'s Plastics Division and PlasticsEurope	Industry associations	USA	Plastics industry	International	Plastic manufacturing pellets (nurdles)	Operation Clean Sweep - Industry pledge of plastic pellet control through product stewardship. Provide guidance and tools to putting pledge into effect.	http://www.opcleansweep.org/default.aspx
SumOfUs	NGO	USA	Public	International	Agricultural	Online petition to supermarkets to ensure that their suppliers dispose of greenhouse plastic sheets and other waste responsibly, particularly focussing on whale deaths from eating the sheets.	http://action.sumofus.org/a/sperm-whale-plastic-tesco/?sub=fb
The Port of Oakland	Government	USA	40 tenant industrial facilities	USA	Stormwater carried debris	Clean Water Program - educating tenant industry in best practice and sponsoring shoreline clean-ups	http://www.portofoakland.com/environment/cleanwater.aspx
Virginia Department of Environmental Quality	Government	USA	Clam and oyster aquaculture	USA	Abandoned, lost or discarded aquaculture clam netting	Virginia Eastern Shorekeeper - Education, industry engagement to create hotline for reporting discarded clam nets	http://www.deq.state.va.us/Programs/CoastalZoneManagement/CZMIssuesInitiatives/VirginiaSeasideHeritageProgram/SeasideHeritageProgramGoals.aspx
Alaska Marine Safety Education Association (AMSEA) and	NPO (AMSEA) and group of private	USA - Alaska	Fishing Industry	USA - Alaska	Abandoned, lost or discarded fishing gear	Trashing Your Livelihood: Marine Debris and Commercial Fishing DVD. The video was produced with NOAA funds in partnership with the Alaska Marine	http://seagrant.uaf.edu/bookstore/pubs/MAPV-65.html

Organisation	Organisati on Sector	Organisat ion country	Audience Group	Audience Country	Debris type	Campaign	Website
Marine Conservation Alliance Foundation (MCAF)	companies and coastal communities (MCAF)					Safety Education Association and Marine Conservation Alliance Foundation.	
Marine Conservation Alliance Foundation (MCAF) and the National Oceanic & Atmospheric Administration (NOAA)	Group of private companies and coastal communities (MCAF) and government (NOAA)	USA - Alaska	School Children	USA - Alaska	Various	2 x 2 week curriculum units for different school ages.	http://www.alaskamsf.org/marine-debris/education/
State of Alaska Division of Environmental Health	Government	USA - Alaska	General public	USA - Alaska	Various	Waste Erosion Assessment and Review (WEAR) Project to inventory and prioritise eroding landfills that are releasing material into the oceans and rivers. Community input to identify sites.	http://dec.alaska.gov/eh/sw/wear.html