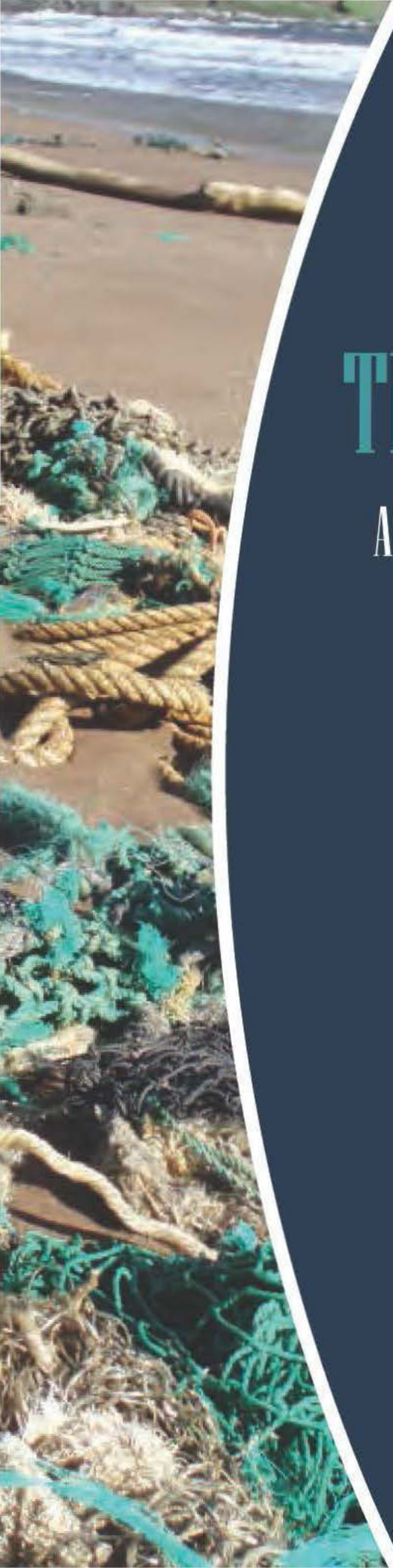

The Honolulu Strategy

A Global Framework for Prevention and Management of Marine Debris

UNEP

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The *Honolulu Strategy* was developed with the support and assistance of scientists, practitioners, managers, and the private sector from around the world. The United Nations Environment Programme (UNEP) and National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program provided technical and financial support throughout the development process before, during, and after the Fifth International Marine Debris Conference. UNEP's technical consultant, Ms. Seba Sheavly (Sheavly Consultants), gathered input from marine debris experts and practitioners to develop the draft elements of the Honolulu Strategy that was provided to participants during the Fifth International Marine Debris Conference. NOAA's technical consultants, Dr. Kitty Courtney (Tetra Tech Inc.) and Mr. John Parks, (Marine Consultants, LLC) developed and refined the framework for the *Honolulu Strategy* through a pre-conference workshop and incorporated comments after the conference to produce the Draft and Final versions of the *Honolulu Strategy*. The draft was then reviewed by the 5IMDC Steering Committee and opened for review and comment by 5IMDC participants and non-participants. We thank the individuals and organizations who provided comments to improve the Strategy.

The writers would also like to address three issues that were raised in several comments – setting a zero target for marine debris creation, Integrated Solid Waste Management (ISWM), and Extended Producer Responsibility. These areas are clearly relevant to the scale and nature of the marine debris problem and were the focus of multiple comments. These issues and comments were discussed by UNEP and NOAA, as the primary document drafters. After much discussion, it was decided that, while extremely important, these issues could not be integrated into the Honolulu Strategy for the following reasons:

- As a Framework, target-setting would not be appropriate within the Strategy itself. Each local, regional, or national organization must set its own targets based on its needs and capabilities. This Strategy is providing ideas for organizations to address marine debris through their own means; it is not creating a global, integrated effort with associated goals, tracking, measurement, or funding.
- Integrated Solid Waste Management is an extremely important and complex issue which is being encouraged by and addressed through other international organizations, which acknowledge marine debris as a related issue. The ISWM is acknowledged within the Strategy, but it would be replicating effort done by others to go into more detail within it.
- Extended Producer Responsibility is another issue that the authors felt was beyond the scope of the Honolulu Strategy to go into detail on, because of the larger issues and the multiple levels of debate regarding them. It also has many layers beyond that of just applying to marine debris prevention and reduction.

As stated, these issues are important and do need to be addressed in a holistic response, but for the reasons outlined above it was decided that the Honolulu Strategy was not the place to explain and address them. In this context, the Honolulu Strategy should be viewed as a companion document to other global, regional and national processes to address these issues.

Executive Summary

The marine debris problem is global in scale and intergenerational in impact. Marine debris, or marine litter, is defined to include any anthropogenic, manufactured, or processed solid material (regardless of size) discarded, disposed of, or abandoned that ends up in the marine environment. It includes, but is not limited to, plastics, metals, glass, concrete and other construction materials, paper and cardboard, polystyrene, rubber, rope, textiles, timber and hazardous materials, such as munitions, asbestos and medical waste. In some instances, marine debris may also be a vessel for dangerous pollutants that are eventually released into the marine environment. Marine debris may result from activities on land or at sea.

Marine debris is a complex cultural and multi-sectoral problem that exacts tremendous ecological, economic, and social costs around the globe.

The *Honolulu Strategy* is a framework for a comprehensive and global effort to reduce the ecological, human health, and economic impacts of marine debris globally. The *Honolulu Strategy* is intended for use as a:

- Planning tool for developing or refining spatially or sector-specific marine debris programs and projects
- Common frame of reference for collaboration and sharing of best practices and lessons learned
- Monitoring tool to measure progress across multiple programs and projects

The *Honolulu Strategy* is a framework document. It does not supplant or supersede activities of national authorities, municipalities, industry, international organizations, or other stakeholders; rather, it provides a focal point for improved collaboration and coordination among the multitude of stakeholders across the globe concerned with marine debris. Successful implementation of it will require participation and support on multiple levels—global, regional, national, and local—involving the full spectrum of civil society, government and intergovernmental organizations, and the private sector.

This results-oriented framework consists of three goals and associated strategies to reduce the amount and impact of marine debris from land-based and sea-based sources and marine debris accumulations (Table ES-1). Conceptual models and results chains were the basis of the framework in the *Honolulu Strategy.* The Fifth International Marine Debris Conference, in March 2011, catalyzed development of the *Honolulu Strategy*. Input from conference participants and stakeholders around the world was solicited and incorporated into development of the *Honolulu Strategy*.

Table ES-1. Global Framework for Prevention and Management of Marine Debris
Goal A: Reduced amount and impact of land-based sources of marine debris introduced into the sea
Strategy A1. Conduct education and outreach on marine debris impacts and the need for improved solid waste management
Strategy A2. Employ market-based instruments to support solid waste management, in particular waste minimization
Strategy A3. Employ infrastructure and implement best practices for improving stormwater management and reducing discharge of solid waste into waterways
Strategy A4. Develop, strengthen, and enact legislation and policies to support solid waste minimization and management
Strategy A5. Improve the regulatory framework regarding stormwater, sewage systems, and debris in tributary waterways
Strategy A6. Build capacity to monitor and enforce compliance with regulations and permit conditions regarding litter, dumping, solid waste management, stormwater, and surface runoff
Strategy A7. Conduct regular cleanup efforts on coastal lands, in watersheds, and in waterways— especially at hot spots of marine debris accumulation
Goal B: Reduced 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
Strategy B1. Conduct ocean-user education and outreach on marine debris impacts, prevention, and management
Strategy B2. Develop and 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.
Strategy B4. Develop and promote use of fishing gear modifications or alternative technologies to reduce the loss of fishing gear and/or its impacts as ALDFG
Strategy B5. Develop and strengthen implementation of legislation and policies to prevent and manage marine debris from at-sea sources, and implement requirements of MARPOL Annex V and 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
Goal C: Reduced amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters
Strategy C1. Conduct education and outreach on marine debris impacts and removal
Strategy C2. Develop and promote use of technologies and methods to effectively locate and remove marine debris accumulations
Strategy C3. Build capacity to co-manage marine debris removal response
Strategy C4. Develop or strengthen implementation of incentives for removal of ALDFG and other large accumulations of marine debris encountered at sea
Strategy C5. Establish appropriate regional, national, and local mechanisms to facilitate removal of marine debris
Strategy C6. Remove marine debris from shorelines, benthic habitats, and pelagic water

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Strategy A3. Employ infrastructure and implement best practices for improving stormwater management and reducing discharge of solid waste into waterways 15

Strategy A4. Develop, strengthen, and enact legislation and policies to support solid waste prevention, minimization and management 15

Strategy A5. Improve the regulatory framework regarding stormwater, combined sewer systems, and debris in tributary waterways 16

Strategy A6. Build capacity to monitor and enforce compliance with regulations and permit conditions regarding litter, dumping, solid waste management, stormwater, and surface runoff 16

Strategy A7. Conduct regular cleanups of solid waste on coastal lands, in watersheds, and in waterways—especially at hot spots of marine debris accumulation 16

Goal B: Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, ALDFG, and abandoned vessels introduced into the sea 18

Strategy B1. Conduct ocean-user education and outreach on marine debris impacts, prevention, and management 19

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 20

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 20

Strategy B4. Develop and promote use of fishing gear modifications or alternative technologies 20

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 21

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Acronyms

ALDFG	abandoned, lost, or otherwise discarded fishing gear
BMP	best management practices
DDT	dichlorodiphenyltrichloroethane
MARPOL	International Convention for the Prevention of Pollution from Ships
IUCN	International Union for Conservation of Nature
PCB	polychlorinated biphenyl
UK	United Kingdom

1.0 Introduction

Marine debris is defined to include any anthropogenic, manufactured, or processed solid material (regardless of 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, stormwater, waves, or winds.[1] Marine debris may result from activities on land or at sea.

The marine debris problem is global in scale and intergenerational in impact. On the one hand, it is a comparatively simple problem: marine debris is tangible and results principally from human behavior. On the other hand, it is extraordinarily complex, with multiple causes and factors combining to affect the nature, quantity, and distribution of debris around the world. As with other complex environmental problems, no single solution is possible. Indeed, marine debris involves many societal and economic dimensions. Because of this complexity, addressing marine debris requires collective and collaborative efforts of a wide cross-section of civil society (local communities, nongovernmental organizations, academic institutions, and individual citizens), governments, and the private sector to implement a broad suite of sustained, strategic, and coordinated initiatives.

Many countries and international organizations have been tackling the marine debris problem for decades, with significant signs of progress. The *Honolulu Strategy: A Global Framework for the Prevention and Management of Marine Debris* (*Honolulu Strategy*) was developed to support and strengthen these efforts and catalyze new efforts around the world. The *Honolulu Strategy* serves as a template for global efforts addressing the problem of marine debris. This framework is not designed for direct implementation by any one country, organization or group, but as a means to support and connect actions implemented by various stakeholders in various geographic contexts and at different levels of governance. The *Honolulu Strategy* is a globally applicable tool that serves two main purposes:

- To describe and catalyze the multi-pronged and holistic response required to solve the problem of marine debris
- To guide monitoring and evaluation of global progress on specific strategies at different levels of implementation—including local, national, regional, and international efforts and achievements

The Fifth International Marine Debris Conference, held in the US State of Hawaii in March 2011, served as a catalyst for development of the *Honolulu Strategy*. Prior to the conference, recommendations from the four previous international marine debris conferences were compiled and analyzed to identify recurring themes. An expert working group was formed to develop the structure and draft content of the *Honolulu Strategy*. Working group members reached out to

[1] This is the definition of "marine debris" used in this document. "Marine litter" is considered synonymous with the term "marine debris."

colleagues throughout the world to identify ongoing initiatives and future plans. The draft elements of the *Honolulu Strategy* were developed and distributed to conference attendees prior to the conference. A number of mechanisms were used before, during and after the conference to develop, review, and incorporate comments (as appropriate) into the *Honolulu Strategy*.

1.1 What's in the *Honolulu Strategy*

The *Honolulu Strategy* is a framework for a comprehensive and global collaborative effort to reduce the ecological, human health, and economic impacts of marine debris worldwide. This framework is organized by a set of goals and strategies applicable all over the world, regardless of specific conditions or challenges. The *Honolulu Strategy* specifies three overarching goals focused on reducing threats of marine debris:

Goal A: Reduced amount and impact of land-based litter and solid waste introduced into the marine environment

Goal B: Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, ALDFG, and abandoned vessels introduced into the sea

Goal C. Reduced amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters

Linked to each goal is a cohesive set of strategies (see Section 3.0). A list of potential actions that could be implemented under each strategy are presented in Annex 1.

Conceptual models and results chains (Annex 2) were used to develop the framework for the *Honolulu Strategy* (FOS 2007, 2009; Margoluis et al. 2009). Conceptual models can serve as useful tools for civil society, government agencies, intergovernmental organizations, and the private sector to identify marine debris issues. Conceptual models document assumed causal links between direct and indirect threats to targets of concern and strategies to address these threats. For example, the lack of capacity and options for proper waste storage (on ship) and disposal (in port) leads to dumping at sea[2]. Both of these indirect threats lead to the direct threat of plastic and other solid waste present at sea. Strategies to address these direct and indirect threats include increasing awareness, providing incentives for proper waste storage and disposal, and others.

Results chains were used to causally link strategies to a set of intermediate results that lead to achievement of each goal. These causal links represent a set of assumptions that can be tested through implementation and monitoring of individual strategies. For example, the strategy to develop and promote use of economic incentives and convenient options for waste storage at sea and disposal at port reception facilities would lead to a chain of intermediate results. Increased availability of low-cost, convenient storage and disposal options would increase use of those

[2] The term "dumping" in this document is used as defined in the Merriam-Webster Dictionary to mean "to let fall in as a mass or to get rid of unceremoniously or irresponsibly" and not intended to be limited to the definition in the London Dumping Convention/Protocol.

options, in turn increasing appropriate waste disposal. Along with other strategies, this presumably would lead to fewer incidences of violations of ocean dumping laws and subsequently to introduction of less solid waste at sea. The results chains in Annex 2 also suggest indicative timeframes over which these results are expected to be achieved.

Monitoring indicators are suggested for each set of results chains to evaluate strategy effectiveness. Research, assessment, and monitoring provide essential information to support the spectrum of marine debris efforts—including how to design effective actions under each strategy, focus attention on specific impacts and targets of concern, define the geographic scale and location to implement activities useful for determining appropriate partners, and monitor intermediate and threat reduction results. Key research, assessment, and monitoring needs for addressing marine debris are discussed in Section 2.2. The results chains identify potential indicators and link research, assessment, and monitoring to threat reduction and status of targets of concern.

The *Honolulu Strategy* does not prescribe specific marine debris reduction targets or actions as these will depend on the social, cultural, environmental and economic context in which they are planned and implemented. Substantial progress toward the achievement of the goals in the *Honolulu Strategy* however, should be expected to occur by 2030.

1.2 How to Use the *Honolulu Strategy*

The *Honolulu Strategy* was developed to provide a framework around which civil society, governments, and the private sector can describe and share their work and learn from one another. For example, the US government's National Oceanic and Atmospheric Administration (NOAA) is using the Honolulu Strategy to align its programs and measure outcomes through local and state-level actions, such as the *Hawaii Marine Debris Action Plan.*

The United Nations Environment Programme (UNEP) introduced the *Honolulu Strategy* to the Third Intergovernmental Review Meeting on the Implementation of the Global Programme of Action for the Protection of the Marine Environment from Land-based Activities, 25-27 January 2012, as the framework that can be adopted and used by member countries and organizations. Representatives of 65 Governments and the European Commission emphasized the relevance of the Honolulu Commitment endorsed at the 5th International Marine Debris Conference, and the *Honolulu Strategy.*

They decided to work with all stakeholders concerned to find innovative solutions and initiatives to address the marine litter problem, including by sharing best practices, technical information about capacity building, and legal, policy, community-based, economic and market-based means of preventing, reducing and managing marine litter.

They also recommended the establishment of a global partnership on marine litter which UNEP will develop in collaboration with relevant stakeholders.

UNEP's marine debris related activities also feed into the workplan of the UNEP -led Global Partnership on Waste Management. This will ensure that marine debris issues, goals, and strategies are tied to global efforts to reduce and manage waste. In addition, UNEP aims to facilitate an on-line forum to enable the global marine debris community to monitor progress on

implementing the Honolulu Strategy and share information, lessons learned, and tools. The *Honolulu Strategy* can serve as a:

- Planning tool for developing or refining marine debris programs and projects
- Common frame of reference for collaboration and sharing best practices and lessons learned
- Tool to support development of a monitoring program to evaluate the effectiveness of the strategy across multiple programs and projects

The *Honolulu Strategy* is a framework document. It does not supplant or supersede activities of national authorities, municipalities, industry, international organizations, or other stakeholders; rather, it provides a focal point for improved collaboration and coordination among the multitude of stakeholders across the globe concerned with marine debris. Successful implementation of it will require participation and support on multiple levels—global, regional, national, and local—involving the full spectrum of civil society, government and intergovernmental organizations, and the private sector.

2.0 Understanding the Problem

Marine debris is a complex cultural and multi-sectoral problem with significant implications for the world's marine and coastal environments and human activities. It exacts significant ecological, economic, and social costs around the globe. The problems caused by marine debris are multifaceted and essentially rooted in inadequate solid waste management practices, product designs that do not consider life-cycle impacts , consumer choices, accidental loss or intentional dumping of fishing gear or ship-generated waste, lack of waste management infrastructure, littering, and the public's poor understanding of the potential consequences of their actions. Quantifiable targets for reducing marine debris are needed and must be based on scientific assessments of impacts. Verification of reduction will depend on a scientifically sound assessment of the time trends of debris present in and discharged into the marine environment. To set the context, what follows is a summary of the issues surrounding marine debris and a discussion about concerns affecting coastal and marine species and habitats, economic health, human health and safety, and intrinsic social values.

2.1 Impacts of Marine Debris

Plastic and other solid waste from land-based and at-sea sources, lost cargo, ALDFG, and abandoned or derelict vessels directly and negatively impact coastal and marine species and habitats, economic health, human health and safety, and social values. Ecological, economic, and social effects of marine debris must be understood to enable thoughtful prioritization and development of strategies to address impacts of greatest concern to a region, country, or locality.

Ecological Impacts

Entanglement/Entrapment

Many forms of marine debris pose serious threats to marine wildlife through entanglement. Entanglement of animals by marine debris presents issues of limited mobility and restricted movement that can lead to starvation, suffocation, laceration, subsequent infection, and possible mortality in marine animals. The duration of the entanglement problem extends beyond the generations of ocean users and most marine animals. Items such as packing bands and ALDFG, including nets, lines, and traps, are often responsible for entanglement and entrapment. Lost or abandoned traps continue to capture both target and nontarget species (Guillory 1993; Matsuoka et al. 2005). In a trap removal project in the Chesapeake Bay of the United States, over 18,000 blue crab traps were removed with over 14,000 trapped animals including ducks, turtles, and fish (Havens et al. 2011). Numerous cases of marine animal entanglement have been documented. Northern fur seal were first observed entangled in "rubber collars" in 1944. It was not until 1948 that USFWS biologists determined the "collars" were likely the remains of Japanese food drop bags from the Aleutian Campaign during World War II. North furs seals continue to be observed entangled in marine debris despite annual efforts to clean beaches of the Pribilof Islands. For example, Northern gannets have been shown to utilize plastic debris, primarily synthetic rope, as nest material, which resulted in 525 entanglements over an 8-year period (Votier et al. 2010). In northern Australia, 290 marine turtles were found entangled in derelict nets within the same 70-kilometer stretch of beach between 1996 and 2002 (Kiessling 2003). Entanglement has been documented in other species such as the endangered Hawaiian monk seal (Donohue and Foley 2007), Australian sea lions and New Zealand fur seals, (Page et al. 2004), bottlenose dolphins, (Barco et al. 2010), Brazilian sharpnose sharks (Sazima et al. 2002), and the dusky shark (Cliff et al. 2002). According to the 1998 U.S. Marine Mammal Commission's last published report, 136 marine species have been reported in entanglement incidents, including six of the seven species of sea turtles, 51 out of the world's 312 species of seabirds, and 32 species of marine mammals (Marine Mammal Commission 1999). Of the 120 marine mammal species listed on the IUCN Red List, 54 (45%) were reported to have interacted (ingestion and/or entanglement) with marine debris.

Ingestion

Ingestion of marine debris, primarily small or degraded plastic items, is a common problem that has been documented in many marine animals. Much of the available literature concentrates on the occurrence and effects of ingestion of plastic by seabirds as they forage for food on the ocean surface where plastic floats (Auman et al. 2004; Baltz and Morejohn 1976; Blight and Burger 1997). Nonetheless, sea turtles (Barreiros and Barcelos 2001; Bjorndal et al. 1994; Tomas et al. 2002), marine mammals (Baird and Hooker 2000; Beck and Barros 1991; Walker et al. 1997), fish (Boerger et al. 2010; Eriksson and Burton 2003), and sharks (Cliff et al. 2002) have all been recorded to ingest marine debris. In studies of the northern fulmar, 95 % of the 1295 dead beached birds collected from 2003 to 2007 had plastic in the stomach. The birds' stomachs contained an average of 35 plastic items, weighing a total of 0.31 grams (van den Brink et al. 2011).

Ingestion of inert, indigestible marine debris has been documented to result in physical obstruction of the mouth, digestive tract, and stomach lining of various species (Derraik 2002). Some obstructions, such as an esophageal blockage, can prevent organisms from taking in food, which can result in nutrient deficiency and eventual starvation (Pierce et al. 2004). Negative correlation of the

weight of Laysan albatross chicks to the amount of plastic carried in their gizzards has been documented. Though cause-effect relationships are not yet established, plastic ingestion may cause physiological stress in the form of false satiation, inducing some animals to stop eating and slowly starve to death (Auman et al. 1997). Additionally, accumulation of indigestible material decreases nutrient uptake and lowers subsequent energy gains, which has been documented in post-hatchling and juvenile loggerheads (McCauley and Bjorndal 1999).

Habitat Destruction

Marine debris can lead to marine habitat alteration, degradation, or destruction through physical interference such as obstruction of sunlight, surface scoring, and abrasion. Corals can become abraded by ALDFG and smothered by plastic bags, fabric, or sheeting. In Hawaiʻi, a positive correlation was established between the impact of monofilament fishing line and dead or damaged cauliflower coral (Asoh et al. 2004). It was also determined that ALDFG, especially nets, is largely responsible for damage to coral reef habitats in the Northwestern Hawaiian Islands (Donohue et al. 2001). Litter can also disrupt the assemblages of organisms living on or in the sediment. The impact of debris on the littoral zone was demonstrated by a study in Indonesia, which found that the flora and fauna of sediment smothered by debris differed significantly from the structure of organisms in areas of the littoral zone that were free of debris (Uneputty and Evans 1997). For example, solid waste dumped into the sea may sink to the seafloor or be introduced through floods or storm activity and cover benthic habitat, in turn interfering with the natural foraging and home range behavior of marine animals (U.S. Commission on Ocean Policy 2004). Continual input of marine debris into the ocean poses a persistent threat to marine and coastal habitats (National Research Council 2008).

Transport of Chemicals and Food Chain Implications

Some forms of marine debris, e.g., plastics, have resulted in adsorption and concentration of pollutants that are present as environmental pollutants in the aquatic environment. Pollutants such as polychlorinated biphenyls (PCBs) and organochlorine pesticides have been recorded in plastic marine debris (Colabuono et al. 2010). These post-consumer plastic fragments, along with pre-production plastic resin pellets, collected in the Pacific Ocean tested positive for the presence of persistent organic pollutants such as dichlorodiphenyltrichloroethane (DDT), polycyclic aromatic hydrocarbons, and aliphatic hydrocarbons (Rios et al. 2007).

Chemical contaminants present immediate and chronic threats to both aquatic and terrestrial food webs. Many of these pollutants, such as PCBs and DDT, are known endocrine disruptors and developmental toxicants. Exposure to these chemicals during pre-natal or early life can lead to irreversible effects in both wildlife and humans (Colborn et al. 1993). Additional studies show that these same pollutants can be detected in wildlife. For example, fat in albatrosses from Midway Atoll revealed pollutant levels near or above levels known to cause adverse effects in other fish-eating bird species (Jones et al. 1996). Blood samples collected from black-footed albatross on Midway Atoll contained organochlorines such as DDT and PCBs, chlordane compounds, and mercury. Organochlorine levels detected correlated significantly with increased lymphocyte proliferation and increased proportion of lymphocytes, indicating that these chemicals may be affecting the

immunological structure of the albatross (Finkelstein et al. 2007). However and notably, these pollutants in the marine environment derive from many non-point sources, which makes it difficult to determine the contributions of plastic debris pollutants to concentrations in marine species. To date, no scientific study has directly linked ingested marine debris to increased contaminant concentrations.

Evidence indicates that chemicals adsorbed onto plastics, as well as those chemicals utilized within the plastic structure, can be incorporated into living tissues. Plastic fragments can pass through some organisms, resulting in little to no accumulation depending upon organism and diet. In vitro experiments show that in mussels, *Mytilus edulis*, microplastics, particles < 5 mm, can translocate from the gut into the circulatory system and persist for up to 48 days (Browne et al. 2008). Another study demonstrated that the amount of plastic ingested by seabirds positively correlated with PCBs found in the seabirds' fatty tissue (Ryan et al. 1988). Teuten (2009) went a step further and demonstrated through mathematical models and a shearwater chick feeding experiment that PCBs transferred from contaminated plastic into the tissue of chicks, where PCB concentrations in preen gland oil increased non-significantly until full depuration after 42 days. Potential transfers of chemicals throughout the food chain and the implications for bioaccumulation in humans are valid concerns (vom Saal et al. 2008), although the science is not clear on the added risk that plastic debris contributes to availability and transfer of chemicals in the marine food web.

Goiun et al. (2011) state that microplastics as a vector for PPT substances to biological organisms is likely of limited importance. At current levels in open ocean, microplastics are unlikely to be an important global geochemical reservoir for historically released POPs such as PCB, dioxins, and DDT (NOAA 2009). It is not clear if microplastics play a larger role as chemical reservoirs on smaller scales. POPs are attracted to plastic in seawater. This is the basis for several POP sampling techniques, including passive sampling. While this high affinity results in elevated POP concentrations on microplastic particles, those POPs may not be readily bioavailable.

Introduction and Spread of Invasive Species

The spread of invasive species is facilitated by human-mediated dispersal. While ballast water is a dominant vector for transporting invasive species, floating marine debris is also recognized as a medium for long-distance dispersion (Wilson et al. 2009). Drifting debris can harbor entire communities (including microbial communities) of encrusting and attached organisms, and carry them great distances—possibly to areas where they may harm or compete with native species. Historically, these organisms have rafted on natural marine flotsam such as algae, pumice, trees, seed pods, and even neustonic animals; but the steady and profuse influx of buoyant, human-introduced materials (such as synthetic materials for fishing nets, lines, and ropes, and other parts of the fishing gear often composed of plastics) has increased the abundance and availability of marine rafts (Aliani and Molcard 2003; Barnes 2002). Barnes (2002) estimates that plastics at sea have roughly doubled the proliferation of subtropical fauna and more than tripled the propagation of high-latitude fauna, which speaks to the increased potential for alien species transport. For example, a non-native sea anemone made its way to the Northwestern Hawaiian Islands aboard a

piece of ALDFG (Zabin et al. 2003). Introduction of non-native species can have devastating environmental effects including loss of biodiversity, changes to habitat structure, and changes to ecosystem functions (Derraik 2002).

Economic Impacts

Marine debris has numerous economic implications, which should be considered when developing strategies and policies to mitigate the issue. Negative effects associated with marine debris can ripple throughout a local economy. Marine debris can cause a broad spectrum of economic impacts that reduce the economic benefits derived from marine and coastal activities and/or increase the costs associated with them (National Research Council 2008).

ALDFG continues to catch, injure, and kill ocean life in a process known as "ghost fishing." Although the amount and extent of loss varies, ghost fishing adversely impacts fishing industries. All lost and abandoned gear can continue capturing economically important fish, crabs, and lobster in addition to non-commercial fish and shellfish species. With populations down, commercial fisheries can suffer economic losses and recreational fishing opportunities can decrease (Macfadyen et al. 2009). A study published in 2002 demonstrated that the United Kingdom (UK) fishing industry loses over €33 million (USD 31 million[3]) a year due to marine debris and ghost fishing (Ten Brink et al. 2009). Research focusing on the Scottish Shetland fishing fleet found that marine debris could cost a vessel up to £30,000 (USD 45,000[4]) a year (Hall 2000). A separate study looking at the Scottish Clyde fishery reported that losses of up to USD 21,000 in lost fishing gear and USD 38,000 in lost fishing time were experienced by a single trap fisher in 2002 [Watson and Bryson 2003 cited in (Macfadyen et al. 2009)]. Ghost fishing in the tangle and gillnet fisheries is equivalent to less than 5% of European Union commercial landings (National Research Council 2008), while the ghost catch of monkfish in the Cantabrian Sea, off northern Spain, equates to approximately 1.46% of landings (Brown et al. 2005). In the United States, an estimated USD 250 million worth of marketable lobster is lost to ghost fishing annually (Allsopp et al. 2006), and four to ten million blue crabs are trapped in ghost fishing gear each year in the state of Louisiana (Macfadyen et al. 2009). Another area of concern for ship captains is lost fishing gear that results from entanglement on benthic habitats. Lost equipment entails the direct costs of repair and replacement and the indirect cost of lost fishing time (McIntosh et al. 2000).

Marine debris can result in economic losses to aquaculture producers (UNEP 2009) as a result of damage to vessels and equipment, removal of debris, and staff downtime. Entangled propellers and blocked intake pipes present the most common problems for aquaculture operators and can result in costly repairs and lost time.

Marine debris can also present a navigational hazard, as nets, ropes, and other objects can get caught in boats' propellers and rudders causing operational problems. Plastic bags clogging and blocking water intakes commonly cause water pumps in recreational craft to burn out. Such

[3] At €1 = 0.945 (Year 2002 mean exchange rate)
[4] At £1 = 1.51616 (Year 2000 mean exchange rate)

incidents involve costly engine repairs and disablement. Valuable time is lost and money is spent fixing the boats. Marine debris can cause fishers to alter their routines, such as avoiding certain fishing areas or using different types of gear, even if this is to their economic disadvantage (Nash 1992). Shipping faces increased costs from marine debris that resulted from vessel damage and downtime (Ten Brink et al. 2009), debris removal and management in harbors and marinas (UNEP 2009), and emergency rescue operations to vessels stricken by marine debris (Macfadyen et al. 2009). For harbors in the UK, removal of debris could cost up to £15,000 (USD 23,000) a year, with manual clearance of the harbor required up to four times per week. Anecdotal evidence received from marinas suggests that some marinas had to be manually cleaned on a daily basis at a cost of up to £10,000 (USD 15,000) a year (Hall 2000). Research in 1998 found that 230 rescues of vessels with fouled propellers occurred in UK waters at a cost of £2,200 to £5,800 (USD 3,600 to USD 9,600[5]) per incident, depending on the type of lifeboat required. This amounted to an overall cost of between £506,000 (USD 767,000) and £1,334,000 (USD 202,000) for that year (Hall 2000). In 2005, the U.S. Coast Guard made 269 rescues in incidents involving marine debris—resulting in 15 deaths, 116 injuries, and USD 3 million in property damage (Moore 2008).

Effects of marine debris on power stations can include blockage of cooling water intake screens, increased removal of debris from screens, and additional maintenance costs. Anecdotal evidence suggests that removal of marine debris can cost companies up to £50,000 (USD 76,000), with additional costs for pump maintenance (Hall 2000).

Presence of litter and debris leads to degradation of the aesthetic quality of beaches and shallow areas. Marine debris can deter visitors, as cleanliness is the most important characteristic for most beachgoers (Ballance et al. 2000). A drop in beach users and tourism can result in less business and revenue for a coastal community. This impact is significant for local economies that rely heavily on tourism. A study by Ofiara and Brown (1999) estimates New Jersey's economic loss in 1988 due to beach closures attributed to marine debris was between USD 53 million and USD 224 million. Research from Sweden suggests that marine debris inhibits tourism there between 1 and 5%, resulting in a loss of £15 million (USD 30.03 million) in revenue (Ten Brink et al. 2009).

Furthermore, news of possible marine debris or pollution can lead to economic loss for the seafood industry. With a public perception of polluted waters, demand and price for seafood decreases (Ofiara and Brown 1999). Although this has not yet been demonstrated, the seafood industry could also undergo long-term effects from marine debris due to ingestion/bioaccumulation by marine animals. Public health risks arise if contaminated fish are eaten. These would lead to economic costs to both public health and to recreational and commercial fisheries (Ofiara and Brown 1999).

Marine debris is also costly to remove. Manual cleanup of cigarette butts in San Francisco cost the city approximately $6 million per year (Schneider et al. 2009). Estimates suggest that the total cost of marine debris removal to all UK local authorities is approximately £14 million (USD 25.65 million[6]) per year [Environment Agency 2004, cited in (OSPAR Commission 2009)]. Cleansing of

[5] At £1 = 1.65675 USD (Year 1998 mean exchange rate)
[6] At £1 = 1.83230 USD (Year 2004 mean exchange rate)

the Swedish Skagerrak coast in 2006 was estimated to cost 15 million SEK (USD 2.0 million[7]) (OSPAR Commission 2009). The total cost reported by local authorities in Denmark, Sweden, UK, and Norway for beach cleanups was £2,913,795 (USD 4.42 million) (Hall 2000). Research in Sweden found that the cost of removing marine debris from the shoreline of two ports amounted to €570,000 (USD 795,000[8]) (Naturvårdsverket 2009). An estimated cost to effectively remove litter from South Africa's wastewater streams is about R2 billion (USD 279 million) per year (Lane et al. 2007).

Social Impacts

Intrinsic and social values associated with coastal and marine environments are diminished by marine debris. Awareness and concern for the sustainability of the environment has increased in recent times, as people now place great value on the earth's natural resources. Non-use value (knowledge that quality coastal ecosystems exist) and option value (ability to use the coastal environments) are two principal intrinsic values decreased by marine debris (National Research Council 2008). Another social value affected is the aesthetic value. Debris is an eyesore, and it reduces the attractiveness of coastal areas and of near-shore and open water areas. This leads to lower beach user enjoyment and lower surrounding property values (Mouat et al. 2010; Ofiara and Seneca 2006). These socioeconomic impacts provide helpful insight into the public's concern and should not be ignored.

Human Health and Safety

Marine debris can directly affect human health and safety in a variety of ways. Marine debris as a navigational hazard can threaten human safety by disabling boats and stranding the occupants, necessitating rescues (National Research Council 2008). It can also be a danger to swimmers and divers, as people can become entangled in submerged debris (Cheshire et al. 2009). The concern for human safety is not confined to in-water situations; marine debris can also impact public health on shore. Items such as broken glass, medical waste, rope, and fishing line and hooks pose immediate risks to human safety when encountered on beaches and shallow underwater areas, as this debris can cause cuts and abrasions to beachgoers (Mouat et al. 2010). Furthermore, medical and sanitary wastes constitute a health hazard and can contribute to water contamination (California Coastal Commission 2010). Discarded syringes, condoms, tampon applicators, and other medical and personal hygiene debris often enter the waste stream through direct sewage outflows or inadequate sewage treatment systems, and can indicate serious water quality concerns. This debris also can suggest the presence of invisible pathogenic pollutants such as streptococci, fecal coliforms, and other bacterial contamination (Dorfman and Rosselot 2009). Such water contamination can impact human health through direct contact and also indirectly through the

[7] At 1 SEK = 0.13574 USD (Year 2006 mean exchange rate)
[8] At €1 = 1.39423 (Year 2009 mean exchange rate)

consumption of contaminated seafood. The human health and safety risks of marine debris are serious and should be an important area of concern.

2.2 Research and Monitoring Needs for Marine Debris

One of the significant barriers to addressing marine debris is the absence of adequate scientific research, assessment, and monitoring. Reliable data and information on the amounts, distribution, and impacts of marine debris at global, regional, national, and local scales is essential to help prioritize, develop, and implement effective strategies to address the problem of marine debris. Scientific research is needed to better understand the sources, fates, and impacts of marine debris (National Research Council 2008). Scalable and statistically rigorous monitoring protocols are needed to monitor changes in conditions as a result of efforts to prevent and reduce the impacts of marine debris. Although monitoring of marine debris is currently carried out within a number of countries around the world, the protocols used tend to be very different, preventing comparisons and harmonization of data across regions or timescales (Cheshire et al. 2009).

Key areas for ongoing research, assessment, and monitoring for marine debris include quantifying marine debris impacts; understanding the behavior, movement, and accumulation of marine debris; and developing and applying new technologies to improve the effectiveness of strategies to prevent marine debris and reduce impacts. Potential topics listed below reflect priorities identified by the global community and presenters at the Fifth International Marine Debris Conference, held in March 2011.

Research, assessment, and monitoring of status and trends of marine debris impacts on targets of concern

Research, assessment, and monitoring are needed to evaluate impacts of marine debris on coastal and marine species, habitats, economic health, human health and safety, and social values. Potential research and monitoring topics include:

- Population-level assessments of marine debris impacts on individual species
- Impacts of ALDFG on coral reefs
- Quantification of ghost fishing impacts
- Role of microbial degradation in the fate, transport, and accumulation of microplastics in sediments and marine life
- Quantitative assessments to characterize pathways of chemical exposure and bioaccumulation from plastics to living marine resources
- Identification of pathogens (human or marine organisms) or harmful algae (e.g., ciguatera) associated with marine debris
- Investigation of seabird foraging habitats to understand the relationship between prey and debris types
- Long-term monitoring of impacts of marine debris on seabirds and marine mammals as indicator species

- Quantitative assessment of economic impacts of marine debris on maritime transportation and coastal tourism

Research, assessment, and monitoring of the status and trends of marine debris

Research and monitoring are needed to understand the status and trends of marine debris. Key research and monitoring topics include:

- Identification and monitoring of hot spots where higher debris accumulation is predicted or observed, in order to establish long-term status and trends in marine debris accumulation, and to help target removal efforts
- Standardization of methodologies to monitor marine debris (including identification and quantification of microplastic) on shorelines, in benthic habitats, and in pelagic waters
- Characterization of sources, transport, and sinks of marine debris in the marine environment
- Survey of marine debris occurrence in benthic environment in waters deeper than 30 meters

Research to develop new technologies and applications

Research is needed to develop new technologies and methods for detecting and removing accumulations of marine debris. Potential research topics include:

- Production of truly biodegradable polymers that meet ASTM standards for biodegradation in the marine environment
- Research and development of at-sea detection and removal protocols
- Life-cycle analysis of waste management techniques to determine the most appropriate conversion approach
- Evaluation of the effectiveness of disposal technologies for marine debris
- Evaluation of biodegradable materials to reduce fishing power of ALDFG such as pots, traps, and gillnets
- Evaluation of biodegradable plastic process outcomes and the relation to the creation of microplastics
- Evaluation of measures to reduce gear loss and increase retrieval
- Studies on fishing gear modifications that will reduce loss

3.0 Strategies to Prevent and Reduce the Impacts of Marine Debris

Strategies to prevent and reduce the impacts of marine debris are organized under three overarching goals:

- Goal A: Reduced amount and impact of land-based sources of marine debris introduced into the sea
- Goal B: Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, ALDFG, and abandoned vessels introduced into the sea
- Goal C. Reduced amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters

Strategies under Goal A and B focus on preventing, reducing, and managing land and sea-based sources of marine debris. These strategies are critical to solving the marine debris problem because they tackle the source. Strategies under Goal C focus on removing the continuing accumulation of marine debris. These strategies are equally important because they reduce the impacts of marine debris on marine life and ecosystems, human health and safety, and the economy.

Goal A: Reduced amount and impact of land-based sources of marine debris introduced into the sea

Problem Statement

Human activities in both inland and coastal areas can contribute to accumulation of marine debris along beaches and in local waterways that carry these wastes to the ocean. Land-based sources of marine debris result from inadequate solid waste management, inappropriate human behavior, and unsustainable production and consumption. Increased development, urbanization, and consumerism can lead to increases in the use of disposable and non-degradable products and packaging, which result in increased generation of solid waste. In addition, natural events such as tsunamis, storms, and hurricanes can transport significant quantities of marine debris from coastal areas.

Mishandling of solid waste materials leads to land-based sources of marine debris (NOAA 2008). Both legal and illegal waste handling practices contribute to marine debris. These include inadvertent release of trash from inadequately covered waste containers and waste transport vehicles; poorly managed waste dumps and landfills, manufacturing sites, processors, and transporters; recreational beach and roadside littering; sewage treatment and combined sewer overflows; and dumping[9] of domestic and industrial garbage into riverine, coastal, and marine

[9] Use of the term "dumping" in this document is not restricted to the definition adopted in the London Convention.

waters. Browne et al. (2011) documented the presence of polyester, acrylic, polypropylene, polyethylene, and polyamide fibers contamination on shores on a global-scale, especially in areas that are densely populated and receive sewage. Any solid material discarded or left on land could enter nearby waterways via rain, snowmelt, and wind (Ten Brink et al. 2009). Without proper garbage collection and disposal of these materials, they can be delivered to marine environments and thus become marine debris.

Marine debris is a part of a broader problem of solid waste management that affects all coastal and upland communities, including inland waterways, and links closely to protection and conservation of the marine and coastal environment and sustainable development (UN-HABITAT 2010). Lack of capacity and funding to effectively manage solid wastes is common, particularly in developing countries. Strategies to improve integrated solid waste management are needed to support marine debris prevention and management; however, that is beyond the scope of this document. Gaining capacity and identifying funding sources must be prioritized. A conceptual model illustrating direct and indirect threats of land-based sources of marine debris is provided in Annex 2, Figure 1.

Strategies | Expected Results

Strategies to reduce marine debris from land-based sources focus on:

- Conducting education and outreach
- Employing market-based instruments
- Employing infrastructure and best practices for stormwater and solid waste minimization
- Developing legislation, policies, and regulations
- Building capacity for monitoring and enforcement
- Removing solid waste from coastal lands, watersheds, and waterways

Each of these strategies and the expected results are described below and depicted on a schematic diagram in Annex 2, Figure 2. A listing of potential actions under each strategy is provided in Annex 1, Table 1.

Strategy A1. Conduct education and outreach on marine debris impacts and the need for improved solid waste management

Education and outreach are components of a cross-cutting strategy to support each of the other strategies listed below. Education of members of the public on impacts of marine debris, waste minimization, and solid waste management practices would raise awareness of impacts of marine debris from land-based sources, expectedly leading to increased watershed stewardship and greater compliance with policies and laws (including those prohibiting dumping and littering). Education and outreach directed at decision makers reasonably would aid development of policy to support a reduction of solid waste. Education and outreach directed at the solid waste management industry would increase compliance with policies and laws. Education and outreach directed at producers and consumers can focus on reduction, reuse, recycling, and recovery of waste generated from packaging and disposable products—from industry choices on production, packaging, and

marketing to institutions' purchasing decisions to consumers' shopping strategies. If less waste is created, less of it can make its way into the marine environment. Decreasing the amount of material to be discarded would decrease the amount of solid waste created, littered or dumped, and lost—in turn decreasing marine debris.

Strategy A2. Employ market-based instruments to support solid waste management, in particular waste minimization

Development and implementation of market-based instruments would decrease creation, dumping, and littering of solid waste. Some examples include extended producer responsibility fees, deposit refunds, waste collection taxes, and recycled product tax rebates. Incentives may also encourage cleanup of littered or dumped materials with deposit refund value.

Strategy A3. Employ infrastructure and implement best practices for improving stormwater management and reducing discharge of solid waste into waterways

Refinement, development, and promotion of existing and new best management practices (BMP), and creation and maintenance of appropriate infrastructure (such as recycling facilities, waste receptacles, waste-to-energy facilities, landfills, debris traps, and booms), would have multiple beneficial effects. Industry codes and institutional purchasing practices can minimize the amount of excessive packaging and disposable products. Infrastructure and best practices related to solid waste management would decrease littering, dumping, and accidental loss of solid waste and its delivery to the marine environment. As one example, increased awareness of industry BMPs on the part of waste management professionals would improve understanding of the benefits of applying BMPs and probably lower costs of accidental loss. Understanding benefits and costs would lead to increased application of BMPs and guidelines for handling, transporting, recycling, recovering, and disposing of solid waste. Application of new practices and technologies would thereby decrease incidences of accidental or intentional loss of waste. In turn, overall reductions of marine debris in the ocean would result.

Strategy A4. Develop, strengthen, and enact legislation and policies to support solid waste prevention, minimization and management

Developing and promoting compliance with legislation and policies to support waste minimization and solid waste management practices and infrastructure would lead to increased capacity and infrastructure for waste disposal and management. Policies and regulations that implement measures to reduce the most common items found as marine debris (e.g. plastic bags, bottle caps, and cigarette butts) are needed to prevent solid waste. Legislation targeting waste reduction, such the European Union's Packaging Directive, Extended Producer Responsibility frameworks for packaging, and requirements for manufacture take-back, could significantly reduce the generation of marine debris. Regional and national policies and legislation would support enforcement and user compliance with proper waste management practices, in turn reducing overall amounts of solid waste introduced into the ocean from land-based sources.

Strategy A5. Improve the regulatory framework regarding stormwater, combined sewer systems, and debris in tributary waterways

Creating or improving the regulatory framework for permitted uses and management of waterways and stormwater and combined sewer systems, through permitting requirements, to decrease the amount and rate of runoff from impervious surfaces, would decrease the amount of litter and solid waste washed into waterways. A corresponding increase in the amount of debris trapped and removed from urban runoff and waterways would reduce the amount of land-based materials that could ultimately become marine debris.

Strategy A6. Build capacity to monitor and enforce compliance with regulations and permit conditions regarding litter, dumping, solid waste management, stormwater, and surface runoff

Building capacity to monitor and enforce regulations would decrease littering, dumping, solid waste violations, and violations of permit conditions. Increased enforcement would result in increased reporting and prosecution of violators, in turn deterring violators and increasing user compliance—resulting in overall reductions of marine debris in the ocean.

Strategy A7. Conduct regular cleanups of solid waste on coastal lands, in watersheds, and in waterways—especially at hot spots of marine debris accumulation

Engaging members of the public and industry employees in cleanups of items on land or in tributary waterways that could become marine debris when washed or blown into marine environments would build a sense of community, watershed, and ocean stewardship among participants, and prevent the creation of marine debris. Waste management costs would decrease as the efforts of volunteer cleanups reduce the need to engage a professional workforce in hands-on removal actions.

Monitoring Indicators | Evaluating Strategy Effectiveness

Monitoring and evaluation are critical components of determining whether strategies are achieving expected results. The following are potential evaluation questions and indicators to be considered in developing an approach to evaluating strategies focused on decreasing land-based sources of marine debris:

What is the level of awareness of specific groups with BMPs, laws and regulations, and marine debris impacts?

- Number of stakeholders briefed by affiliation (for example, industry, government, public)
- Pre- and post-outreach tests for knowledge and intent
- Percentage of specific groups adopting BMPs (for example, waste haulers, packaging industry, institutions, environmental and health agencies)
- Recycling rates pre- and post-outreach

Are infrastructure and use of BMPs sufficient?

- Number of informal dumping sites
- Number of receptacles per quantity of beach, park, or street user
- Rate of escape of pre-production pellets into waterways
- Tonnage of solid waste recovered from waterways

What is the capacity to monitor and enforce compliance with regulations and permit conditions?

- Number/types of permits or regulations in place to prevent land-based debris
- Number of enforcement and compliance officers
- Number of violations
- Number of repeat violations
- Number of violations as a percentage of total permits

How effective are regulatory measures?

- Number of waterways exceeding allowed trash load
- Number of violations

How effective are litter and solid waste cleanup efforts at preventing marine debris?

- Frequency of clean-up activities by location
- Accumulation rate of trash by location
- Number of volunteers; number of hours
- Tonnage of solid waste recovered from coastal lands, watersheds, and tributary waterways
- Tonnage of solid waste recovered at booms and debris traps with and without watershed cleanups
- Number of removal actions necessary to maintain a set level of cleanliness

Goal B: Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, ALDFG, and abandoned vessels introduced into the sea

Problem Statement

Human activities at sea contribute to the accumulation of marine debris in the ocean. Cargo, solid waste, gear, and other types of marine debris are accidentally or intentionally introduced from merchant shipping vessels, ferries and cruise liners, fishing vessels, public vessels, private vessels, offshore oil and gas platforms and drilling rigs, and aquaculture installations (NOAA 2008). Abandoned and derelict vessels are also a form of marine debris. These sources can produce a substantial amount and broad assortment of marine debris that can be widely dispersed throughout the ocean.

At-Sea Sources of Marine Debris

- Cargo ships
- Ferries
- Cruise liners
- Recreational boats
- Fishing vessels
- Military vessels
- Aquaculture installations
- Offshore oil and gas platforms

Types of Marine Debris Introduced at Sea

- Fishing gear
- Cargo
- Fishing and aquaculture equipment
- Plastic and other solid waste from vessels
- Damaged, lost vessels
- Munitions and other hazardous materials

Accidental loss of cargo, equipment, or fishing gear at sea results from mechanical failure or equipment fatigue; poor or unimplemented standards of practice in properly handling, securing, or maintaining cargo or gear; human error; poor navigation; gear conflicts; and inherent design flaws that lead to or increase the risk of at-sea loss of cargo, fishing gear, and other equipment. Rough seas, poor weather conditions, and storms further increase the likelihood of accidental cargo, equipment, or fishing gear loss, as well as vessel grounding or sinking. A catastrophic natural event (such as extreme weather or a tsunami) or major mechanical damage or failure (such as an explosion on a ship or oil platform) can also lead to accidental introduction of marine debris.

Decisions by ocean users to illegally dump solid waste and fishing gear at sea is influenced at least in part by the high cost and limited availability of convenient, proper, on-board waste storage options and in-port waste disposal facilities, as well as a lack of ocean-user and public awareness of the negative impacts that illegal dumping and marine debris have on the ocean environment. Illegal, unreported, or unregulated fishing and vandalism can also lead to intentional dumping or abandonment of fishing gear. Vessels are sometimes abandoned when damaged by storms or when owners can no longer sustain the maintenance required to keep the vessel operational and in compliance with safety inspections. In some cases, illegal dumping at sea may result from ignorance of ocean laws against dumping or from unfamiliarity with BMPs for handling or storing solid waste at sea. Some countries may lack national legislation and policies that regulate or explicitly prohibit ocean dumping within national waters and the exclusive economic zone in accordance with international standards and guidance outlined under Annex V of International Convention for the

Prevention of Pollution from Ships (MARPOL). The challenges and frequent lack of enforcement presence in coastal waters and on the high seas further increases the problem of illegal dumping.

Offshore operations such as aquaculture and energy can be a significant source of marine debris. The amount of marine debris generated from aquaculture activities depends upon the type of culture systems, construction quality, vulnerability to damage, aquaculture regulations restricting at-sea disposal, and degree of operator compliance. Marine debris generated from energy facilities can result from improper disposal of solid waste or equipment, or loss during heavy weather.

The conceptual model illustrating the direct and indirect threats of at-sea sources of marine debris is shown in Annex 2, Figure 3.

Strategies | Expected Results

Strategies to prevent and manage at-sea sources of marine debris focus on:

- Conducting education and outreach
- Applying market-based instruments
- Developing and promoting best practices
- Developing and promoting new technologies
- Developing legislation, policies, and regulations
- Building capacity for monitoring and enforcement

Each of these strategies and the expected results are described below and depicted on a schematic diagram in Annex 2, Figure 4. A listing of potential actions under each strategy is provided in Annex 1, Table 2.

Strategy B1. Conduct ocean-user education and outreach on marine debris impacts, prevention, and management

Activities to raise awareness of ocean users should be incorporated in all strategies targeted to specific users, issues, and expected results. Education and outreach would raise awareness and promote use of BMPs and compliance with policies and laws. Education and outreach are components of a cross-cutting strategy to support each of the other strategies listed below. Education of ocean users on impacts of marine debris; proper management of solid waste and gear; and best practices in handling, storing, and maintaining cargo, equipment , and solid waste would raise awareness of impacts of marine debris from at-sea sources and increase compliance with policies and laws, including those prohibiting ocean dumping. Education and outreach directed at decision makers would encourage and lead to development and implementation of national laws and international agreements related to preventing and managing marine debris from at-sea sources. Decreasing incidences of accidental loss of cargo, gear, solid waste, and other marine debris, as well as lessening at-sea violations of ocean dumping laws, would reduce marine debris introduced at sea.

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

Proper management of solid waste, unwanted fishing gear, other items generated on vessels, and other sources of marine debris at sea is constrained by cost and convenience. Minimizing the amount of solid waste generated at sea would reduce the amount of waste necessarily stored on vessels and disposed of at port reception facilities. Development and promotion of low-cost, convenient options for storage of solid waste generated on vessels and for disposal of that waste would decrease incidences of ocean dumping. Increased availability and use of low-cost and convenient waste storage options at sea would increase proper waste disposal in port reception facilities. This would apply to any waste, including damaged fishing gear. Increased use of appropriate disposal options on land would minimize incidences of ocean dumping and result in overall reductions of marine debris in the ocean.

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

Refinement, development, and promotion of existing and new BMPs would decrease incidences of vessel abandonment and accidental loss of cargo, solid waste, and gear at sea. Increased captain and crew awareness of industry BMPs would improve understanding of the benefits of applying BMPs and lower costs of accidental loss. Understanding benefits and costs would lead to increased application of BMPs and guidelines for handling, storing, and maintaining cargo, equipment, and solid waste. Application of new practices and technologies would decrease incidences of accidental at-sea cargo, waste, and gear loss, and of vessel abandonment. In turn, this would result in overall reductions of marine debris in the ocean.

Strategy B4. Develop and promote use of fishing gear modifications or alternative technologies

New technologies or modifications in fishing gear can be designed to minimize risk of accidental loss or impacts of lost gear. The benefits of using alternative or modified existing fishing gear should be promoted to encourage use by fishers. Increased awareness of the benefits of alternative or modified fishing gear would result in increased use of the alternative or modified gear instead of loss-prone gear or gear that negatively impacts the marine environment when lost; in turn, increased use of alternative or modified gear would lead to fewer incidences of accidental loss or impacts, and ultimately reduce marine debris at sea. New technologies can also facilitate recovery of lost gear or reduce impacts of lost gear on the marine environment.

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

Development of legislation and policies to implement MARPOL Annex V requirements would decrease incidences of at-sea violations. Regional and national policies and legislation assumedly would enhance enforcement capacity and user compliance with proper waste management practices, in turn reducing marine debris in the ocean. In addition to legislation and policies developed to implement requirements of international conventions, regional, national, and local laws and policies can play an important role in establishing requirements for marine debris management. Policies and legislation assumedly enhance enforcement capacity and compliance with solid waste management, resulting in overall reduction of marine debris in the ocean.

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

Building capacity to monitor and enforce national and local laws and MARPOL Annex V requirements would decrease incidences of at-sea violations. Increased enforcement would increase reporting and prosecution of violators, in turn detering violators and increasing user compliance—resulting in overall reduction of marine debris in the ocean.

Monitoring Indicators | Evaluating Strategy Effectiveness

Monitoring and evaluation are critical components of determining whether strategies are achieving expected results. The following are potential evaluation questions and indicators to be considered in developing an evaluation approach for strategies focused on shipping, boating, and transport:

What is the level of awareness of specific groups of ocean users regarding 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
- Percentage of ocean users adopting best practices by specific industry or group
- Tonnage of lost cargo
- Cost of lost cargo

What percentage of specific groups of ocean users are using proper waste storage and disposal options?

- Percentage of ocean users using proper waste storage onboard and disposal at port reception facilities
- Tonnage of waste collected at port reception facilities

What is the level of awareness of fishers regarding BMPs, modified or alternative fishing gear, and legislation and policies?

- Percentage of fishers who think current practices and methods to prevent 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

What percentage of fishers are adopting best practices and modified or alternative fishing gear?

- Percentage of fishers adopting best practices by fishing fleet or area
- Percentage of fishers using alternative/modified fishing gear by fishing fleet or areaq
- Number of gear items lost
- Tonnage of gear lost
- Cost of lost gear

Goal C. Reduced amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters

Problem Statement

Despite efforts to minimize land-based and at-sea sources of debris, marine debris has accumulated and persists in many coastal areas and the open ocean. Prevention efforts will not be immediately or completely successful; nor will they address the impacts of the debris already evident in the environment. Therefore, marine debris removal must continue into the foreseeable future. Accumulated marine debris poses direct threats to marine resources and habitats, threatened and endangered species, human health and safety, and economic health. Wind and currents concentrate marine debris on shorelines, in benthic habitats, and in pelagic waters of the world's oceans. Land-based and at-sea sources of marine debris introduced into the ocean disperse and accumulate in shoreline, benthic, and pelagic areas of the coastal and marine environments. Despite attempts to prevent and manage these sources, ongoing efforts to remove accumulations of marine debris are needed to minimize ecological, social, and economic impacts.

Wave action and currents can bring the various types of debris floating offshore onto the beach during regular tidal cycles, with higher deposition during certain stages of the lunar cycle or as a result of a storm or other extreme event (e.g., hurricanes and tsunamis). Spatial distribution can be influenced by wind and the size, and density of plastic debris (Browne et al. 2010). The movement of this debris through the near-shore and onto the beachfront can damage submerged habitats of coral reefs, sea grass beds, and other sensitive communities and habitats. Once on the beach, this debris can harm wildlife that live and forage in this area, serving as a source of entanglement and an improper food source if eaten. In addition, marine debris can result in impacts to people that depend on a clean and healthy shorelines for subsistence fishing and other livelihoods, especially coastal tourism.

A significant proportion of debris that enters the sea eventually sinks and accumulates on the seabed in near-shore and deep-water habitats [termed "benthic litter" (UNEP 2005)]. Benthic litter is rarely seen by the general public and therefore elicits little attention or public reaction (Galgani et al. 2000). Nevertheless, benthic litter continues to pose numerous problems. It is a potential navigation hazard, impedes trawl fishers (OSPAR 2006), and can entrap or smother marine biota (NOWPAP 2007). A conceptual model illustrating the direct and indirect threats of accumulations of marine debris is provided in Annex 2, Figure 5.

Strategies | Expected Results

Strategies to remove marine debris focus on:

- Conducting education and outreach
- Developing new technologies to locate and remove marine debris
- Building capacity to manage removal

- Developing market-based instruments
- Removing legal barriers for marine debris removal
- Removing marine debris

Each of these strategies and the expected results are described below and depicted on a schematic diagram in Annex 2, Figure 6. A listing of potential actions under each strategy is provided in Annex 1, Table 3.

Strategy C1. Conduct education and outreach on marine debris impacts and removal

Education and outreach is a cross-cutting strategy. Activities to raise awareness of ocean users should be incorporated into all strategies targeted to specific users, issues, and expected results. Education and outreach would raise awareness of the impacts of marine debris on marine ecosystems, human health and safety, and economic health; sustain public involvement in marine debris removal efforts; and build support for funding marine debris removal.

Strategy C2. Develop and promote use of technologies and methods to effectively locate and remove marine debris accumulations

Marine debris is geographically dispersed on remote, unpopulated shorelines; submerged in benthic habitats; and floating in coastal areas and the high seas, as well as in populated coastal areas. Development of effective methods to locate marine debris using remote sensing technology, low-altitude visual flights, and other methods would help reduce the search area, direct removal operations more efficiently to areas with marine debris accumulations, and improve the efficiency and effectiveness of marine debris removal efforts. This, coupled with more effective removal technologies and methods, would increase the rate of marine debris removal—ultimately resulting in a decrease of marine debris accumulated if current levels of introduction from land-based and at-sea sources remain constant. Efforts to prevent introduction of marine debris into the ocean would accelerate the decline of accumulated marine debris.

Strategy C3. Build capacity to co-manage marine debris removal response

Capacity and jurisdictional issues often complicate or impede response to reports of marine debris accumulations. Training in safe and efficient location and removal methods, as well as improving co-management of marine debris removal, would increase the effectiveness of marine debris removal. Development and promotion of effective reporting systems and coordinated rapid response mechanisms would increase the efficiency of locating marine debris. Effective coordination among civil society, government, and the private sector would improve the response to and rate of removal of marine debris.

Strategy C4. Develop or strengthen implementation of incentives for removal of ALDFG and other large accumulations of marine debris encountered at sea

Ships transiting or fishing frequently observe accumulations of marine debris, some of which could be safely removed and properly disposed of. Incentives such as recognition or monetary rewards would increase the likelihood of opportunistic marine debris removal. Ocean users aware of

incentives for marine debris removal would increase removal rates and reduce accumulated marine debris.

Strategy C5. Establish appropriate regional, national, and local mechanisms to facilitate removal of marine debris

Legal constraints in the form of prohibitions on removal of different marine debris types, except by the legal owner, impede removal efforts. Examples include ALDFG and derelict vessels. A legal authorization or agreement for marine debris removal by relevant organizations would remove this barrier and increase the rate of marine debris removal.

Strategy C6. Remove marine debris from shorelines, benthic habitats, and pelagic water

Marine debris has been accumulating in the world's oceans for decades. Marine debris removal is the only strategy to reduce historical accumulations and keep up with new introductions of marine debris. Development of and adherence to best practices is expected to prioritize marine debris removal efforts and encourage efficient use of resources. These include preventing further impacts to sensitive habitats and species, considering of the threat of severe weather, and data collection on the types and quantities of debris removed.

Monitoring Indicators | Evaluating Strategy Effectiveness

Monitoring and evaluation are critical components of determining whether strategies are achieving expected results. The following are potential evaluation questions and indicators to be considered in developing an evaluation approach for strategies focused on removal of marine debris accumulations:

How effective are methods to detect marine debris at sea?

- Marine debris detection rate based on size of search area, number of search days, and number and size of marine debris accumulations detected

How effective are removal efforts?

- Amount of marine debris removed
- Amount of marine debris recovered through incentive programs
- Catch per unit effort of marine debris removal operations
- Length of time between marine debris reporting and removal

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Annex 1 – Potential Actions by Strategy for the Prevention and Management of Marine Debris

Table 1. Potential Actions for Strategies Focused on the Prevention and Management of Land-based Sources of Marine Debris[10]

Goal A: Reduced amount and impact of land-based sources of marine debris introduced into the sea
Strategy A1. Conduct education and outreach on marine debris impacts and the need for improved solid waste management
• Promote an assortment of behaviors and actions – "4Rs"related to waste management – reduce, reuse, recycle, and recover
• Encourage changes in behaviors and practices by the public, government and industry related to the amount of packaging in the products they use, purchase and/or produce
• Promote the use of reusable bags and containers as an educational tactic to reduce the use of disposable products
• Facilitate collaborative industry partnerships with government programs and local organizations (NGOs) to increase reduction
• Educate the industry, government, and the public on the concept of "life cycle analysis" and the "cradle to cradle" concept for products and the consequences of choices
• Develop and implement an education campaign for citizens to support sustainable material use choices and new innovations (including practices)
• Develop and implement an education campaign to increase recycling and proper disposal efforts
• Expand/revise existing public awareness and education programs for solid waste management to include marine debris issues and address public perceptions about the impacts of improper waste management and the creation of marine debris
• Conduct education and outreach campaigns (primary and elementary schools & adult groups) involving multiple sectors of user groups (i.e., beach goers, fishers, fishing associations, fisheries cooperatives, boaters)
• Conduct tourism campaigns working with staff and patrons of water-front hotels and restaurants
• Collaborate with industry and government groups in developing programs for employees on litter prevention and proper waste disposal options
• Produce necessary educational materials (for primary and secondary schools and adult groups) and training to help modify the public's perception of littering and its impacts – litter free events, litter-free public outdoor areas, litter-free parks, schools, businesses, etc.
• Train beach wardens on BMPs for patrol of beach areas and to work with the public on handling trash and litter
• Encourage corporations and governments to develop sustainable practices
• Promote beach certification programs such as "Blue Flag" (http://www.blueflag.org/) and others
Strategy A2. Employ market-based instruments to support solid waste management, in particular waste minimization

[10] Annex 2 provides a listing of potential actions by strategy, some of which may have applications. This is considered an indicative list and not intended to be prescriptive as there are many additional activities that could be developed for each strategy.

Goal A: Reduced amount and impact of land-based sources of marine debris introduced into the sea
• Develop purchasing strategies as a tool to reduce all highly littered items (including single-use items)
• Provide economic incentives to develop products with less potential to contribute to marine debris, taking into consideration life cycle assessment and waste management hierarchy of those products – *less solid waste will help to reduce potential marine debri*s
• Develop partnerships between packaging producers, brand owners (including consumer packaged goods companies) and point-of-sale retailers to offer sustainable, cost-effective and convenient ranges of goods for consumers to select from
• Develop purchasing strategies as a tool to increase the market value of recycled materials
• Create increased value for waste by implementing incentive programs
• Encourage waste handlers to become materials brokers
• Depending on local socio-economic circumstances, existing infrastructure, and suitable alternatives, create incentives (e.g., taxes, deposits) for consumers, governments and industry to assist in the recovery of highly littered products
• Promote economic incentives for recycling and composting by encouraging governments to make recycling and composting more widely available and cost effective (i.e. , free or with low associated costs) and the landfilling option more expensive – *"Pay as you throw"*
• Develop approaches for end-of-life materials management (e.g., recycling, energy recovery, extended producer responsibility/cradle-to-cradle methodology) for packaging materials, sharps (needles, lancelets), medical wastes (blood /IV infusion bags), electronics (computers, cell phones) and other products
• Utilize economic instruments such as taxes/fines for littering and impose heavier fees for not recycling when those activities are available
• Utilize economic instruments such as taxes/fines for improper waste disposal actions/violations
Strategy A3. Employ infrastructure and implement best practices for improving stormwater management and reducing the discharge of solid waste into waterways
• Ensure proper waste transport to municipal landfills
• Ensure proper landfill management by municipalities
• Promote BMPs to encourage proper disposal of solid wastes
• Increase recycling efforts and the use of alternative materials taking into consideration life cycle assessment and waste management hierarchy of those products and materials
• Develop an infrastructure for establishing full-scale material recycling that includes glass, organics, paper/cardboard, plastics, and metals
• Facilitate collaborative industry partnerships with government programs and local organizations (NGOs) to increase recycling and recovery efforts, in particular for plastics packaging
• Support production and implementation of approaches based on life cycle information to include comprehensive environmental impacts of alternative materials and products
• Improve product labeling (including an explanation of recycling/resin identification` codes) to facilitate proper disposal methods (including recycling labels and "end-of -life" options)
• Develop local/regional recycling/recovery programs that will divert glass, organics, paper, plastic, and metal materials from the waste stream and identify innovative opportunities for reuse/recycling should these not be readily available

Goal A: Reduced amount and impact of land-based sources of marine debris introduced into the sea
• Develop recycling programs for the recovery of all materials (glass, metals, organics, paper/cardboard, plastics, etc.) for closed loop recycling activities – material is recycled back into same type of product (glass bottles into new glass bottles) and open loop recycling – material recycled into an alternate product (plastics into clothing)
• Develop conversion (e.g., biomass, ethanol) and waste-to-energy technologies (including BMPs to control air pollution) for utilization of complex materials to prevent landfilling and increase recovery of all material types, utilizing existing efforts as applicable
• Develop and promote BMPs by waste managers to improve waste management technical capacity and infrastructure
• Develop and implement plans to improve public waste management services through public-private partnerships
• Establish model twinning projects between mentor countries and partner countries to share information and work to develop initiatives for integrated solid waste management programs that include marine debris issues
• Facilitate greater south-south and north-south exchanges of experiences and technologies for waste reduction, re-use, recycling, and recovery including appropriate waste to energy and waste to fuel technologies. In the case of Small Island Developing States (SIDS) with limited land area for waste disposal, innovative technological options for waste processing and the use of marine transportation for off-island recycling and disposal should be considered.
• Provide adequate waste and recycling receptacles in public areas
• Provide adequate collection and removal of solid wastes at key collection points
• Ensure placement of adequate trash, cigarette and recycling receptacles for visitors to use as they leave the beach and coastal areas
• Provide recycling opportunities for beach visitors as part of the municipal solid waste management program
• Promote and implement BMPs for the capture of trash in municipal stormwater systems, including the installation and maintenance of full trash-capture devices as well as the specific good housekeeping measures (street sweeping, trash hot spot identification and cleanup, and compliance assistance)
• Implement adequate technology and BMPs for stormwater debris control
• Expand and encourage participation in pellet control programs, such as Operation Clean Sweep (http://www.opcleansweep.com/overview/environment.asp), a plastics industry containment program to prevent the pellets from getting into waterways that eventually lead to the ocean
• Encourage programs for commercial facility management and government facilities that demonstrate proper waste management and removal practices
• Provide adequate collection, cleaning and maintenance of stormwater drains and collection devices
• Expand voluntary "Extended Producer Responsibility" activities and promote stewardship projects with industry, and where applicable, establish timelines and metrics for implementation
• Develop partnerships among waterfront hotels, restaurants, and businesses to promote litter prevention and adopt clean beaches
Strategy A4. Develop, strengthen, and enact legislation and policies to support solid waste prevention, minimization and management

Goal A: Reduced amount and impact of land-based sources of marine debris introduced into the sea
• Adopt policies and regulations that ban, place fees, or other measures to reduce the most common items found as marine debris (e.g. plastic bags, bottle caps, cigarette butts)
• Enact or change public policies regarding waste management, including appropriate penalties for violations
• Establish policies to support implementation of technically adequate collection, cleanup systems, and disposal sites as part of an integrated solid waste management program
• Strengthen national and municipal/local capacities for managing solid wastes related to planning for natural disasters, such as tsunamis, floods, hurricanes, earthquakes and other events that can produce marine debris
• Enact or change public policies regarding littering and illegal dumping, including appropriate penalties
• Prepare new anti-littering ordinances as needed
• Develop and implement regulatory tools to prevent the release of pre-production pellets when voluntary programs are not successful
• Promote the ratification and legislative implementation of MARPOL Annex V at the national level, as the facilities that are needed for port reception of ship-borne wastes are a component of the general solid waste management for the surrounding community/ municipality
Strategy A5. Improve the regulatory framework regarding stormwater, sewage systems, and debris in tributary waterways
• Create greater levels of treatment at treatment plants and reduce the allowed stormwater overflow
• Develop Total Maximum Daily Load (TMDL) levels for trash in rivers and other water systems
Strategy A6. Build capacity to monitor and enforce compliance with regulations and permit conditions regarding litter, dumping, solid waste management, stormwater, and surface runoff
• Enforce existing laws and regulations regarding solid waste management
• Enforce existing laws and regulations regarding littering and illegal dumping
• Support enforcement efforts for solid waste management regulations through education and training opportunities for judicial officials/ magistrates/enforcement officers, park rangers and others on the importance of solid waste management regulations and marine debris prevention practices
• Engage solid waste management professionals to collaborate with law enforcement and regulatory authorities to encourage and increase public, government and industry compliance with existing laws and regulations regarding solid waste management practices
Strategy A7. Conduct regular cleanup efforts on coastal lands, in watersheds, and in waterways—especially at hot spots of marine debris accumulation
• Develop a plan for removal activities before the next tide or storm in the community
• Develop a plan to routinely clean/clear drains, ditches, culverts, gullies, streams and other stormwater pathways to help prevent marine debris accumulation and flooding
• Promote and support community-based cleanup campaigns as education/outreach events and as MD management activity
• Develop and promote best cleanup and disposal options, including manual cleanup, when advisable, in non-beach shoreline areas

Table 2. Potential Actions for Strategies Focused on the Prevention and Management of At-Sea Sources of Marine Debris[11]

Goal B: Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, ALDFG, and abandoned vessels introduced into the sea
Strategy B1. Conduct ocean-user education and outreach on marine debris impacts, prevention, and management
• Conduct awareness raising programs on impacts of marine debris on human activities and ecosystem services
• Provide cruise ship passengers outreach materials on the ecological and conservation issues associated with their transport
• Implement education and outreach programs for commercial and recreational fisher, fishing associations, and fisheries cooperatives on: (a) fishing gear dumping laws and penalties, (b) impacts of ALDFG and benefits of its minimization, (c) at-sea BMPs for fishing gear deployment, handling, and maintenance, (d) new technologies, including fishing gear that minimizes accidental loss and facilitates location and recovery of ALDFG for gear disposal in port, (e) waste minimization practices to reduce gear loss and/or replacement rate, and (f) BMP for non-gear fishing waste (e.g., detergent containers, oil filters, oil containers maintenance materials, bait boxes)
• Conduct seminars and workshops on ALDFG problems and solutions directed at fishers, the fishing industry, and port users and operators at local, national, regional and international levels
• Engage ocean users in programming on fishing gear handling and maintenance best practices and the application of new gear technologies that reduce the probability of accidental gear loss at sea.
• Conduct education and outreach programs related to relevant legislation and best practices/technologies for the prevention, reduction, and management of aquaculture-related debris and other solid wastes that engage aquaculturists
• Develop and promote the application of BMPs for aquaculture operations and practices, including aquaculture equipment and gear deployment, handling, and maintenance, in order to minimize or reduce the probability of accidental aquaculture equipment and gear loss at sea
• Promote best practices for the environmental management of aquaculture
• Conduct education and outreach programs on legislation and regulations regarding the prevention, reduction, and management of marine debris for the oil and gas industry and other offshore ocean infrastructure industries
• Inform the public on steps that can be taken to ensure vessels are not abandoned
• Develop and promote the application of BMPs for offshore operations and practices, in order to minimize or reduce the probability of marine debris generation
Strategy B2. Develop and strengthen implementation of waste minimization and proper waste storage at sea and disposal at port reception facilities to minimize incidents of ocean dumping
• Develop programs for economical in-port disposal options of ship-borne wastes to minimize incidences of illegal, ocean dumping
• Create port reception facility incentives and markets to enhance ocean users access and probability of use

[11] Annex 2 provides a listing of potential actions by strategy, some of which may have applications. This is considered an indicative list and not intended to be prescriptive as there here are many additional activities that could be developed for each strategy.

Goal B: Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, ALDFG, and abandoned vessels introduced into the sea
• Create port reception facilities for Annex V wastes and determine indirect financing of in-port disposal
• Develop incentives to take waste back to port. (e.g. reward fishers for retrieving marine debris found at sea)
• Provide adequate, accessible, and affordable reception facilities for shipping, boating and transport waste in ports, marinas, and small-scale harbors. Such facilities should be part of the broader waste management system in the municipality
• Develop easier ship-to-shore waste handling systems
• Promote use of empty container space to ship waste off island nations
• Expand onboard waste minimization procedures to include reuse and recycling
• Provide low-cost, convenient reception facilities for damaged and discarded fishing gear in ports and marinas
Strategy B3. Develop and strengthen implementation of industry BMP designed to minimize abandonment of vessels and accidental loss of cargo, solid waste, and gear at sea
• Develop and promote best management practices by users to minimize accidental loss of cargo, equipment, solid waste or vessels at sea
• Work to identify barriers to good waste management practices in maritime industry and work jointly to remove barriers
• Conduct meetings with specific ocean-user groups s to identify their challenges and to brief them on industry best practices
• Conduct training programs on best management practices/technologies for waste prevention, reduction, and management at sea and introduce these programs at nautical colleges
• Immediately remove vessels after grounding and develop removal guidelines and mechanisms for owners to responsibly dispose of vessels to avoid abandonment
• Develop guides to industry best management practices for dissemination to specific ocean user groups
• Develop incentives for shipping, boating, and transportation stakeholders to develop best management practices.
• Develop and promote materials and BMPs for alternative gear to minimize accidental loss.
• Develop and promote the application of BMPs for fishing gear design, deployment, handling, and maintenance in order to minimize or reduce the probability of accidental gear loss at sea
• Develop a compendium of environmentally safe fishing gear and practices that will be accessible to the public
• Engage ocean users through training and outreach on fishing gear handling and maintenance BMPs and the application of new gear technologies that reduce the probability of accidental gear loss
• Require fishing nets to have electronic gear marking and transponders attached for location and identification if lost at sea
• Require aquaculture nets to have electronic gear marking and transponders attached for location and identification if lost at sea
• Develop plans to address mass vessel grounding and standings from storms and natural hazards
• Promote development of BMP for the environmental management of aquaculture facilities
Strategy B4. Develop and promote use of fishing gear modifications or alternative technologies
• Research the development of improved gear technologies and efficiency of different measures

Goal B: Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, ALDFG, and abandoned vessels introduced into the sea
to reduce the loss of fishing gear
• Conduct education and outreach campaigns to promote the use of technologies that reduce ghost fishing of nets and traps such as escape mechanisms, rot cords, weak ropes, acoustic beacons, biodegradable and oxy-degradable materials, and sound reflecting substances
• Conduct education and outreach campaigns to promote the use of technologies that minimize loss of fishing gear and ghost fishing
• Require traps to have biodegradable components to minimize ghost fishing if lost or abandoned
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 and other relevant international instruments and agreements
• Develop legislation and policies to implement MARPOL 73/78, particularly Annex V
• Develop legislation and polices to implement the London Dumping Convention/Protocol
• Implement a policy goal of zero discharge of MARPOL Annex V solid waste products
• Conduct education and outreach programs to engage ocean-users (ship officers and crew, boaters) on ocean dumping laws
• Conduct regional exchanges to share expertise, experience, and lessons learned implementing requirements of MARPOL Annex V and the London Dumping Convention/Protocol
• Develop legislation and policies to require insurers and shippers to disclose information on lost cargo
• Develop legislation that will hold ship owners and captains accountable for the solid operational waste that comes from their ships
• Impose fines and taxes for cargo and/or debris accidentally lost or intentionally dumped at sea (unless done to preserve human life at sea)
• Promote development of packaging standards and accountability regulation
• Encourage countries to ratify relevant conventions/protocols, in particular MARPOL Convention with annexes and London Dumping Convention/Protocol
• Promote a system that will (a) impose fines and taxes for debris lost or dumped at sea (unless done to preserve human life at sea), and (b) develop and implement a compulsory detection system, using electronic gear marking and transponders, for lost fishing gear
• Develop legislation and policies to implement MARPOL Annex V through close cooperation with relevant international organizations, Regional Fisheries Management Organizations, Regional Seas Organizations, national governments, the fishing industry, ports and environmental NGOs
• Provide adequate, accessible and affordable reception facilities for waste fishing gear in ports, marinas and small-scale harbors. Such facilities should be part of the broader waste management program in the municipality
• Implement marine spatial planning to prevent conflict between different fishing activities, existing ferry or shipping lanes, , and offshore infrastructure and development
• Develop and implement legislation and policies at the regional and national levels to minimize marine debris from aquaculture, through close cooperation with relevant UN agencies (FAO, IMO and UNEP), Regional Seas Organizations, national governments, the aquaculture industry, ports, and environmental NGOs
• Review existing regulations and waste management programs to reduce potential introduction of solid waste materials into the sea from offshore infrastructure
• Develop and implement legislation and policies at the regional and national levels to minimize

Goal B: Reduced amount and impact of sea-based sources of marine debris including solid waste, lost cargo, ALDFG, and abandoned vessels introduced into the sea
marine debris from offshore infrastructure through close cooperation with relevant UN agencies (IMO and UNEP), Regional Seas Organizations, national governments, ports, energy, petroleum and mineral extraction industry and environmental NGOs
• Standardize and enforce fines against ships that do not maintain garbage logs, garbage management plans, or post Annex V placards
• Strengthen the enforcement of existing abandoned and derelict vessel laws and regulations
• Provide specific fishing gear avoidance training in boater safety course
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
• Develop monitoring protocols and database to track amounts of and vessels disposing of waste at port-reception facilities
• Conduct dock-side inspections of solid waste storage facilities on vessels to ensure adequate storage based on length between ports and crew size
• Build national capacity to actively monitor and enforce MARPOL Annex V requirements for minimizing fishing gear loss and involve fishers, fishing associations, and fishing cooperatives in implementation of this activity
• Build national capacity to actively monitor and enforce requirements of relevant legislation for minimizing marine debris from aquaculture
• Actively monitor and enforce requirements from relevant legislation for minimizing equipment and gear loss of aquaculture
• Adopt international protocols for monitoring equipment loss/breakage in aquaculture production
• Develop a compendium of environmentally safe aquaculture gear
• Establish partnership at the regional and national level with aquaculture industry to minimize their debris output.
• Build national capacity to actively monitor and enforce relevant legislation requirements for minimizing marine debris from offshore infrastructure (energy, petroleum, mining, etc.)
• Adopt international protocols for monitoring marine debris from offshore infrastructure including equipment loss/breakage
• Promote permit review and pre-development environmental analysis of offshore infrastructure projects as potential source of marine debris

Table 3. Potential Actions for Strategies Focused on the Removal of Accumulated Marine Debris[12]

Goal C: Reduced amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters
Strategy C1. Conduct education and outreach on marine debris impacts and removal
• Develop partnerships among waterfront hotels, restaurants, and businesses to adopt beaches and shorelines
• Engage people who may not typically be involved in cleanup efforts and use social media to encourage positive behavior
• Support and promote beach and underwater cleanup events within the public and private sectors (e.g., International Coastal Cleanup, Clean Up the World and other public beach cleanup efforts)
• Create and promote stewardship concepts such as adopt-a-beach or adopt-a-dive site programs.
• Promote and support community based cleanup campaigns as education/outreach events and as MD management activity
• Conduct targeted education and outreach to commercial fishers as the primary source of ALDFG
Strategy C2. Develop and promote use of technologies and methods to effectively locate and remove marine debris accumulations
• Develop predictions of accumulation on the basis of models in order to maximize efforts on cleanup activities and to identify "hot spots"
• Develop/use standardized methods for assessing the amount of marine debris (including microplastics) on shorelines, in benthic habitats, and in pelagic waters which can be used for the assessment of time series trends
• Analyze collected debris to determine the source and focus prevention efforts
• Develop models on the transport and distribution of marine debris for use in targeting removal efforts
• Develop a public innovation process to drive technology development in the remote detection and tracking of ALDFG in open ocean environments, including aerial and satellite photography
• Develop techniques for identification of accumulation areas on the seafloor
• Develop and promote the use of new or modified methods to improve the removal process of observed marine debris accumulations at sea
• Research best recovery options for debris collected at sea
• Develop and promote community based volunteer monitoring networks
• Use data from different specialized areas (drift modeling, degradation modeling, marine life impacts, etc.) to demonstrate relationships between sources and impacts in order to focus removal efforts
Strategy C3. Build capacity to co-manage marine debris removal response
• Create an international database, using standardized data collection methods

[12] Annex 2 provides a listing of potential actions by strategy, some of which may have applications. This is considered an indicative list and not intended to be prescriptive as there here are many additional activities that could be developed for each strategy.

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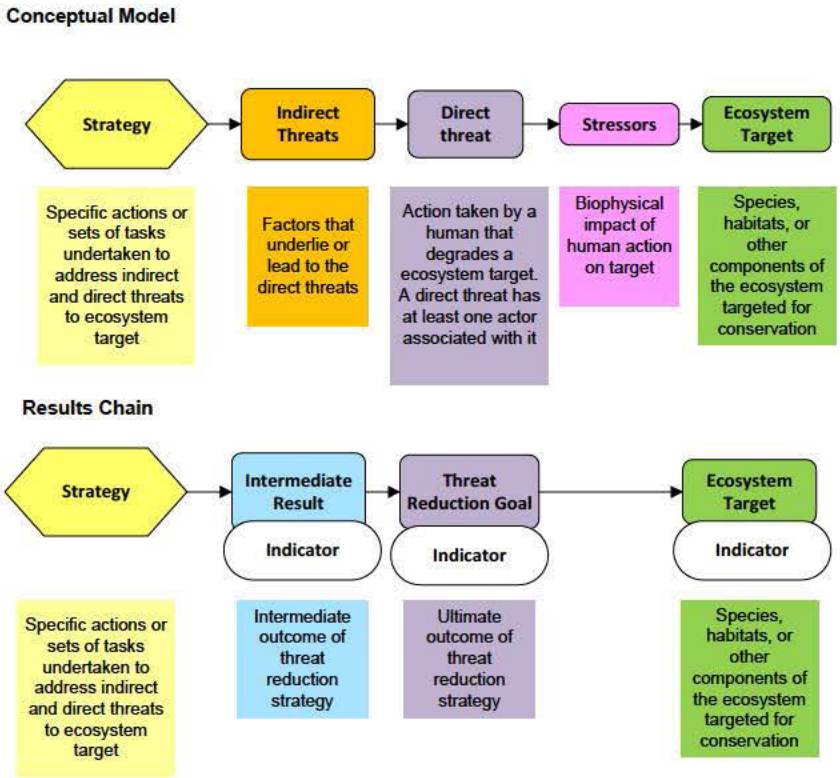
Goal C: Reduced amount and impact of accumulated marine debris on shorelines, in benthic habitats, and in pelagic waters
• Integrate existing monitoring and data collection protocols
• Develop and promote use of reporting systems for marine debris accumulations
• Develop cooperation mechanisms to leverage human and financial resources to respond to reports of marine debris
• Increase capacity for removal of accumulated marine debris at beach and underwater sites
Strategy C4. Develop or strengthen implementation of incentives for removal of ALDFG and other large accumulations of marine debris encountered at sea
• Develop removal capacity from ships of opportunity (e.g., the commercial fishing community) for retrieval of large aggregations of marine debris (e.g., ALDFG)
• Encourage the private sector to compete in innovative removal technology
• Encourage and implement the "Fishing for Litter" initiative and other fishing cooperatives for retrieval and possible resale
• Develop incentive programs for those who recover and land ALDFG
Strategy C5. Establish appropriate regional, national, and local mechanisms to facilitate removal of marine debris
• Establish fishery-based ALDFG removal projects
• Ensure fishery regulations address the need for locating and removal of ALDFG
Strategy C6. Remove marine debris from shorelines, benthic habitats, and pelagic water
• Develop and promote best cleanup and disposal options, including manual clean-up, when advisable, in non-beach shoreline areas
• Develop actions plans to target specific marine debris sources and items
• Focus land-based removal on high density urban areas
• Develop ways to gauge success of debris cleanups by establishing target thresholds and benchmarks of cleanliness
• Develop and make available processing technologies to dispose of collected debris
• Research best disposal or recovery options for debris collected at sea
• Develop and implement removal programs for debris on the sea floor

Annex 2 – Conceptual Models and Results Chains on the Prevention and Management of Marine Debris

Introduction to Conceptual Models and Results Chains

Conceptual models and results chains presented in this Annex (Figures 1 through 6) serve as the underpinning for the *Honolulu Strategy.* A conceptual model is a planning tool that helps managers depict the relationship among various threats that are believed to directly or indirectly impact one or more management targets (FOS 2009). Over the last two decades, various diagrammatic methods have been used for planning purposes in a variety of fields including international development, public health, and environmental management (FOS 2009). Of these methods, conceptual models are believed to be the most useful for environmental management planning (Margoluis et al. 2009).

Results chains are another planning tool, derived from conceptual models. A results chain is used by managers to define and communicate why a specific management strategy is believed to logically lead to a desired outcome (FOS 2007). A results chain is the visual representation of the management team's assumptions regarding how a particular action they plan to take will lead to a specified series of intended results. They are depicted as a chain of causal statements that link short-, medium-, and long-term results in an "if...then" fashion (FOS 2007). Such "intermediate" results ultimately lead to the reduction of a threat, which in turn leads to successful conservation of specified targets of concern, such as marine species and habitats, economy, and human health and safety. Results chains logically guide management effectiveness evaluation efforts in that managers can periodically evaluate their progress made along the results chain through time by measuring indicators that are tied both to intermediate results and the ultimate achievement of the stated threat reduction result (FOS 2007).



A generic illustration of the components within a conceptual model (top) and results chain (bottom). Adapted from FOS (2007) and FOS (2009).

Results chains differ from conceptual models in that that while a conceptual model is a visual representation of the state of the operating conditions (particularly the threats) before a management action is implemented, a results chain shows the state of the world that is assumed to result from the successful implementation of the management strategy to be used. Results chains are a type of logic model used by many organizations. The value of the results chain is that it has the potential to draw attention to links in the logic of management that are not properly implemented, not working, or not fully effective. Hence the value is in both accountability and learning for adaptation.

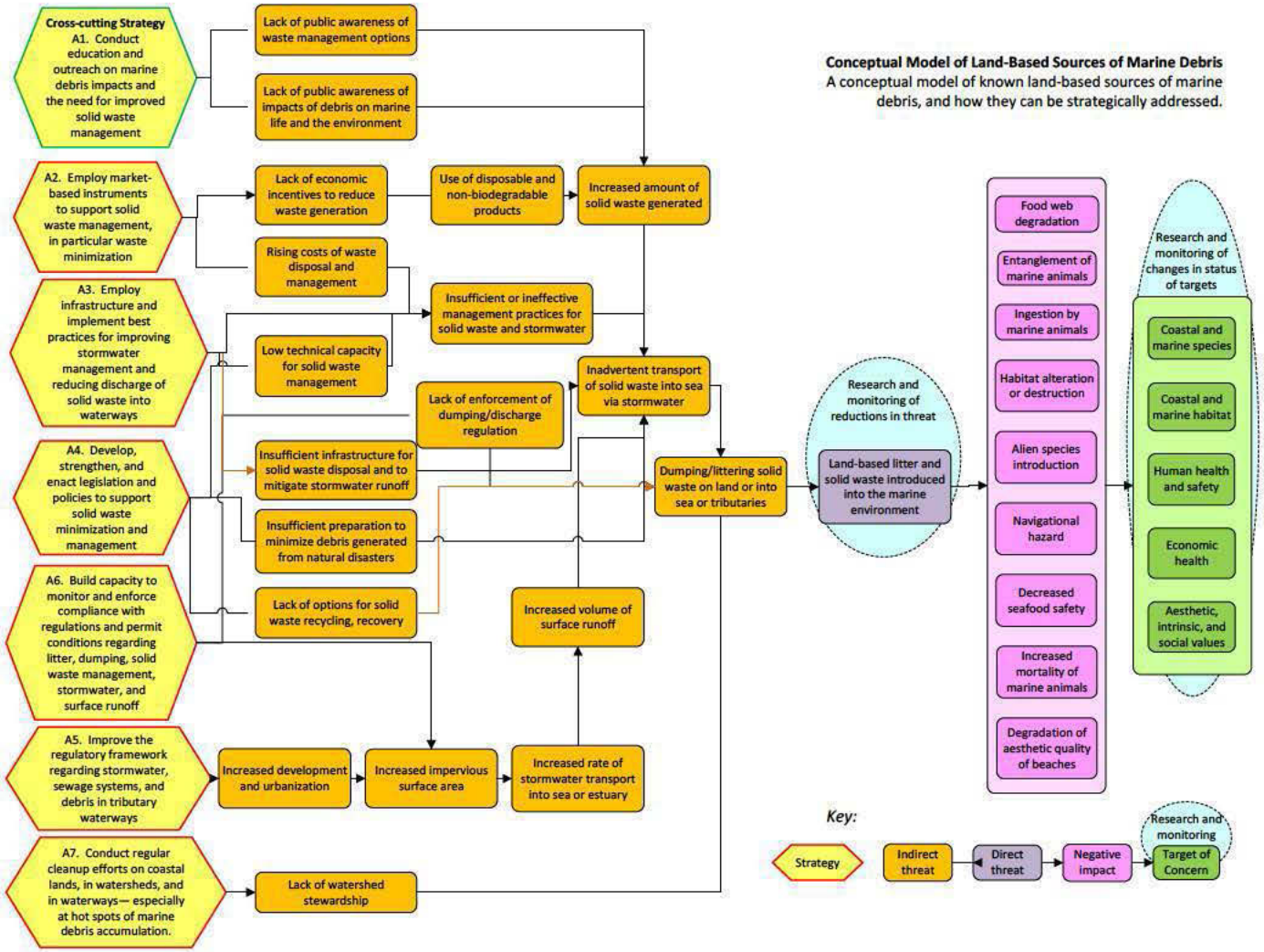


Figure 1. Conceptual Model of Land-based Sources of Marine Debris[13]

[13] Conceptual model reviewed and modified by participants of the Results Chain Workshop conducted during the 5th International Marine Debris Conference

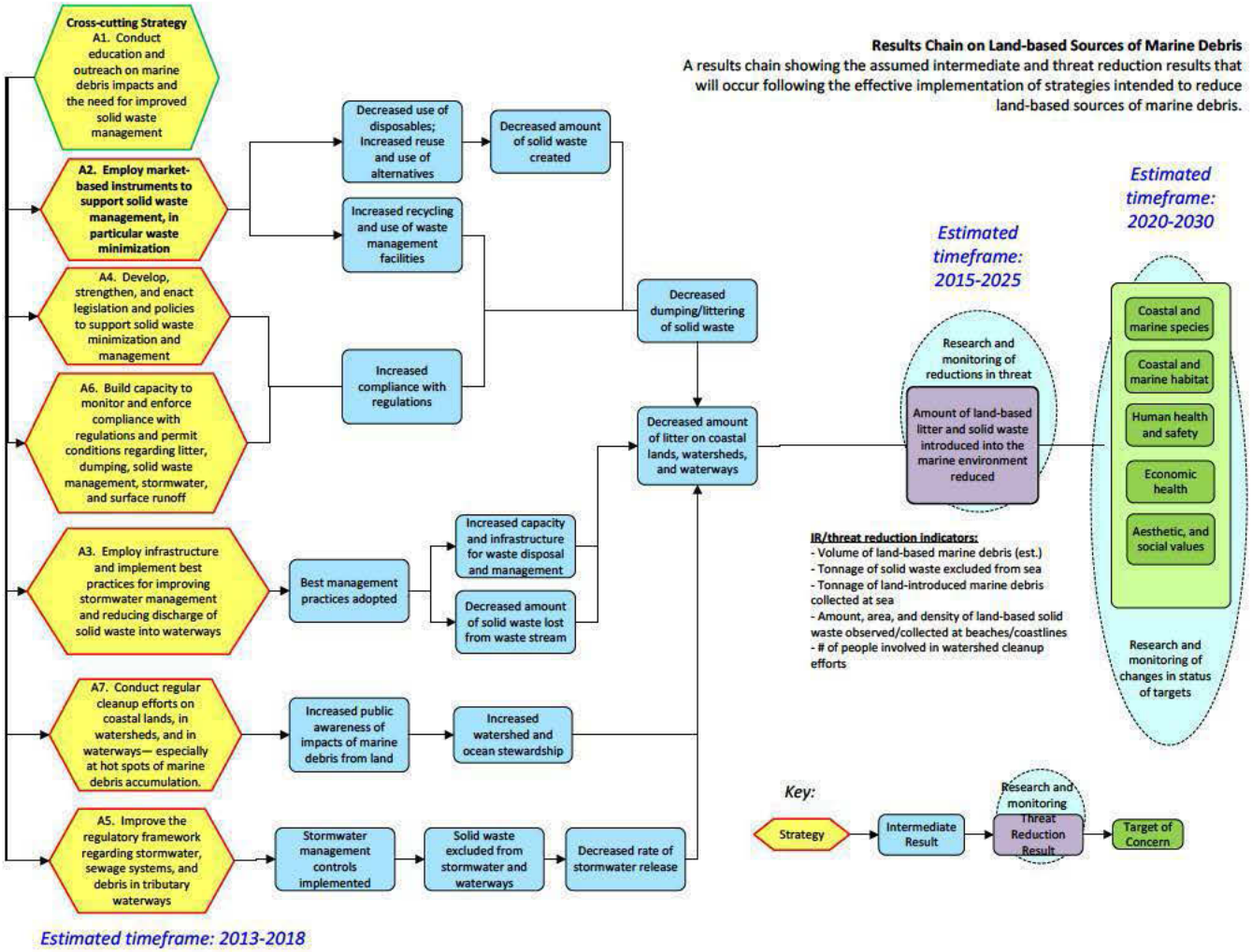


Figure 2. Results Chain of Land-based Sources of Marine Debris[14]

[14] Results chain reviewed and modified by participants of the Results Chain Workshop conducted during the 5th International Marine Debris Conference

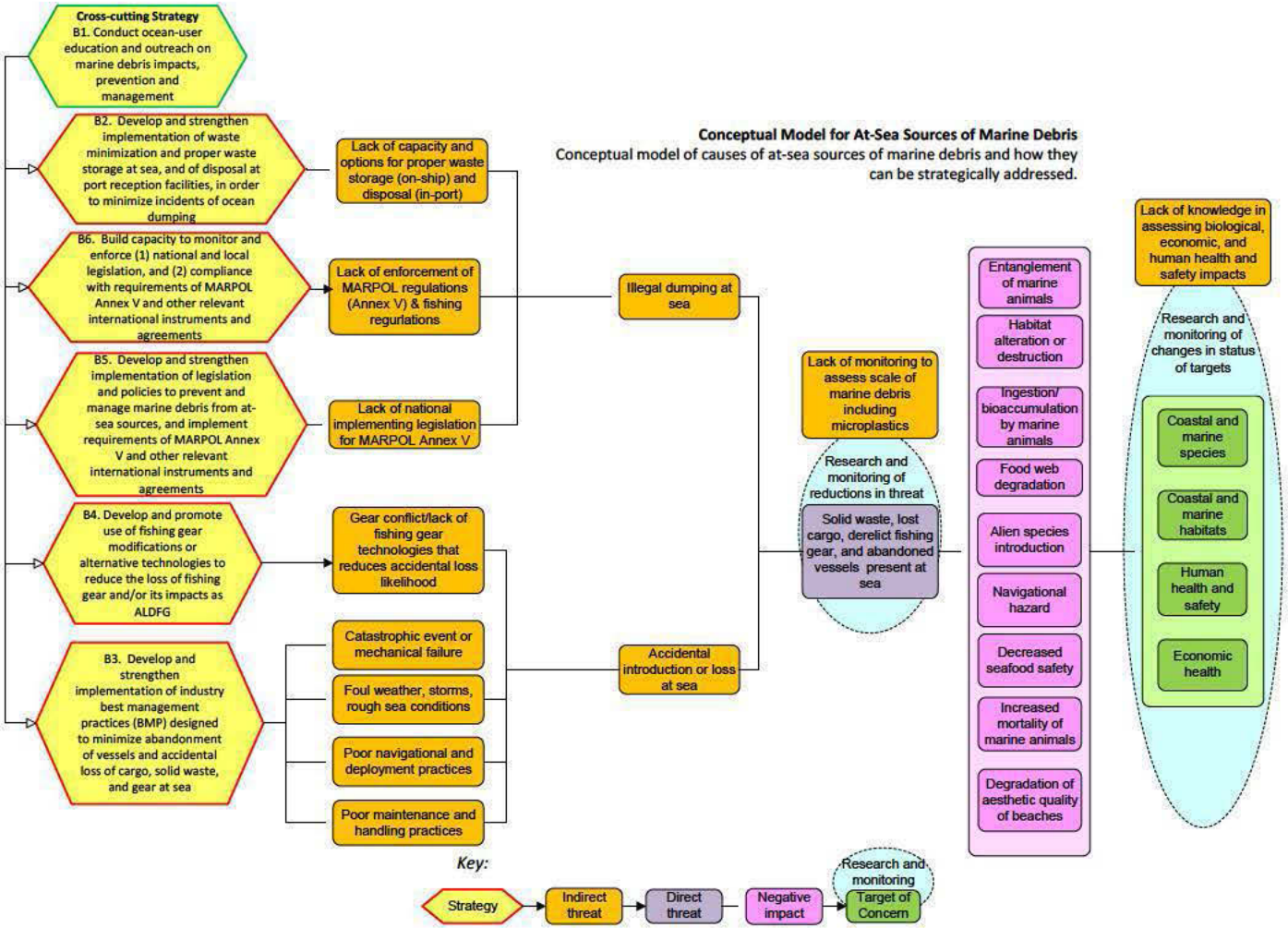


Figure 3. Conceptual Model of At-Sea Sources of Marine Debris[15]

[15] Conceptual model reviewed and refined by participants in the Results Chain Workshop conducted during 5th International Marine Debris Conference

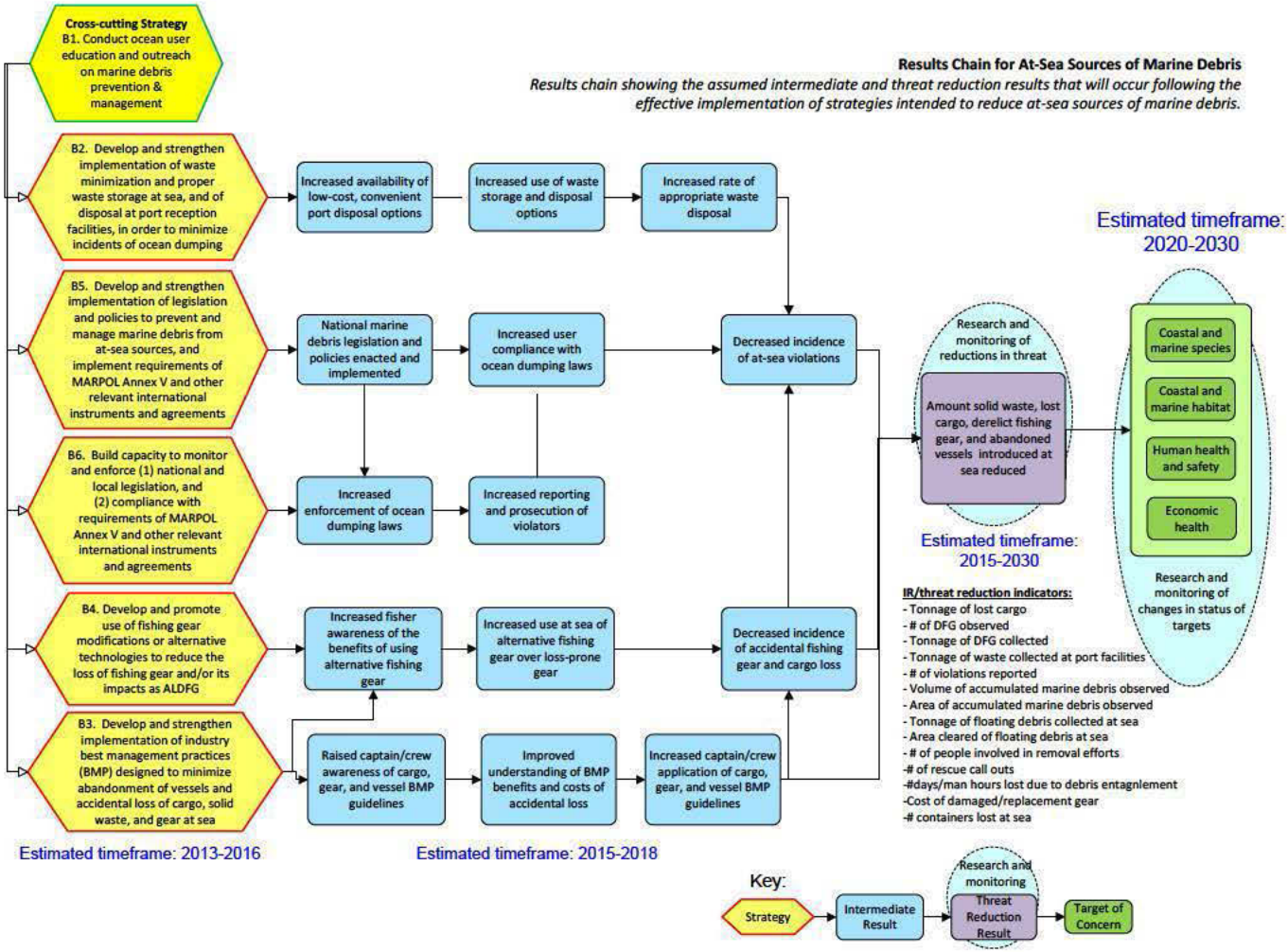


Figure 4. Results Chain of At-Sea Source of Marine Debris[16]

[16] Results chain reviewed and modified by participants of the Results Chain Workshop conducted during the 5th International Marine Debris Conference

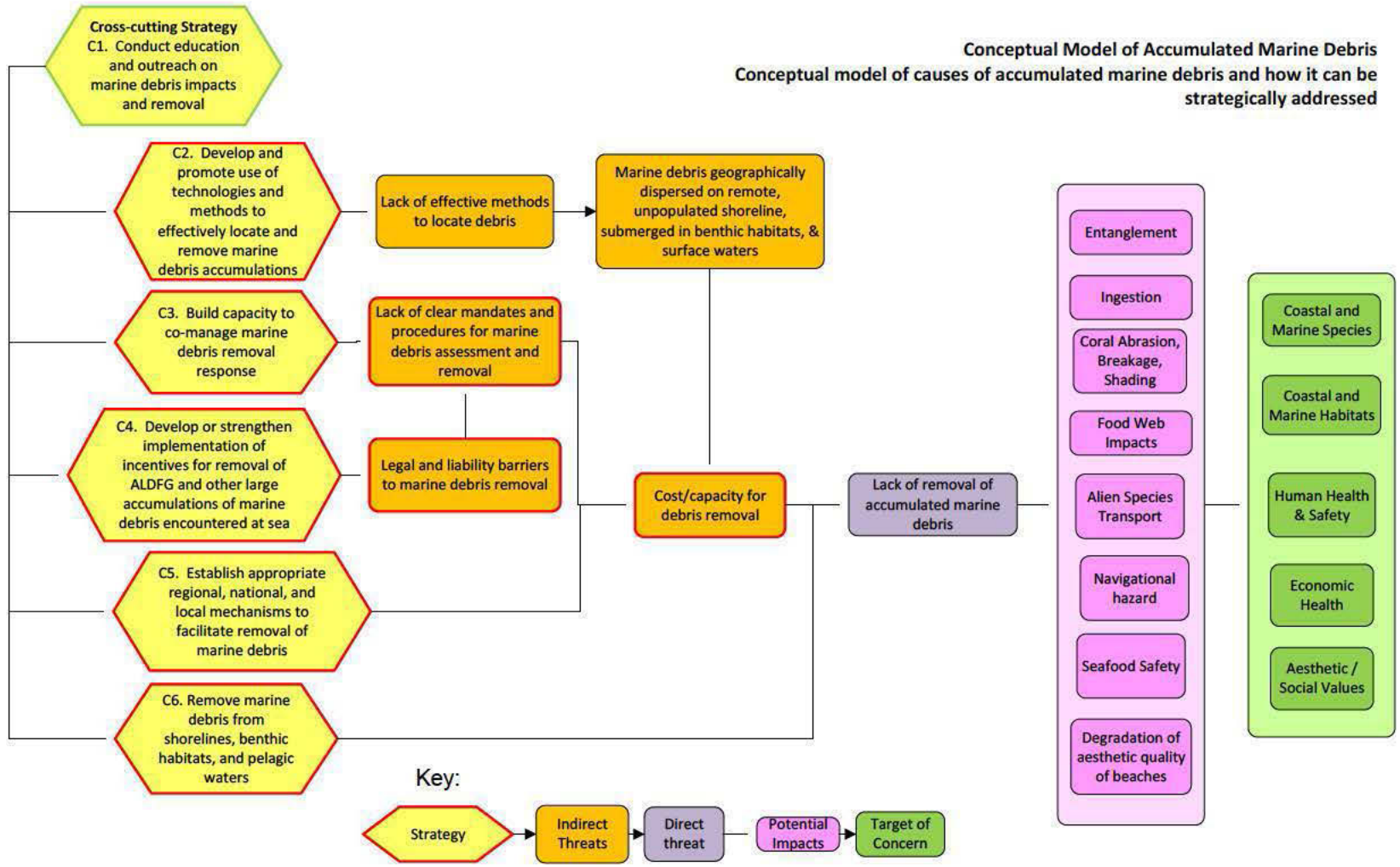


Figure 5. Conceptual Model of Accumulated Marine Debris[17]

[17] Conceptual model reviewed and refined by participants in the Results Chain Workshop conducted during 5th International Marine Debris Conference

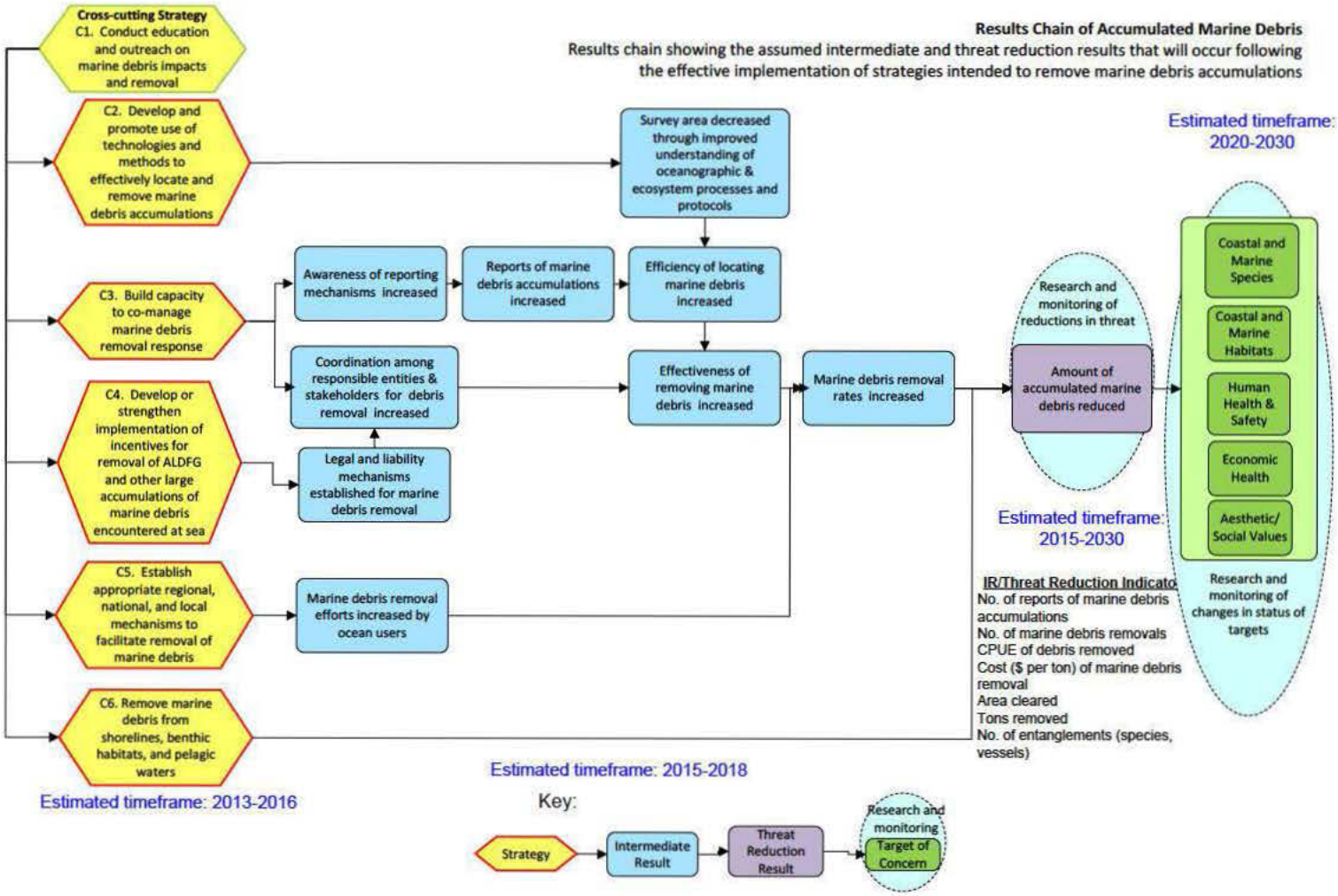


Figure 6. Results Chain of Marine Debris Accumulation[18]

[18] Results chain reviewed and modified by participants of the Results Chain Workshop conducted during the 5th International Marine Debris Conference