MARINE DEBRIS AND BIODIVERSITY IN LATIN AMERICA AND THE CARIBBEAN

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ACRONYMS

ACOREMA	Áreas Costeras y Recursos Marinos
CaMPAM	Caribbean Marine Protected Area Management
CEPF	Critical Ecosystem Partnership Fund
CFR	Code of Federal Regulations
FONDEPES	National System of Reserves and the National Fundo for Fisheries Development
GAP	Grupo Aves del Perú
GCFI	Gulf and Caribbean Fisheries Institute
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	greenhouse gas emissions
GPML	Global Partnership on Marine Litter
IMARPE	Instituto Marino de Perú
IUCN	The International Union for Conservation of Nature
IUU	illegal, unreported, and unregulated
LAC	Latin America and Caribbean
MARPOL	Marine Pollution
MINAM	Ministry of Environment
MOU	Memoranda of Understanding
MPA	Marine Protected Areas
MT	metric tons
NGO	Non-Governmental Organizations
NOAA	National Oceanic and Atmospheric Administration
OBFS	Board- Oracabessa Foundation
RNSIIPG	Reserva Nacional Sistema de Islas, Islotes y Puntas Guaneras
SERNAP	National Service of Protected Areas
SDG	Sustainable Development Goals
SFF CGSM	Santuario de Flora y Fauna Ciénaga Grande de Santa Marta
SIDS	Small island developing states
SIOBMPA	Sandy Island Oyster Bed Marine Protected Area
SPAW	Specially Protected Area and Wildlife

UN	United Nations
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
US EPA	United States Environmental Protection Agency
USAID	United States Agency for International Development
USD	United States Dollars
WCR	Wider Caribbean Region

EXECUTIVE SUMMARY

The Latin American and Caribbean region is an important biodiverse region containing over 50 percent of the world's biodiversity. Regional biodiversity hotspots include the Caribbean Islands biodiversity hotspot, the Mesoamerica biodiversity hotspot, and in South America, the Tropical East Pacific, the Humboldt Current, and the Tropical West Atlantic. Within the region, key ecosystems of biodiversity importance include mangroves, seagrass and coral reefs while key fauna of biodiversity importance include marine mammals, sea turtles, fish, and birds. To protect these rich natural resources, approximately 21.7 percent of total territorial area is protected in Latin America and the Caribbean (UNEP-WCMC 2019); 30 percent of reefs in the Wider Caribbean region are protected via marine protected areas (WRI 2011).

However, marine biodiversity in the Latin America and Caribbean (LAC) is impacted by a range of factors, including overfishing, coastal development, sedimentation, contamination, climate change, and weak or uncoordinated management of natural resources, among others. Latin American and Caribbean nations also produce 424,000 tons of waste daily, and less than 25 percent is processed into regulated sanitary landfills (UNEP, 2005). While the prevalence and impacts of marine debris are widely recognized, its effects have historically been understudied in the region (Bravo et al, 2009). Most marine debris in the Caribbean region is from shoreline and recreational activities, with plastic beverage bottles accounting for nearly 20 percent of total litter, according to the UNEP (2005) report. Plastic and paper bags comprise nearly 17 percent of marine litter, followed by caps and lids (11.4 percent), utensils, cups and plates (9.6 percent), cigarettes (8.4 percent) and glass beverage bottles (8.3 percent) (CEP 2014). The plastic degrades into one of three general size classes: macroplastics, microplastics and nanoplastics (Section 1).

Sources of marine debris include both land and sea-based marine debris (Section 1).

Land-based:

- Plastics/improper management of waste
- Marine tourism
- Terrestrial sources are urban settlements and industry,
- Sewage outfall, which transports debris to the sea
- Waterways transporting litter from inland to ocean
- Litter transported by wind from landfills near the coast, and direct beach littering
  - A smaller but significant stream of plastic litter originates from Small Island Developing States (SIDS) because many have difficulties establishing and maintaining efficient waste management systems. (Lachmann et al. 2017)

Marine-based sources of debris:

- Derelict and/or lost fishing gear; aquaculture materials
- Offshore development
- Recreational fishing
- Offshore dumping
- Loss of shipping containers

Marine debris impacts habitat throughout Latin America and the Caribbean via a variety of pathways, including the following (Section 4):

- Plastic debris is a potential transport **vector for contamination** of beach environment by toxic metals.
- Marine debris becomes trapped among mangroves and their aerial roots, possibly **blocking mangrove tidal channels**. A high debris load can prevent the rehabilitation of mangrove forests by smothering seedlings and creating water quality issues in the surrounding bay. The effects of microplastics on the mangrove habitat are still largely speculative, so further studies are planned to measure the presence of microplastics in mangrove biota and assess any toxicological impacts. (NOAA 2016).
- Derelict fishing gear is particularly **damaging to seagrasses** because fishing gear can resuspend sediment, disturb the rhizome, and impact the root structure of seagrasses.
- Marine-litter has caused **ecological disruptions** on 418 species across eight reef taxa (Carvalho-Souza et al. 2018).
- **Corals ingest plastic** and a recent investigation showed that plastic debris can stress coral by depriving them of light and oxygen and tissue abrasions can facilitate the development of diseases (Carvalho-Souza et al. 2018).
- **Entanglement/catches** in derelict fishing gear were found to have impacted at least 298 reef species as the most common disruption (Carvalho-Souza et al 2018).

Marine debris stresses key fauna and ecosystems within a multi-driver scenario that includes coastal development, overexploitation of fisheries, and increasing population, among others. Marine biodiversity is directly impacted via interactions of marine organisms with debris, including entanglement and ingestion (Section 5). More than 800 marine and coastal species are affected by marine debris from ingestion, entanglement, ghost fishing and dispersal by rafting. An estimated 640,000 tons of fishing gear is lost globally in the oceans every year (Global Ghost Gear Initiative, 2017). Fifteen percent of the species affected through entanglement and ingestion are on the (International Union for Conservation of Nature) IUCN Red List. Population level effects are evident in some species such as the northern fulmar (*Fulmarus glacialis)* and the commercially important lobster, *Nephrops norvegicus* (CBD 2012). Over 40 percent of marine mammals have been affected by ghost gear, with many of these species on the IUCN Red List (Global Ghost Initiative 2017). For marine mammals, entanglement in marine debris appears to be most common among seals and sea lions (pinnipeds), less common in baleen whales (mysticetes) and manatees (sirenians).

In many parts of the ocean, the concentration of microplastics outnumbers plankton by up to six times. (GiZ 2015), increasing ingestion rates of microplastics. Physiological effects stemming from plastic ingested by seabirds include obstruction of the intestines and of subsequent passage of food into the intestines, blockage of gastric enzyme secretion, diminished feeding stimulus, lowered steroid hormone levels, delayed ovulations and reproductive failure (Azzarello and VanVleet 1987). Microplastics' composition and relatively large surface area make them prone to adhering waterborne organic pollutants and to the leaching of plasticizers that are considered toxic. Ingestion of microplastics may therefore be introducing toxins to the base of the food chain. (Cole et al. 2011).

- Plastic debris has a large mixture of chemical contaminants associated with it: the chemical ingredients of 56 percent of plastic polymers are hazardous (CBD 2016).

- Invasive species: Floating debris is now the most common seagoing transport system and is responsible for the widespread distribution of many marine animals.
- Microplastics develop a microbial biome that is different from what is naturally found in the sea. The potentially toxic additives contained in plastic influence the composition of the microbial community (Herrera 2018).

Marine debris negatively impacts critical ecosystems and taxa in the region. Given the lack of data on population-level effects of marine debris, it is difficult to effectively determine whether marine debris has a greater impact on species abundance and richness than other factors (Section 5). However, the literature clearly demonstrates marine debris has deleterious effects on organisms via ingestion, entanglement, contamination, disease introduction, nutrition, and alteration of habitat. It damages ecosystems via abrasion, filtration of light, alteration of hydrologic processes, and suffocation.

Several initiatives are focused at the global, regional, and country levels on reduction of plastic use, increase of recycling, and improving awareness regarding impacts of plastics in the marine environment. These strategies emphasize the following five principles: (Section 6).

- Reducing production and consumption of plastics;
- Strengthening solid waste management infrastructure, including plastics recycling;
- Increasing collaboration between the public and private sectors to address the issue;
- Funding additional research into the impacts of marine debris on the environment and biodiversity, as well as which types of interventions are the most successful;
- Encouraging innovation and entrepreneurship in plastics alternatives and clean-up.

Despite a growing body of evidence regarding the deleterious impacts of marine debris on organisms and key ecosystems, the following data gaps exist:

- Few country-specific studies on marine debris for this paper's targeted countries
- Few studies linking marine debris impacts and biodiversity
- Limited studies on habitat-level impacts of marine debris
- Lack of studies on population-level impacts of marine debris
- Limited characterization of marine debris pollution in targeted countries
- Invasive species transported by plastics is understudied.

INTRODUCTION

This research paper focuses on countries in Latin America and the Caribbean where United States Agency for International Development (USAID) works bilaterally or regionally (Figure 1), including Dominican Republic, Jamaica, Haiti, Grenada, and St. Vincent and the Grenadines, El Salvador, Honduras, Nicaragua, Guatemala, Peru, and Colombia. Given the paucity of information regarding country-specific impacts of marine debris, the issue is presented from regional and global perspectives, highlighting evidence from targeted countries, as available. It is important to acknowledge that marine debris is one type of contaminant affecting the marine and coastal environment in the region; Section 5 discusses the impacts of marine debris versus other stressors.

Figure 1. Regions of focus for marine debris research

OBJECTIVES

This document is intended to enhance the LAC Bureau's understanding of the impacts of marine debris on biodiversity and the broader environment in the region. The compiled research will inform USAID staff on the status and impacts of this issue related to biodiversity in Latin America and the Caribbean. As such, the specific questions addressed in this white paper are:

1. What is the extent to which marine debris affects areas of high biodiversity in the targeted geographies?
2. What is the evidence that marine debris has significant impacts (e.g., direct, indirect or cumulative) on coastal and marine biodiversity?
3. Where impacts are thought to be significant, how do they compare to other stresses to biodiversity in the target areas?
4. What is known regarding successful principles and strategies for addressing the threats posed by marine debris to biodiversity in the targeted geographies?

The last question (4) is addressed at a high level in the white paper and a case study in Annex C further explores the issue of marine debris and waste management in Peru.

METHODOLOGY

To synthesize current and historical information on marine debris in the targeted geographies and potential or known impacts on biodiversity, this paper was developed in several stages.

The following methods were used to collect data:

- Initial literature review to establish the level of existing knowledge;
- Identification of subject-matter experts for telephone or in-person interviews;
- Expanded literature review and preparation of an annotated bibliography;
- Conducted telephone interviews with experts in the marine debris field;
- Summarized existing research and knowledge in a draft document for review;
- Field visit to Peru for development of a site-specific case study;

DEFINITIONS OF BIODIVERSITY TERMINOLOGY

The terminology used to describe the effects of marine debris on biodiversity are aligned with USAID definitions based the Open Standards for the Practice of Conservation (CMP 2013) and described in their Biodiversity How-To Guides[1] and Biodiversity policy. Concepts used in this paper include:

Biodiversity: "The variability among living organisms from all sources including, *inter alia,* terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems" (Convention on Biological Diversity, 1992, via USAID Biodiversity Policy).

[1] https://usaidlearninglab.org/library/usaid-biodiversity-programming-how-guides

Example: Coral reefs can host up to 4,000 individual species on a single reef including algae, fish, dugongs, marine turtles, sea snakes, worms, crustaceans, mollusks and starfish, all of which contribute to the health and functioning of the ecosystem (Ekos Communications, 2009).

Biodiversity Focal Interest: An element of biodiversity (species, habitat, and/or ecosystem), within the defined scope, on which a program has chosen to focus.

Examples: Coral reefs; mangroves; whales

Direct Threat: A human action or unsustainable use that immediately degrades one or more biodiversity focal interests.

Examples: Over-fishing and destructive fishing practices; uncontrolled waste dumping

Driver: A constraint, opportunity, or other important variable that positively or negatively influences direct threats.

Examples: Population growth; weak laws and regulations

Stressor: An altered key ecological attribute of biodiversity focal interest. In many cases, a stress is the biophysical way in which a direct threat impacts a biodiversity focal interest.

Examples: habitat loss and fragmentation; deforestation, pollution

Ecosystem Service: Service that functioning ecosystems, species, and habitats provide and that can benefit people.

Examples: Water filtration; flood protection; products for subsistence or livelihoods (food, fiber, etc.)

This paper uses these definitions to summarize the potential impacts of marine debris on the environment, biodiversity focal interests, and to a lesser extent, human health.

ORGANIZATION OF THIS PAPER

This paper first provides a background of the issue of marine debris (Section 1), including a detailed description and definition of the term "marine debris". Sections 2 and 3 describe marine biodiversity in the region and the extent of marine debris impacts on areas of high biodiversity in the LAC region, answering research objective #1. Section 4 describes the evidence of significant marine debris impacts on coastal and marine biodiversity, addressing research objective #2. Section 5 describes the impacts of marine debris compared to other threats/stressors to biodiversity in the region, addressing research objective #3. Section 6 describes existing strategies, policies and plans for addressing marine debris, addressing research objective #4. The conclusion (Section 7) summarizes the main issues and topics addressed in this paper. The references contain supplementary data, including treaties, laws, and policies (Annex A), a list of marine protected areas (MPAs) in the region (Annex B), the marine debris and waste management case study (Annex C) and a list of experts consulted (Annex D).

BACKGROUND

PROBLEM STATEMENT

Annual global plastics production has doubled every eleven years since the 1950s, increasing from 1.5 million tons in the 1950s to 288 million tons in 2012 (PlasticsEurope 2013). Furthermore, production of synthetic fibers, which are thin strands of plastic, has more than doubled between 2000-2017; these thin strands degrade into microplastics that are becoming ubiquitous in waterways globally. Jambeck et al. (2015) estimated that 192 coastal countries produced 275 million metric tons (MT) of plastic waste in 2010, of which 4.8 to 12.7 million MT of mismanaged plastic waste entered the oceans. The authors defined the mismanaged plastic waste as plastic littered or inadequately disposed by populations living within 50 km of the coast worldwide, entering the oceans via inland waterways, wastewater outlets and transported by wind or tides. Because of these inputs and weathering of plastic, it is estimated the surface of the world's oceans contains more than 5 trillion individual plastic pieces (Lavers and Bond 2017).

Marine debris has garnered global attention as the negative effects on organisms, human health, economies, and ecosystems have become more apparent; this is especially apparent via social media and in news stories highlighting bird and whale stomachs full of plastic debris or sea turtles tangled in plastic. On the macro-level, marine debris is a nuisance as it accumulates on beaches, causes vessel damage, and negatively affects tourism and recreational activities, causing significant negative economic impacts[2]. At the micro-level, marine debris, specifically plastics, also impacts wildlife species via ingestion, entanglement, contamination, and transport of invasive species. While the physical impacts of macroplastics are well-documented, all macroplastics degrade over time into microplastics, which may be ingested and accumulated throughout the food chain.[3]

KEY POINTS

- Plastic is by far the most prevalent and impactful type of marine debris, due to exponential increases in plastic production and its persistence in the environment.
- All known species of sea turtles, about half of all species of marine mammals, and one-fifth of all species of sea birds are affected by entanglement or ingestion of plastic marine debris.
- Most marine debris originates from land-based sources and enters oceans via waterways.
- Once in the ocean, marine debris accumulates in certain areas based on currents, winds and gyres. Climate change will impact transportation dynamics.
- Latin America and the Caribbean are facing a growing challenge in marine debris, mainly due to poor waste management in the region.
- At the macro-level, marine debris is a nuisance that negatively impacts tourism, recreation, fisheries and industry, thereby creating indirect economic consequences.
- At the micro-level, biodiversity is impacted in various ways when ecosystems and species interact with marine debris via ingestion, entanglement, contamination, and transport of invasive species.

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[2] Conservative estimates place the overall financial damage of plastics to marine ecosystems at $13 billion each year (Wang et al 2016).

[3] Macroplastics are classified as plastics larger than 5 mm, while microplastics are <5 mm in size. Nanoplastics do not have a defined size range but are generally are not visible to the eye and can be less than 0.1 micron in size.

Evidence of the impacts of plastics at the species and population levels is unclear, mainly due lack of population-level studies. However, effects of microplastics, such as compromised ability to capture and digest food, sense hunger, escape from predators, and reproduce, as well as deteriorated body condition and impaired locomotion, have been documented (Thompson 2013; Law 2017). Of the different types of solid waste (e.g., paper, metal, plastic, etc.), plastics are the primary cause of negative impact to marine organisms. For example, Thompson (2013) notes that all known species of sea turtles, about half of all species of marine mammals, and one-fifth of all species of sea birds are affected by entanglement or ingestion of plastic marine debris.

In Latin America and the Caribbean, there is growing recognition and calls for action on management of marine debris. Less than 25 percent of the 424,000 tons of waste generated daily in Latin America and the Caribbean is processed into regulated sanitary landfills (UNEP 2015). As a result, much trash is transported from terrestrial sources to the sea, negatively impacting marine life. At the border of Honduras and Guatemala, there is a persistent island of trash (Agencia AFP 2017), while in the Dominican Republic waste regularly is transported from the Ozama River to the coast (Katz 2018). In the Bay Islands of Honduras marine debris has become a persistent issue impacting marine ecosystems and tourism (Davis-Mattis, 2005). In Grenada, a burgeoning tourism industry coupled with inadequate waste management infrastructure is threatening the island's marine and terrestrial biodiversity (GiZ 2015).

Addressing the marine debris issue will require reduction in plastic use, improvement of waste management infrastructure, and a transition to more sustainable production (e.g., biodegradable plastics, plastic products with longer lives) and consumption patterns on an international level. The growing acknowledgement of marine debris as a serious issue is evident from the international regulatory measures that have been taken to address this issue. The UN Sustainable Development Agenda includes targets to prevent and reduce marine pollution, including marine debris (Löhr et al. 2017) and the Sustainable Development Goals (SDG) include SDG 6: Clean water and sanitation; SDG 11: Sustainable cities and communities; SDG 12: Responsible consumption and production; and SDG 14: Life below water, all of which marine debris. Furthermore, the 2016 UN Environment Assembly acknowledged the gravity of the marine debris issue via unanimous adoption of a stand-alone resolution on marine debris. Additionally, there are numerous partnerships to address the issue, such as the US Environmental Protection Agency's (EPA) and United Nations Environment Program (UNEP) Trash Free Waters program. Finally, the MARPOL Convention Annex V addresses marine pollution from ships (http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-(marpol).aspx).

OVERVIEW OF MARINE DEBRIS

DEFINITION OF MARINE DEBRIS

The U.S. National Oceanographic and Atmospheric Administration (NOAA) defines marine debris as any persistent solid material that is manufactured or processed and directly or indirectly, intentionally or unintentionally, disposed of or abandoned into the marine environment or the Great Lakes"[4], while the United Nations Environment Program (UNEP) defines marine debris or litter as "any persistent, manufactured, processed, or solid material discarded, disposed of, or abandoned in the marine and coastal environment."[5]

According to UNEP, marine debris has the following five characteristics: (UNEP, 2005)

- Consistency: Composed of a variety of plastics (90-95 percent), metals, and glass;
- Mobility: Ocean currents and winds transport it long distances;
- Persistency: Long-lived and dynamic;
- Effects (impacts): Threat to marine life and humans, direct and indirect; and
- Impacts: Economic losses to coastal communities, tourism, loss of biodiversity, beach and nearshore contamination.

TYPES OF MARINE DEBRIS

While plastic is the most common form of marine debris found in the world's oceans, other forms of solid waste are also abundant, such as glass, metal, wood, and paper. A 2012 Convention on Biological Diversity (CBD) report reviewed the impacts of marine debris for 663 species and found that the impact of these non-plastic items was much lower than the impacts of plastic. In their review, paper, glass, and metal accounted for less than two percent of associated impacts on the marine environment from marine debris, while plastic accounted for over 80 percent. These materials degrade or decay at a rate much faster than plastics, thus, the discrepancy may be due to the brittle and less durable nature of these materials compared to plastics. During the 2013 International Coastal Cleanup, discarded cigarette butts (made of non-biodegradable cellulose acetate – a type of plastic) were the most common type of trash collected globally. Cigarette butts contain hundreds of carcinogens and other toxins that leach into the water and are poisonous when ingested (UNEP-CEP 2014).

Relative to other materials, plastics represent 82 percent of demonstrated impacts of marine debris on the marine ecosystem, and 89 percent of impacts at the sub-organismal level (i.e., molecular, cellular, tissue) (Rochman et al. 2016). The durability and light weight of plastics increase the threat to animals as they persist much longer in the environment (Daly 2018). Estimates of the longevity of plastics range from hundreds to thousands of years, and, excluding incinerated materials, it is believed that all conventional plastic that has ever been introduced in the environment remains unmineralized as whole items or fragments (Barnes et al. 2009). Single-use plastic products are the main source of marine plastic waste, followed by waste from plastic goods with an intermediate lifespan such as electronics and vehicles (UNEP 2016). Globally, the most prevalent types of plastic found in the marine environment (based on production data) are polypropylene (24 percent), low-density polyethylene (21 percent), polyvinyl chloride (19 percent), high-density polyethylene (17 percent), thermoplastic polyester (7 percent), polystyrene (6 percent), and nylon (<3 percent) (Andrady 2011). The highest prevalence of plastic items in the marine environment are cigarette butts, rope, bottle caps, and netting followed by

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4 https://oceanservice.noaa.gov/hazards/marinedebris/

5 http://www.un.org/depts/los/consultative_process/documents/6_guchte.pdf

plastic bags, bottles, six-pack rings, straws, and netting. Even if production of plastic stopped immediately, the abundance of plastic on the Earth's surface would persist for centuries.

SIZE CLASSES OF MARINE PLASTICS

Overall, plastics are the most common item collected from the ocean surface and in beach clean-ups (Law 2017). The 2018 Ocean Conservancy Coastal Cleanup report found that in the most recent 2018 clean up, they collected 2,326,893 foam pieces, 1,933,146 plastic pieces, and 459,249 glass pieces. The top ten most collected items were plastic-based products (Ocean Conservancy 2018). Plastics degrade over time into various size classes via five general pathways: biodegradation, photodegradation, thermo-oxidative degradation, thermal degradation, and hydrolysis (Andrady 2011). The three main size classes of marine plastics are macroplastics, microplastics, and nanoplastics, described further below (Table 1).

Macroplastics are plastic debris that have not yet degraded to the size of microplastics; thus are larger than five millimeters (mm) in size (Lahens et al. 2018).

Microplastics range in size from 0.1 micrometer (μm) to five mm (ESFA 2016) and include primary microplastics (original manufacturing size) and secondary microplastics (originate from fragmentation) (ESFA 2016). Further subdivisions include fragments (hard, jagged-edged), micro-pellets (hard, rounded), films (thin, 2-dimensional, foam), and fibers (thin uniform plastic strands) (Rezania et al. 2018). The growing prevalence of microplastics from the cumulative breakdown of larger items has increased concern regarding these contaminants in recent years (Costa and Barletta 2015). In some cases, microfibers (fragments from textiles) have been identified as the most common type of marine debris found in habitats and within animal tissue (NOAA 2018).

Nanoplastics do not yet have an agreed upon size class but are invisible to the human eye. They are generated via fragmentation of macro and microplastics or may be engineered (Koelmans et al. 2015).

A methodology for detection of nanoplastics in the marine environment is still under development; at present, their effects are speculative. As a result, nanoplastics are likely the least studied area of marine litter but have the potential to be the most hazardous because of their ability to penetrate cells and move into tissues and organs, and their affinity for toxic compounds (Koelmans et al. 2015; Royte 2018). In experiments with rats, nanoplastics were found throughout the body, including the brain, indicating systemic exposure and adverse effects such as immunosuppression, immune activation, abnormal inflammatory responses, and tissue or organ damage and dysfunction (EFSA 2016). How these particles behave in the marine environment is an important area of emerging research. Table 1 provides a summary of the main size classes and descriptions of marine plastics.

TABLE 1. TYPES, SIZE CLASSES AND EXAMPLES OF MARINE PLASTICS		
TYPE	SIZE CLASS	EXAMPLES
Macroplastics	Greater than 5mm in size	• Plastic bags • Water bottles
Microplastics	Range in size from 0.1 µm to 5 millimeters (ESFA 2016).	• Microfibers from textiles released during washing • Microbeads from cosmetics and personal care products
Nanoplastics	Definition yet to be agreed upon; some suggest using the definition used for non-polymer nanomaterials—a plastic particle of less than 0.1 µm (ESFA 2016; Koelmans et al. 2015).	Nanoplastics used or formed during product lifecycles of the waterborne paints, adhesives, coating, biomedical products, magnetics, and optoelectrics

SOURCES OF MARINE DEBRIS

From manufacture of plastics through use and disposal, there are multiple pathways that plastic enters the marine environment (Figure 1). Land-based sources of marine debris include urban settlements and industry, sewage outfall, waterways transporting litter from inland to ocean, litter transported by wind from landfills near the coast, and direct beach littering (Lachmann 2017). Population size and quality of waste management systems largely determine which countries contribute the greatest mass of uncaptured waste available to become marine debris. Assuming no waste management infrastructure improvements, the cumulative quantity of plastic waste available to enter the marine environment from land is predicted to increase by an order of magnitude by 2025 (Jambeck et al. 2015).

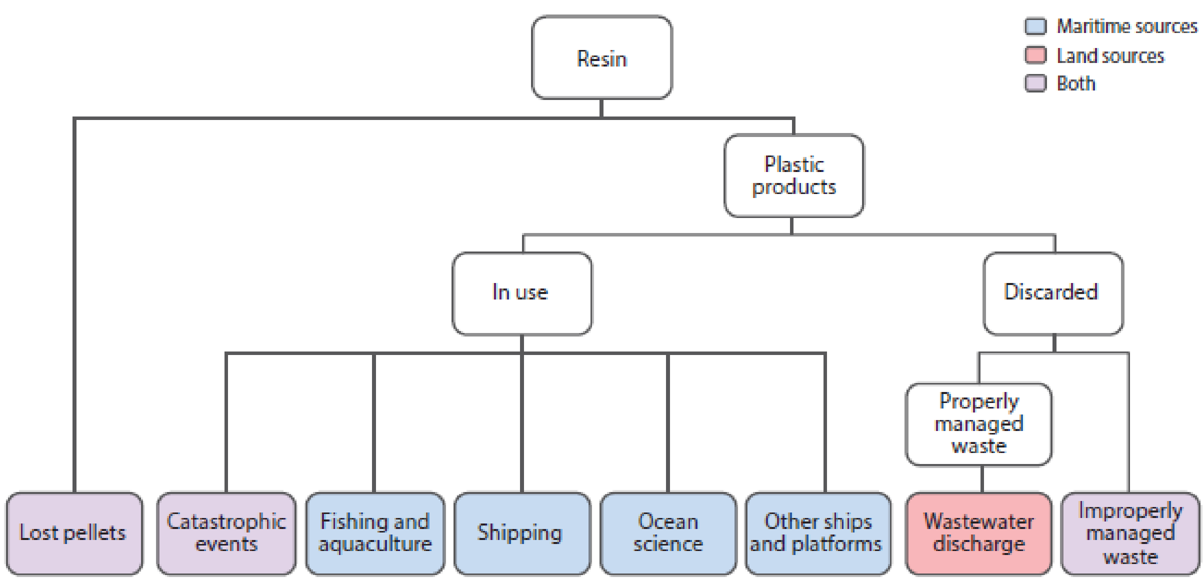

Figure 2 Sources of plastics into the marine environment from Law, 2017.

Sea-based sources of marine debris include fishing vessels/activities, container ships, cruise liners, and leisure boats (Lachmann 2017). However, the origin of some sea-based litter items is difficult to determine as items, such as plastic wrappers, bottles, and other items could be disposed of at sea or originate from the land (Corbin 2011). Regardless, one of the major sources of ocean-based marine debris is the fishing industry. While most discarded gear is lost accidentally or is abandoned due to safety concerns such as bad weather, in other cases it is deliberately discarded. This is especially true for gear used in illegal, unreported, and unregulated (IUU) fisheries. Every year, an estimated 640,000 tons of fishing gear is lost in the world's oceans (GGCI 2017). Ghost fishing gear accounts for over half of all macroplastics in the oceans today, and these remnants eventually break down into microplastics (GGCI 2017). Local experts often cited ghost fishing gear as a common problem; for example, discarded fishing nets and abandoned lobster traps are especially common off the coast of Honduras (Drysdale, pers. comm., 2018; Andino and Vasquez, pers. comm. 2018). Fishermen in Honduras are legally allowed 2,500 traps at the beginning of the season, many will lose some at sea or they try to hide them at sea so that they can fish over the limit next season.

The shipping industry, including cruise ships, also contributes to the marine debris in the world's oceans. The North Sea is one of the world's busiest shipping areas, and it has been estimated that up to 40 percent of marine debris in this region comes from the shipping industry. In Europe about 20,000 tons of waste is dumped into the North Sea by ships (Seas at Risk 2019). Globally, according to the World Shipping Council, an average of 733 shipping containers, containing a wide variety of items, including plastic, were lost at sea in the years 2011, 2012, and 2013, and 612 in 2014, 2015, and 2016, not including catastrophic events. When catastrophic events are included (a loss of 50 or more containers in a single incident), the number for 2011, 2012, and 2013 drastically increases to 2,683 and the number for 2014, 2015, and 2016 jumps to 1,390 (World Shipping Council 2017).

TRANSPORTATION OF MARINE DEBRIS

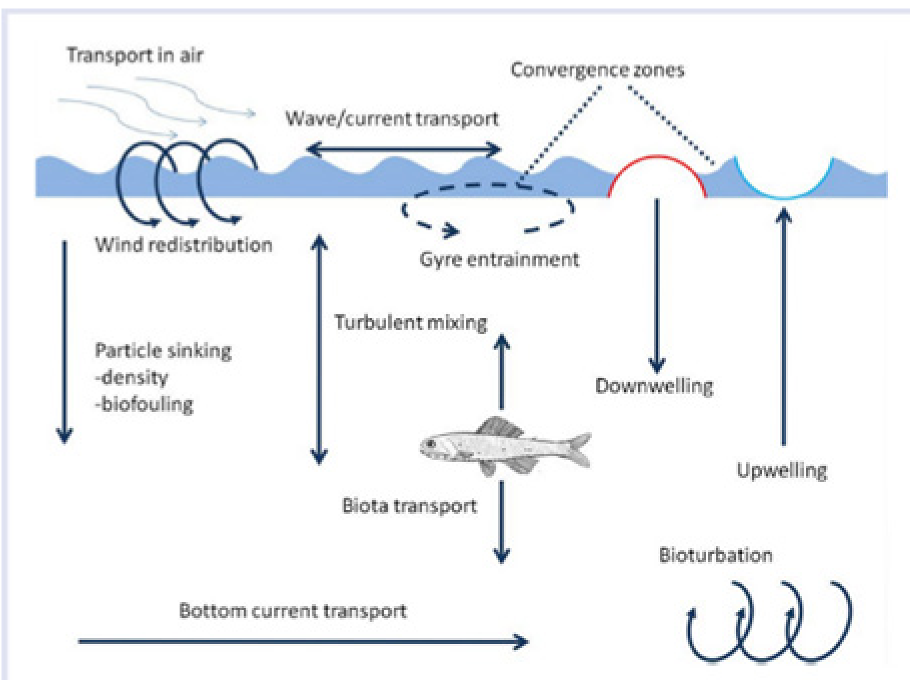

Figure 3 Factors influencing the distribution of plastics in the marine environment (Welden & Lusher 2017).

Most marine debris originates from land-based source. As such, poor waste management and plastic pollution in freshwater habitats is closely linked to the marine debris issue. Eighty-eight to 95 percent of the global load of mismanaged plastic waste is transported to the ocean by the top ten ranked river catchments (Schmidt et al. 2017; Jambeck et al. 2015). The top 122 polluting rivers contributed over 90 percent of the plastic; of the top 122, eight of those are in South and Central America (Lebreton et al. 2017).

Once marine debris reaches the ocean, primarily via rivers transporting land-based debris, oceanic currents and winds then influence the transportation and distribution of marine debris globally (see Figure 2). Marine debris often accumulates in oceanic gyres (convergence zones, see Figure 3), while debris that is not in a gyre system may be transported by currents, wind, or bottom-water transport (Welden and Lusher 2017). Marine debris is found throughout the water column, depending on the density of the debris. Some types of marine debris typically are found near the surface or suspended vertically in the upper water column, while other kinds are found on or near the seabed (NOAA 2016). Once debris reaches the ocean, one of the most recognized areas where it collects is the North Pacific Central Gyre (NPCG) between Japan and the west coast of North America. This patch, nicknamed the Great Pacific Garbage Patch, is estimated to contain one million plastic particles per square kilometer (GIZ 2015).

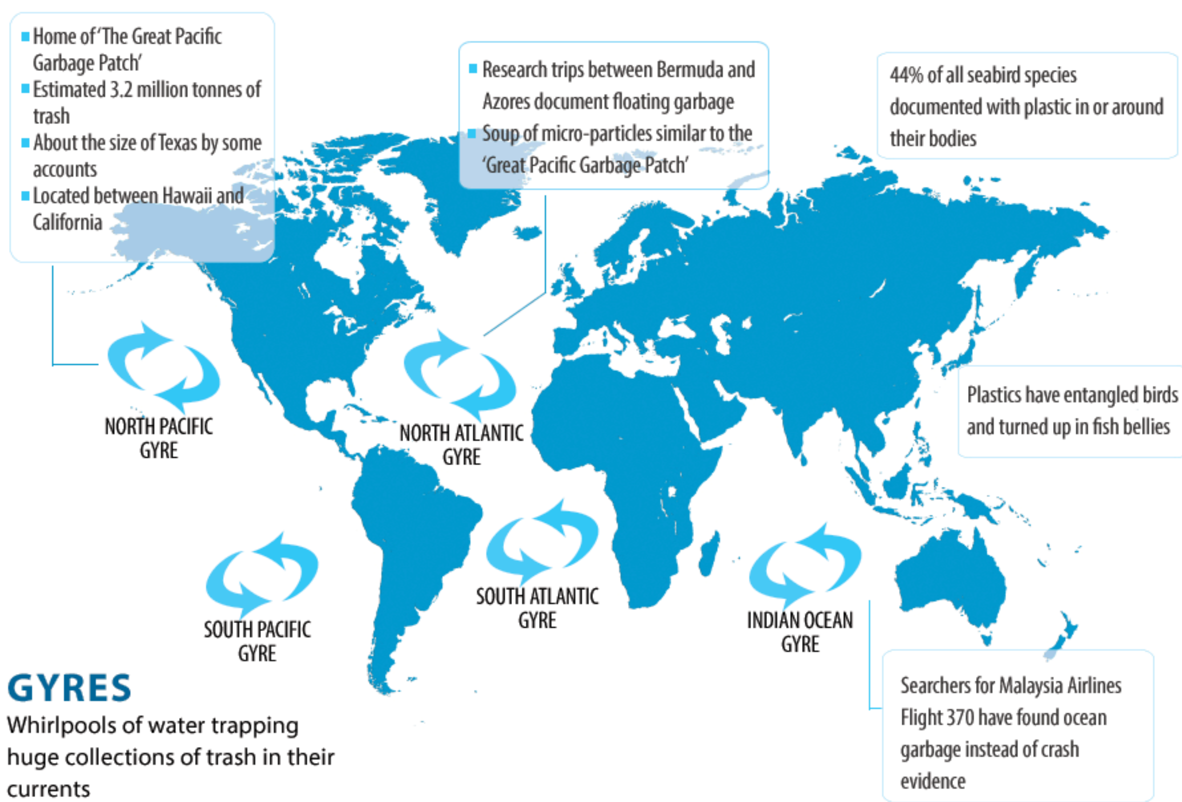

Figure 4: Location of the five major gyres; Source: https://www.cbc.ca/news2/interactives/ocean-garbage/

CLIMATE CHANGE AND MARINE DEBRIS

Climate change, coupled with increases in plastic production, is likely to exacerbate the issue of marine debris in coastal ecosystems by impacting "circulation patterns and marine debris movement, accumulation, and retention in space and time" (Howell et al. 2012). Changes are expected in both large-scale systems (sea level, rainfall, windspeed, and wave height), as well as in short-term events (floods, storms, hurricanes, and tsunamis). For example, changes in currents and upwelling patterns may cause marine debris to reach places that have previously been less impacted, while increased wave action from storms can surface and strand subtidal debris that would have otherwise not reached the shore (Browne et al. 2015). While many studies have shown that large-scale circulation patterns are important in predicting where and when debris will appear, more research is needed to understand how short-term events interact with these larger-scale processes to influence the location of marine debris (Browne et al. 2015). Further, changes in ocean density resulting from increasing freshwater inputs impact the relative buoyancy of debris, causing it to sink, while areas experiencing high evaporation rates (and increasing sea density) will see plastics persist on the water's surface, where they can be transported by the factors mentioned above (Welden and Lusher 2017). Furthermore, increased temperatures are predicted to influence the amount of precipitation associated with storms, which may result in additional run-off and more debris transported to the sea. It is therefore vital to understand both changes in global circulation and ocean dynamics resulting from climate change, as well as shorter-term climate-related events, to fully comprehend the current and future risks of increased debris in marine ecosystems.

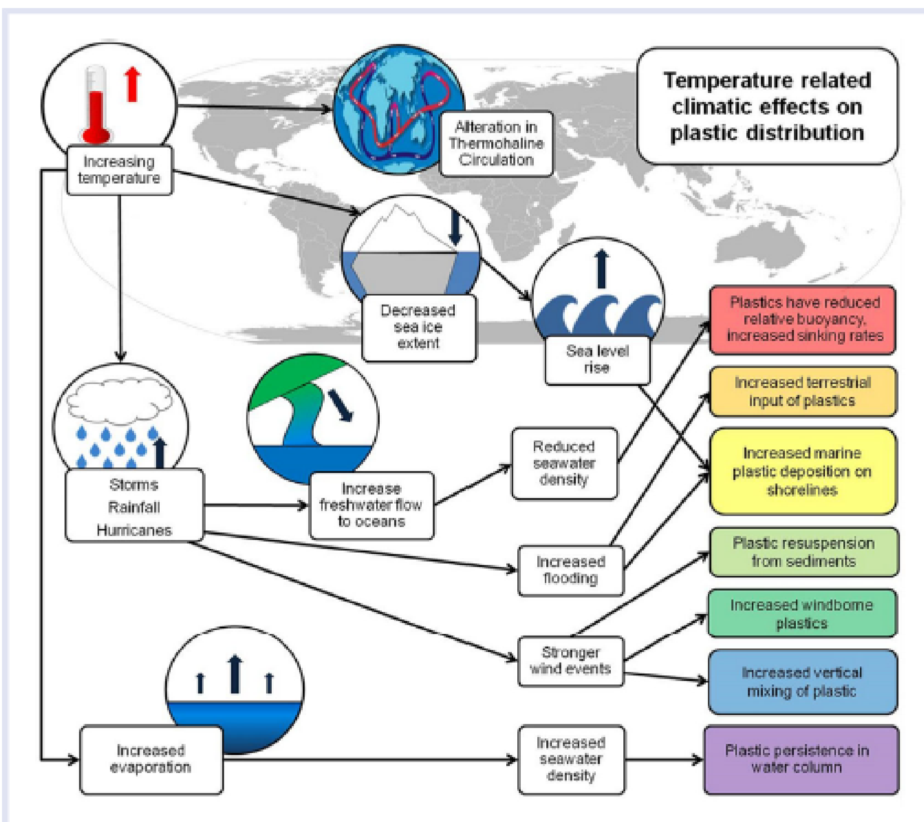

Figure 5. Predicted effects of climate change on plastic input, distribution and accumulation (Welden and Lusher, 2017)

BIODIVERSITY IN LATIN AMERICA AND THE CARIBBEAN

The following section describes the biodiversity focal points in Latin America and the Caribbean, including key ecosystems and fauna, as well as the presence of Marine Protected Areas (MPAs).

KEY POINTS

- Latin America and the Caribbean contain over 50 percent of the world's biodiversity.
- Regional biodiversity hotspots include the Caribbean Islands biodiversity hotspot, the Mesoamerica biodiversity hotspot, and in South America, the Tropical East Pacific, the Humboldt Current, and the Tropical West Atlantic.
- Key ecosystems of biodiversity importance include mangroves, seagrass and coral reefs.
- Key fauna of biodiversity importance includes marine mammals, sea turtles, fish, and birds.
- Marine Protected Areas (MPAs) are vital for protecting marine ecosystems and species. Thirty percent of coral reefs in the Caribbean are in marine protected areas.

REGIONAL BIODIVERSITY HOTSPOTS

Latin America and the Caribbean contain over 50 percent of the world's biodiversity. The region is home to some of the most species-rich biomes, including coral reefs, mangroves, and wetlands (UNEP 2016). Two of the world's 36 biodiversity hotspots, as designated by the Critical Ecosystem Partnership Fund (CEPF), are located within the Caribbean and Central America, the Caribbean Islands Biodiversity Hotspot, and the Mesoamerica Hotspot. The Caribbean Islands Biodiversity Hotspot includes 30 nations and territories and encompasses about 4 million square kilometers of ocean (CEPF 2010). The Mesoamerica hotspot covers the whole of Central America. The biodiversity of the Central American region is enhanced as it is a terrestrial bridge between two biogeographic regions, the Neoarctic of North America and the Neotropic of South and Central America and the Caribbean (CEPF 2004).

The Caribbean Island Biodiversity hotspot contains four major terrestrial forest types. These include tropical/subtropical moist broadleaf forests, tropical/subtropical dry broadleaf forests, tropical/subtropical coniferous forest, and shrublands and xeric shrub. The region also supports important freshwater habitats, such as rivers, streams, lakes, and underground karst networks (CEPF 2010). The Mesoamerica hotspot contains about 24,000 species of vascular plants of which 21 percent are endemic. It is the hotspot with the highest reptile species diversity and has the second highest biodiversity of amphibians, birds, mammals, and non-fish vertebrates (CEPF 2004).

Although the biodiversity hotspots designated by CEPF focus more on terrestrial biodiversity, these regions also contain critical marine ecosystems. The region contains about 10,000 square kilometers of coral reefs, 22,000 square kilometers of mangroves, and up to 33,000 square kilometers of seagrass beds (CEPF 2010). It is home to 10 percent of the world's total coral reefs and 13,000 plant species (USAID n.d). These ecosystems provide wintering and nursery grounds for many migratory species, including the North Atlantic humpback whale (CEPF 2010). The Caribbean Island hotspot is an important area for marine biodiversity as 8 to 35 percent of the species within the global marine taxa are endemic to this region. The marine region is home to 25 coral genera, 117 sponges, 633 mollusks, over 1,400 fish, 76 sharks, 45 shrimps, 30 cetaceans, and 23 species of seabirds (CEPF 2010). Overall, there are over 12,000 documented marine species (Table 1); these include organisms from 31 animal phyla, two plant phyla, one group of Chromista, and three groups of Protoctista (Miloslavich et al. 2010). Data documenting species richness have been concentrated in shallow, nearshore waters while offshore and deep environments have been less studied. Per a review by Miloslavich et al. (2010), coastal species richness in the Caribbean is concentrated along the Antillean arc (Cuba to the southernmost Antilles) and the northern coast of South America (Venezuela – Colombia). No pattern can be observed in the deep sea with the available data, possibly because of limited sampling in the deep sea.

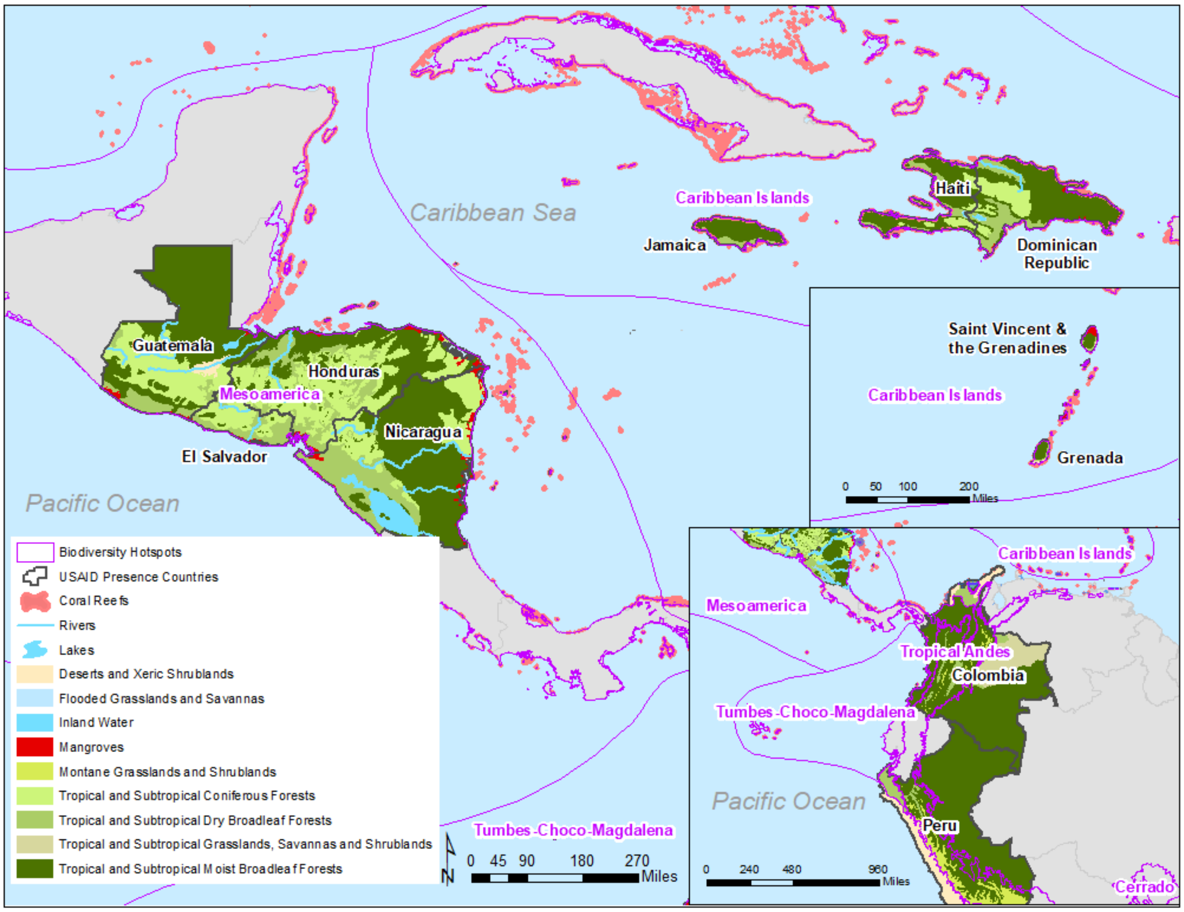

Figure 6. Map of Biodiversity hotspots (Data source: Biodiversity Hot Spots: "Biodiversity Hotspots Revisited, Conservation International" (2011) from Data Basin)

Unfortunately, these ecosystems are under threat. This region has among the highest numbers of globally threatened species in the world (CEPF 2010). Within the Caribbean itself, over 75 percent of coral reefs are categorized as degraded or threatened (USAID, n.d.); in some areas coral reef coverage has declined from more than 50 percent live cover to less than 10 percent cover in three decades (1970 – 2001) (Gardner et al. 2003). Mangroves in the Caribbean have decreased at a rate of 1 percent per year since 1980, resulting in a net loss of 430,000 ha (Miloslavich et al. 2010).

In addition to the Caribbean region, South America is home to various other high biodiversity sub-regions, including the Tropical East Pacific, encompassing Costa Rica, Panama, Colombia and Ecuador, the Tropical West Atlantic, encompassing Guyana, French Guiana, Suriname, and Venezuela, and the Humboldt Current along the western coast of Peru and Chile.

The Tropical East Pacific region also includes several islands and archipelagos, such as the Galapagos and islands off the coast of Peru. The Pacific coasts of Panama, Colombia, and northern Ecuador are characterized by mangroves and dense rainforest. This region has a high rate of endemism; of the 1,300 species of fish recorded in the region, 71 percent are endemic. However, this area is not as widely studied as other regions in Latin America, particularly the Colombian and Ecuadorian coastal waters (Miloslavich et al. 2011).

The Humboldt Current region is a globally significant area for biodiversity and contains some of the world's most productive fisheries. The area is characterized by nutrient rich water which allows it to provide 6 percent of the global fish catch (GEF 2017). The main species of fish found in this region are mostly sardines, anchovies, jack mackerel, and hake. Tuna, sword fish, shark, and giant squid can also be found in this region between Chile and Peru. About 0.11 percent of the Humboldt Current region is protected and it contains 24 major estuaries (Heileman et al. 2009).

BIODIVERSITY IMPORTANCE OF KEY ECOSYSTEMS AND FAUNA

ECOSYSTEMS

MANGROVES

Mangroves are one of the most carbon-rich of all tropical forest biomes; they protect shorelines and provide shelter and food resources for estuarine and coastal fishery food chains. They also safeguard marine trophic ecosystems by acting as a filter for hazardous agricultural effluent as well as urban pollution (Bulow and Ferdinand 2013). Mangroves are habitat for over 2,000 species of fish, shellfish, invertebrates, and plants, and they serve as breeding grounds for fish, shrimp, prawns, crabs, shellfish, and snails (OECS 2009). They are found in 123 countries worldwide but are relatively rare as they only cover an area of about 152,000 square kilometers, which is less than one percent of all tropical forests (UNEP 2017). Mangroves are known for their functional adaptations for coping with saline, oxygen deprived soils, and regular tidal inundations (UNEP 2017). Mangroves develop in a wide range of sedimentary environments, from alluvial habitats with abundant mineral input to oceanic islands with little or no allochthonous contributions to sediment (McKee et al. 2007). As the link between marine and fresh water ecosystems, mangrove ecosystems are so specialized that any minor variation in their hydrological or tidal regimes causes notable mortality. They are currently disappearing at a rate faster than both coral reefs and tropical rainforests (Kawelakar 2015).

As of 2000, there were about 20 million people living within 10 kilometers of significant mangrove areas in Central and South America (UNEP, 2014). These communities rely on the various ecosystem services provided by the mangroves near them. The mangrove ecosystem provides communities with timber and non-timber products such as wood for construction, fuel, medicine, and honey, among many others (OECS, 2009). Mangroves also support fisheries, both subsistence and commercial, and there are established links between healthy mangrove ecosystems and high fish yields (OECS 2009). About 75 percent of commercial fish species spend part of their lifecycle in mangroves (UNEP 2017). In fact, the ecosystem services provided by mangroves are estimated to be worth 33-57 thousand USD per hectare per year to the national economies of developing countries where mangroves are found (UNEP 2017).

The mangrove wetlands located in the Caribbean and along the Pacific coast of Central America are some of the world's most biodiverse ecosystems. Mangroves are vitally important in the Caribbean region and ring the fragile island ecosystems that support many endemic species (UNEP-CEP 2014). Approximately 11,560 square kilometers of mangroves remain in the Caribbean (Miloslavich et al. 2010). Caribbean mangroves host the world's richest mangrove-associated invertebrate fauna and provide habitat for multiple globally-endangered animal species (OECS 2009). The 3,900 km Pacific coast of Central America transcends climatic zones and different environments and is fringed by over 340,000 ha of mangrove forests. Pacific coast mangroves demonstrate higher diversity than the Caribbean mangroves as climatic and hydrological variations shape the floristic composition, structure, and dynamic processes distinguishing them from their Caribbean counterparts (Jimenez 1992). Latin American and Caribbean mangroves are highly threatened ecosystems. Because of the wealth of biodiversity in Latin American mangroves, this is particularly concerning for the region's biodiversity. As an example, Panamanian mangroves are vitally important for the country's biodiversity, and one to two million birds from over 30 bird species depend on mangroves in Panama Bay for their migration (Bulow and Ferdinand 2013). Between 1980 and 1990, Panama lost 75 percent of its mangrove forests. This destruction could result in significant habitat loss and stress for millions of birds and other fauna in Panama (ibid).

SEAGRASS

Seagrass beds are another critically important marine ecosystem that exists in tropical regions globally. These large areas of underwater marine flowering plants are typically found in shallow waters or on continental shelves, and often are found landward of coral reefs (OECS 2009). There are 72 different species of seagrass and they are divided into four main families: Zosteraceae, Hydrocharitaceae, Posidoniaceae, and Cymodoceaceae (Smithsonian 2018). The main species within the Caribbean are turtle grass, manatee grass, and shoal grass (OECS 2009). They are believed to be the third most valuable ecosystem in the world, with one hectare of seagrass estimated to be worth over 19,000 USD per year. Seagrasses provide a variety of ecosystem services. They are known as the lungs of the sea, as one square meter of seagrass can generate 10 liters of oxygen per day. They also provide important functions such as absorption of nutrients, filtration of sediment, such as runoff from land, slow the flow of water, and capture sand, dirt, and silt particles, all of which improve water quality. Their roots stabilize the sediment, which helps to improve water clarity and quality, and reduce erosion and protect coastlines against storms (Smithsonian 2018). In a similar manner as mangroves, seagrasses play an important role as a carbon sink. It estimated that the world's seagrass meadows can capture up to 83 million metric tons of carbon per year. Seagrasses only occupy about 0.1 percent of the total ocean floor; however, it is estimated that they are responsible for up to 11 percent of the organic carbon stored in the ocean (Smithsonian 2018). Additionally, seagrass beds provide important habitats for a variety of species, including green turtles, fish, crabs, sea urchins, and conch. They also provide protection for nursery species such as the blue-striped grunt, red-tail parrotfish, and the great barracuda (OECS 2009).

CORAL REEFS

Tropical coral reefs are present in limited areas of the marine environment but are home to over a quarter of all known marine fish species and thousands of other species. Coral reefs are critically important habitat, breeding grounds, and substrate for a wide range of species. Representative species found dwelling in coral reefs include longspine sea urchins, sea fans, moray eels, crustaceans, conch, and other mollusks. Fish also depend on coral reefs for shelter, food, and reproduction (NOAA 2018). Filter-feeding sponges, bivalve mollusks, crustaceans, worms, and echinoderms live on the reef and filter surrounding water, while the reef structure itself protects coastlines from storms by absorbing their impact (NOAA 2018). This prevents coastal erosion, flooding, and damage to properties on shore.

Most reefs are fringe reefs found along the coastline of nearby landmasses. Corals are present in all oceans, however they form reef structures only in tropical latitudes utilizing symbiotic algae, called zooxanthellae, to build the coral skeleton. The zooxanthellae photosynthesize and provide nutrients to the coral, which, in turn, facilitates deposition of the carbonate skeleton. Reefs are comprised of many layers of carbonate skeleton, which forms the reef-building corals common in the Caribbean. While reefs cover less than one percent of the earth's surface, the estimated value ecosystem services provided by coral reefs is $30 billion per year on the lower end and up to $172 billion per year on the higher end of the estimate (Smithsonian 2018). They are one of the world's most productive and biodiverse ecosystems and provide critical ecosystem services, such as (OECS 2009):

- Habitat for other organisms in reef caves and crevices
- Nursery grounds for fish species
- Water filtration
- Coastal protection
- Medicinal products
- Recreation
- Fisheries

Of the world's coral reefs, about 7.64 percent (26,000 square kilometers) are in the Caribbean (Burke and Maidens 2004) (Map 3). The Caribbean has the highest coral reef diversity in the Atlantic Ocean (OECS 2009). In the Caribbean, some of the common fish species found in reefs include rainbow parrotfish, angelfish, yellowtail damselfish, lizardfish, clown fish, trumpetfish, butterfly fish, triggerfish, wrasses, parrotfishes, basses, and groupers. The soft coral polyps are an important source of food for many other aquatic species. In the Caribbean, the annual value of coral reefs is estimated to be between $3.1 to $4.6 billion dollars (Burke and Maidens 2004). Coral reefs are also an important source of income and sustenance for the communities of the Caribbean as they serve as nurseries for about 25 percent of the region's fish (OECS 2009).

The Mesoamerican Reef is the largest barrier reef in the Western Hemisphere. It extends over 1,000 km from the northern tip of the Yucatan Peninsula in Mexico down through the Bay Islands of Honduras. The Mesoamerican Reef provides shelter and food for hundreds of fish species, marine turtles, and sharks (WWF 2019).

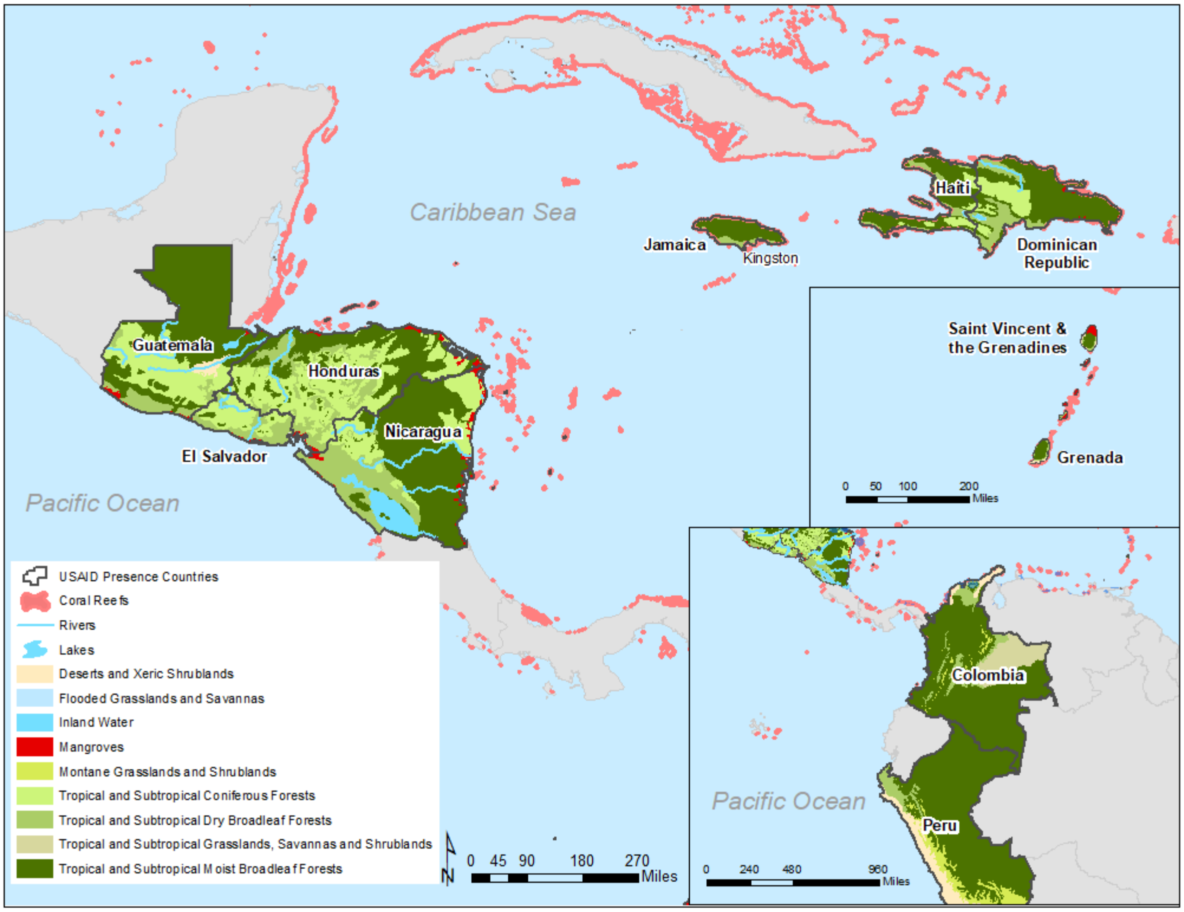

Figure 7. Map of regional presence of coral reefs

FAUNA

MARINE MAMMALS

Marine mammals play critical roles in marine ecosystems and provide services to humans in terms of products, meat for consumption, and tourism benefits. Some species (such as sea otters, dugongs and walruses) can structure their habitats through their diets. For example, when sea otters suppress sea urchin populations, kelp beds thrive. Other high-order predators manage to regulate prey populations with cascading effects, while sperm and blue whales can transport nutrients from the deep ocean to surface-level feeding areas (Smith 2016). In the Caribbean, at least 34 species of marine mammals have been historically documented, including six species of baleen whales, 24 species of toothed whales, the West Indian manatee, and three pinnipeds (Caribbean monk seal – now extinct, hooded seal, and California sea lion). These species use the Caribbean waters as critical habitats for feeding, mating and calving (CEP n.d.). Several of these species are considered endangered by the IUCN (2018), including the Blue Whale, North Atlantic Right Whale, Fin Whale, and Sei Whale, with the Humpback Whale listed as vulnerable. (IUCN 2018). In the coastal Pacific currents of Central America, there are resident populations, such as humpback whales, pantropical spotted dolphins, Guiana dolphins, bottlenose dolphins, and Caribbean manatees. These coastal resident species are vulnerable to gillnets, uncontrolled tourism, habitat loss, and direct hunting (May-Collado 2009). In coastal Pacific South America, the most common marine mammals are two otariids (South American sea lion and South American fur seal) and two small cetaceans (dusky dolphin and Burmeisters porpoise), as well as the South American marine otter and pygmy beaked whale off the coast of Peru (What-When-How, n.d.). While detailed status on many of these marine mammal species is scarce, threats to their populations include illegal hunting, by-catch, habitat destruction and pollution (Hucke-Gaete 2002).

SEA TURTLES

Sea turtles play an important role in marine and coastal ecosystems. Through constant grazing on seagrass (and marine sponges for hawksbill turtles), they maintain healthy habitats for other species, while their shells also provide a habitat to epibionts (small marine organisms). Further, by laying eggs on sandy shores, they help supply nutrients to dunes through contact with unhatched eggs. Sea turtles also support healthy food webs; leatherbacks, loggerheads and green sea turtles support a balanced food web as a top jellyfish predator while fish and shrimp can feast on barnacles and algae carried around on sea turtle shells. Finally, loggerhead turtles support nutrient cycling on ocean floors through foraging (Wilson et al., n.d.). Five out of a total of seven sea turtle species live in the Caribbean and Latin America: the green turtle (endangered), the hawksbill turtle (critically endangered), the loggerhead turtle (vulnerable), the Olive Ridley turtle (vulnerable), and the leatherback turtle (vulnerable) (IUCN). Over time, what began as subsistence-level exploitation of sea turtles for food and traditional uses has turned more severe through human-based threats such as bycatch from fisheries, loss of habitat to development and resource extraction, poaching, boat strikes, and other stresses such as pollution, and climate change. Centuries of human pressure along South America's Caribbean coastline have reduced sea turtle nesting colonies significantly. While the Gulf of Uraba in Colombia still has one of the largest leatherback colonies in the wider Caribbean, loggerhead and hawksbill turtles are now only rarely seen. On the Pacific coast of South America, Olive Ridley and green turtles are common (with generally healthy populations), while leatherbacks, loggerheads, and hawksbill are rarer – the Eastern Pacific leatherback, Eastern Pacific hawksbill, and North Pacific loggerhead are some of the most threatened sea turtle subpopulations in the world.

FISH POPULATIONS

Fish are vital both for marine ecosystems and as a livelihood source for people all over the planet. Fish are supported by coastal ecosystems, such as mangroves, seagrasses, and coral reefs, which play a crucial role in the production and maintenance of fisheries (Posner et al. 2010). Coral reefs provide habitat to one third of all marine fish species and thousands of other organisms (NOAA 2016); while mangroves serve as nursery habitats for many fish species and other wildlife and their presence increases fish populations on nearby reefs. Declines in local fish yields occur when mangrove forests are degraded or removed—480 kilograms of fish annually for every hectare of mangroves removed. Caribbean fisheries are an important contributor to GDP and employ approximately 182,000 people, mostly socioeconomically disadvantaged and least educated rural poor and women (UNEP 2016). From 1980 to 1990, there was a ten percent decline in mangrove area within the Caribbean that paralleled a ten percent decline in total marine fish catch in the same period (OECS 2009). In the greater Latin America and Caribbean region, aquaculture provides employment for more than 200,000 people directly and 500,000 indirectly. Additionally, more than 100,000 families in the region practice limited resource aquaculture. The region accounted for three percent of total global fish production; Chile, Brazil, Ecuador, and Mexico account for more than 80 percent of the regional production (FAO 2019).

BIRDS

Seabirds (any birds that forage at sea) provide many important ecosystem services. They guide fisherman, serve as a tourist attraction, and contribute to nutrient cycling in marine ecosystems. Birds (generally) and seabirds, are reliable proxy indicators of healthy and productive habitats (Caribbean Seabird Working Group n.d.). In Peru, more than 90 species of seabirds have been identified, attracted to the nutrient-rich coastal waters resulting from the Humboldt Current meeting a strong coastal upwelling (Austermuhle 2015). Several species are under threat, such as the Galapagos petrel (critically endangered), waved albatross (critically endangered), Humboldt penguin (vulnerable) and the Peruvian diving petrel (endangered) (IUCN Red List). On Malpelo Island off the coast of Colombia, rocky outcroppings provide breeding and nesting grounds for numerous seabirds. This includes the masked booby, which has the second largest colony in the world on the island, the swallow-tailed gull, red-billed tropicbird, red-footed booby, black noddy, brown noddy, white tern, and frigatebirds (Schipper n.d.). The Caribbean is home to more than 185 species of water birds, which includes seabirds, wading birds, marshbirds, waterfowl and shorebirds (Birds Caribbean n.d.). However, tropical seabird populations are in serious decline in the Caribbean. Most populations consist of only several thousand pairs and some species are close to extinction (Birds Caribbean n.d.).

PRESENCE OF MPAS

The World Wildlife Fund (WWF) defines Marine Protected Areas (MPAs) as "areas designated and effectively managed to protect marine ecosystems, processes, habitats, and species, which can contribute to the restoration and replenishment of resources for social, economic, and cultural enrichment" (WWF 2015). From a policy standpoint, the Convention on Biological Diversity (CBD) Aichi Target 11, which was adopted in 2010, requires that at least 10 percent of coastal and marine areas are conserved by 2020 through protected areas and area-based conservation measures. Despite this goal, it is estimated that only about 3.4 percent of the ocean is designated for protection in areas such as marine parks and reserves and often even those areas are poorly managed. The IUCN World Parks Congress 2014 Promise of Sydney, which is supported by over 6,000 participants from 170 countries, recommended that at least 30 percent of the ocean is protected from extractive activities by increasing the ocean area that is managed in systems of MPAs or other conservation measures by 2030. When managed properly, MPAs provide ecosystem services such as coastal protection, species survival and reproduction, fisheries, carbon storage of coastal vegetation, jobs and commerce, and cultural value of the protected ecosystem (WWF 2015).

The marine protected areas in the Atlantic region, which includes the Caribbean basin and the Atlantic coast of South America, cover approximately 30 percent of the region's reefs (WRI 2011). The Caribbean Marine Protected Area Management (CaMPAM) Network and Forum maintains a regional MPA database. CaMPAM was created in 1997 under the framework of the UN Environment Program's Caribbean Environment Programme (UNEP-CEP) and its Specially Protected Area and Wildlife (SPAW) Protocol of the Cartagena Convention. The network is a partnership between managers, educators, non-governmental organizations (NGOs), governmental organizations (GOs), and other users of MPAs in the Gulf of Mexico and Caribbean. CaMPAM aims to build the capacity of MPAs and to ensure their success. Some of their activities include training, internet distribution list, annual scientific and management technical sessions at the Gulf and Caribbean Fisheries Institute (GCFI), a Small Grants Program, and the regional MPA database (CaMPAM 2010).

Outside of the Caribbean, there are 33 MPAs in the Tropical East Pacific region, six in Costa Rica, 19 in Panama, five in Colombia, and nine in Ecuador. In the Humboldt Current region, there are 36 protected areas that only cover about 1.4 percent of the region. In Chile, there are 22 protected areas covering over 30,000 square kilometers. In Peru, there are 14 MPAs covering over 3,000 square kilometers. There are very few MPAs in the Tropical West Atlantic region. There are two protected areas in Venezuela, the Turuepano National Park and the Orinoco Delta National Park. There are seven MPAs in Suriname, and only one in French Guiana (Miloslavich et al. 2011).

A comprehensive list of the MPAs in the target region as determined by the CaMPAM database, as well as details on their status is included in Annex B.

MARINE DEBRIS IN LATIN AMERICA AND THE CARIBBEAN

This section corresponds to research question #1: What is the extent to which marine debris affects areas of high biodiversity?

As described in Section 2, Latin America and the Caribbean, the geographies of focus in this paper, encompass areas of high biodiversity. However, Latin American and Caribbean nations also produce 424,000 tons of waste daily, and less than 25 percent is processed into regulated sanitary landfills (UNEP 2005). While the prevalence and impacts of marine debris are widely recognized, its effects have historically been understudied in the region (Bravo et al. 2009). This section will provide an overview of the marine debris issue in Latin America and the Caribbean, focusing on the sources, transportation, and dynamics of marine debris in this region.

KEY POINTS

- The rivers transporting the most marine debris in the region are the Amazon and Magdalena.
- In the southeast Pacific, debris is transported by strong currents into gyres, such as the southeastern Pacific gyre, where marine debris accumulates.
- In the Caribbean, the Caribbean current and Antilles Current are mainly responsible for the transportation of debris.
- Waste management is particularly challenging in Small Island Developing States (SIDS) in the Caribbean, who import most products but do not have the capacity to manage the resulting waste.

SOURCES AND TRANSPORTATION OF MARINE DEBRIS IN LATIN AMERICA AND THE CARIBBEAN

Globally, rivers transport most land-based marine debris to the ocean. The Amazon and the Magdalena River of Colombia are both listed among the top 20 contributors of plastic waste transported to the ocean. Using a global river plastic inputs model, the upper mass input estimate for the Amazon is 63,800 tons per year, and the Magdalena contributes and upper limit of 29,500 tons per year (Lebreton 2017). In addition to the contribution of these larger rivers, such as the Amazon and the Magdalena, smaller rivers act as major regional contributors. The Motagua river that runs through Guatemala and Honduras is a major contributor to the debris found in neighboring Honduras (UN Environment 2018; Finska et al. 2018). Debris into the Motagua River, which runs between Guatemala and Honduras, and accumulates on the Honduran coastline, costs about to $6,000 USD annually to manage (Andino and Vasquez, pers. comm. 2018). Accumulation of plastics in the ocean around the Bay Islands in Honduras was noted as a pressing issue and lack of management in the islands and mainland was cited as the primary cause (Drysdale, pers. comm. 2018). Along the Caribbean coast, the San Juan river that runs through Costa Rica and Nicaragua is another such contributor. This river, like the Motagua, contributes over 1,000 tons of plastic into the ocean per year (Finska et al. 2018). The principal contributors to marine debris are major rivers with higher volume and flow in Central and South America that drain into the Atlantic and Caribbean.

Marine debris in the southeastern Pacific gyre, off the Pacific coast of South America, is primarily from land-based sources and density of debris decreases further from shore as the strong currents transport debris to the open ocean (Thiel et al. 2018). Along the coast of Chile and Peru, marine debris originates from adjacent land via river transport, beach visitors, and marine activities, including aquaculture and fisheries (Thiel et al. 2018). On beaches, where marine debris collects on a regular basis, accumulation rates depend upon the rate of decay, burial-exhumation rates, coastal dynamics, and source intensity (Santos et al. 2007). In the southeast Pacific, there are strong currents that quickly transport plastics from coastal areas to oceanic gyres; studies indicate a higher density of microplastics along the coast and decreases with distance from shore.

HENDERSON ISLAND: A DIRE WARNING

Henderson Island is a remote, uninhabited island in the South Pacific 5,000 km away from major terrestrially based industrial facilities or human habitations. On this isolated island, the density of debris is the highest reported anywhere in the world: 671.6 items/m2 on the surface and an estimated total of 37.7 million items weighing a collective 17.6 tons (Lavers and Bond 2017). The island is located on the western side of the South Pacific Gyre which accumulates debris. Given the island's isolation, the marine debris has not been subject to clean-up or other reduction strategies and, therefore, is a proxy representing the long-term accumulation of debris in the oceans. Henderson Island demonstrates the ubiquity of marine debris and the potential for large-scale impacts if the issue is not addressed in a comprehensive manner.

Based on historical data from International Coastal Cleanup (ICC), the predominant source of marine litter in the Caribbean region (89.1 percent) can be attributed to land-based sources (UNEP-CAR 2008). Interviews with local experts noted that in the Caribbean almost all, consumable goods are imported to the region and contributing to the plastic waste problem. The plastic waste from imported consumable goods, coupled with the waste imported by the tourism industry, means that the average consumer on these Caribbean islands has very little control on their waste production. Additionally, once the waste is imported or brought to the island, the lack of a strong waste management system means that the waste is poorly disposed, sometimes even buried or burned openly on beaches (Andino and Vasquez, Cristoph, Ambrose, and Edwards, pers. comm. 2018). About 11 percent of marine debris in the Caribbean comes from lost or abandoned fishing gear (Corbin 2011). In the Wider Caribbean Region (WCR), the main distribution pathway for marine debris is believed to be ocean currents and winds, with seasonal fluctuations in debris abundance due to stronger onshore winds in the dry season, which result in greater coastal accumulation. The two main ocean currents in the region are the Caribbean Current, which flows through the Caribbean along the coast of South America, originating from the flow of the South Equatorial current off the coast of Brazil, and the Antilles Current, which flows northward and is sourced from the dominant Atlantic North Equatorial current systems (Schmuck et al. 2017). The rate at which plastic degrades accelerates with warmer water temperatures of 30^{o}C and above. This creates a strong possibility for microplastic "hot spots" in equatorial seas such as the WCR (UNEP-CEP 2014).

MARINE DEBRIS DYNAMICS IN LATIN AMERICA AND THE CARIBBEAN

Marine debris issues are widely affecting Latin America and the Caribbean; the most visible evidence is from accounts of trash filled beaches (e.g., Dominican Republic) and islands of trash floating in the ocean (e.g., Roatan). While there is limited information available as to the extent of marine debris issues for the Pacific coastal areas of Latin America, in 2017, Marine Institute of Peru (IMARPE) reported 473 microplastic fragments per square meter on a beach in Callao, located near Lima, Peru (Keck 2018). The presence of marine debris, mostly plastics, has long been documented in the Humboldt current region near Chile (Ivar do Sul and Costa 2007). Marine debris is a significant stressor in the Pacific coast of Central and South America, as well as in the Pacific Ocean islands as Pacific coast of this area is highly populated but does not boast well-developed waste management systems (Barraza and Ivar do Sul, pers. comm. 2018).

In contrast, there are more reports of marine debris along the Caribbean coast of Central America, as well as the Caribbean itself. Off the Caribbean coast of Honduras and Guatemala, there is a "sea of trash" that contains dead animals, hospital waste, rope, cans, glass, plastic, and other forms of solid waste (Meléndez, 2017). This problem is caused in large part due to improper waste management in the two countries. In 30 Guatemalan municipalities along the Motagua River, waste is indiscriminately disposed of in the river and is then inadvertently pushed to beaches during the rainy season where it will eventually enter the sea (El Comercio, Agencia AFP 2017). Other possible sources of this waste are the Chamelecon River, characterized as having high pollution levels from Honduran cities, Puerto Cortes and San Pedro Sula, by Guatemalan authorities (Samuels and Galdemes 2017).

Caribbean nations face unique challenges regarding solid waste management: small land mass (with proportionally more coast), poorly developed waste management infrastructure, vulnerability to extreme weather events, and most populations being located within ten km of the coastline (Schmuck et al. 2017). Tourism has contributed to relatively high levels of economic growth in Caribbean nations resulting in generation of large amounts of waste, which can enter the ocean if the local waste management infrastructure is overwhelmed. As many Caribbean economies are heavily dependent on beach tourism, this is a looming problem for these nations. Maintaining an effective waste management system can be economically challenging for Caribbean nations. For example, Grenada claims a waste collection rate above 98 percent, but the cost of this system is greater than the income that waste collection fees generate (GIZ 2015). As noted previously, solid waste collection coverage in major Caribbean cities varies greatly – generally covering from 60 percent to over 90 percent of the population, with much lower coverage in Haiti.

Small island developing states (SIDS) in the Caribbean with high levels of biodiversity are more vulnerable to environmental changes, including from marine debris, than other countries (Lachmann et al. 2017). Marine litter management is a particularly difficult challenge that requires the engagement of a broad range of sectors and stakeholders in SIDS. This is compounded by the fact that local communities, as often occurs elsewhere, do not always fully appreciate the connection between personal behavior and generation of marine debris. However, the amount of marine debris that island nations generate is also significant (Corbin et al. 2011). Because of the semi-closed nature of the Caribbean Basin, there is the possibility that high levels of plastics will continually circulate throughout the basin (Herrera 2018).

In response to research objective 1, marine debris is present and a growing problem in Latin America and the Caribbean, which include some of the most biodiverse regions in the world. While still a growing area of research, numerous studies (see Reference list) have already identified links between the presence of marine debris and impacts to biodiversity. These links and impacts are explained further in Section 5.

EVIDENCE OF SIGNIFICANT MARINE DEBRIS IMPACTS ON COASTAL AND MARINE BIODIVERSITY

This section corresponds to research question #2: What is the evidence that marine debris has significant impacts (e.g., direct, indirect or cumulative) on coastal and marine biodiversity?

This section first summarizes the main drivers of marine debris in Latin America and the Caribbean before describing the stressor pathways by which marine debris interacts with key ecosystems and fauna. Finally, it provides evidence of marine debris stressors on key ecosystems (mangroves, seagrass, coral reefs) and fauna types (marine mammals, sea turtles, fish and birds) in the region.

KEY POINTS

- The main drivers (or influences factors) contributing to the direct threats associated with marine debris are (1) population growth, urbanization and increasing tourism; (2) increasing demand for and production of plastic products; (3) climate change; and (4) poor governance, including weak land use planning, regulation and enforcement; poor municipal waste management; and poor fisheries and aquaculture management.
- The main stressor pathways by which marine debris impacts ecosystems are contamination, persistent bioaccumulative and toxic substances, and dispersal and transport of invasive species. For example, in beach ecosystems, plastic accumulation can deter birds, turtles, and other species that are uniquely adapted to nesting, breeding, and living on sandy shores.
- The main stressor pathways by which marine debris impacts fauna are ingestion and entanglement. For example, sea turtles can become entangled in debris, leading to difficulties in feeding, diving, surfacing to breathe, and other essential behaviors.

MARINE DEBRIS DRIVERS

As defined earlier, a "driver" is a "constraint, opportunity of other important variable that positively or negatively influences direct threats." The following drivers provide enabling conditions for the threats associated to production of marine debris, which in turn, stresses marine fauna, flora, and ecosystems via various pathways described in the next sub-section.

POPULATION GROWTH, URBANIZATION AND INCREASING TOURISM.

As population growth and urbanization strain municipal waste management, particularly in coastal areas, many cities in the Caribbean and Latin America are also experiencing increases in tourism, which often revolves around viewing the region's magnificent biodiversity. In turn, this means that areas with high biodiversity overlap with high levels of human traffic, and therefore consumption and waste disposal. Jambeck et al. (2015) have directly linked countries with high populations and poor waste management infrastructure to higher levels of uncaptured waste, which often ends up as marine debris.

INCREASING DEMAND FOR AND PRODUCTION OF PLASTIC PRODUCTS.

As discussed in Section 2, global demand and production of plastic continues to increase, with little to no flattening of demand predicted in the near-term. The growing production and demand for single-use plastics is a significant driver behind the growing impacts of marine debris to biodiversity and marine ecosystems globally. If current trends continue, by 2050, there will be about 12 billion tons of plastic litter in landfills and the environment (UNEP 2018) further exacerbating the threat of debris in the marine environment.

INCREASING GHG EMISSIONS.

As mentioned above in Section 2, increasing GHG emissions lead to climate change, which will impact currents, upwelling patterns, wave action, and ocean density, all of which can affect the movement and circulation of marine debris. Land-based changes in precipitation patterns can also cause increased run-off, increasing the amount of marine debris transported to sea. The increased likelihood of severe storms could also create additional debris (land-based or marine-based) that ends up in the sea. For example, one expert in Puerto Rico observed that natural disasters, such as Hurricane Maria, generate debris and disrupts normal waste management processes. For example, after the hurricane, many people stopped recycling, considering it a lost effort relative to all of the hurricane clean-up efforts required.

POOR GOVERNANCE

In the context of marine debris in Latin America and the Caribbean, poor governance includes weak land use planning, regulation, and enforcement; poor municipal waste management (combined with increasing demand for and production of plastic products, mentioned above); and poor fisheries and aquaculture management (including insecure tenure, poor enforcement, and lack of ecosystem-based management). Governments in Latin America and the Caribbean often do not have the capacity to effectively manage municipal waste or clean up marine debris that may originate from elsewhere, particularly in the context of increasing populations, urbanization, and tourism, which put pressure on already stressed waste management systems. Many countries in Central America and the Caribbean do not have enough or adequate landfills, which can contribute to land-based sources of marine debris (UNEP n.d.). Further, poorly management fisheries and aquaculture operations can lead to marine-based sources of debris, such as abandoned fishing gear (NOAA 2016; Hinojosa and Thiel 2009).

STRESSORS TO KEY MARINE ECOSYSTEMS

ECOSYSTEM PATHWAYS FOR MARINE DEBRIS STRESSES

CONTAMINATION

Marine debris acts as a contaminant and pollutant in beach ecosystems. The loss of aesthetic value and environmental quality are the most frequently cited consequences of marine debris contamination on beaches (Ivar do Sul and Costa 2007). The accumulation of beach debris depends on the rate of decay, burial-exhumation rates, coastal dynamics, and source intensity (Santos et al. 2007). Sandy beaches provide a habitat for many forms of wildlife, from microorganisms in the sand to birds and turtles that make their nests on the beach. Most of these species are uniquely adapted to the sandy beach environment and are not found in other habitats. Plastic debris on beaches creates a physical barrier with harmful impacts for various marine species. It contributes to a reduction in the number of sea turtle egg-laying attempts, lowered diversity of shoreline invertebrate communities, and an increased hazard of entanglement for coastal-nesting seabirds. These problems are compounded on remote islands where significant amounts of debris accumulate and where prevention and mitigation are extremely challenging (Lavers and Bond 2017). Plastic fragments and microplastics on beaches can change the physical properties of beaches in the forms of increased permeability and lowered sub-surface temperatures. For species with temperature-dependent sex-determination, such as sea turtles, this could lead to dangerous adverse effects (NOAA 2016). Medical wastes and drug paraphernalia is another major pollutant transported onto beaches by winds and waves. This can threaten public health through disease transmission and broken glass (UNEP-CEP 2015).

PERSISTENT BIOACCUMULATIVE AND TOXIC SUBSTANCES

In addition to physical effects, plastic debris contains a large mixture of chemical contaminants which can be toxic to wildlife or absorb other toxic pollutants. The chemical ingredients of 56 percent of plastic polymers are hazardous (CBD 2016). Plastics in seawater have been found to absorb and concentrate contaminants that have arisen in the environment from other sources. These contaminants can become several orders of magnitude more concentrated on the surface of plastic debris than in surrounding seawater (Barnes et al. 2009). The gradual fragmentation of plastics releases toxins, such as biophenols or polychlorinated biphenyls (PCBs) (Masó et al. 2016). Microplastics' composition and relatively large surface area make them prone to adhering waterborne organic pollutants and to the leaching of plasticizers that are considered toxic, a process known as marine biofouling. The ingestion of plastics by marine organisms may be introducing toxins to the base of the food chain, paving the way for the potential bioaccumulation of these toxins and associated sub-lethal and lethal effects (Cole et al. 2011). In the case of marine mammals, researchers have identified plastic derivatives such as phthalates in the blubber of fin whales (Lusher et al. 2018). Top predators rely on a large amount of prey (in biomass) to supply their energy requirements, and previously contaminated prey enhances the potential for bioaccumulation of these potentially harmful contaminants (Ferreira et al. 2016).

DISPERSAL AND TRANSPORT OF INVASIVE SPECIES

Because of the durability and highly mobile nature of plastic debris, marine debris serves as a vehicle for introducing marine alien invasive species to areas in which they were previously not present, with potentially dramatic effects for island ecosystems. Floating marine debris has become the most common seagoing transport system and is responsible for the widespread distribution of many marine organisms that use it to travel to other parts of the ocean. Marine biofouling is described as the undesired growth of marine organisms on submerged surfaces of anthropogenic origin. Any surface introduced into the marine environment are quickly covered by extracellular polymeric substances produced by archaea, bacteria, and eukaryotic microbes. Marine biofouling and the associated contamination on plastic particles can contribute to the spread of marine invasive species. Common invasive species that use plastic debris as transport include bryozoans, barnacles, polychaete worms, hydroids, and mollusks, in order of abundance (Barnes 2002). Several species of bacteria have been identified on ocean plastics, so there is an additional concern of harmful pathogens spreading throughout the environment via these contaminants (Lachmann et al. 2017).

MANGROVES

In recent decades, mangroves around the world have been increasingly exposed to plastic pollution and other forms of human waste (UNEP 2017). High debris loads can thwart attempts to rehabilitate depleted mangrove forests through the smothering of seedlings, and perpetuating run-off and water quality issues in the bay. Marine debris becomes trapped among mangrove trees and their aerial roots, possibly blocking mangrove tidal channels. While mangrove roots naturally filter the water from pollutants, they cannot self-regulate the continuous volume of trash that accumulates within them (The Beach Review 2014). In a study of the Goiana Estuary in Northeastern Brazil, mangrove vegetation contributed to marine debris retention. The low hydrodynamics of the area caused debris items to become buried, sometimes for long periods. Plastic debris in these habitats can be retained for at least six months but likely longer, resisting even extreme tidal events and seasonal riverine flushes (Ivar do Sul et al. 2014). Microplastics pose a potentially serious threat for coastal mangroves compared to larger-sized plastic. Organisms such as plankton that occupy lower trophic levels are particularly susceptible to the ingestion of microplastics and could pass consequent effects onto higher trophic levels (Nor and Obbard 2014). However, the effects of microplastics on the mangrove habitat are still largely speculative, thus NOAA plans further studies to measure the presence of macroplastics in mangrove biota and assess any toxicological impacts (NOAA 2016). As debris loads continue to accumulate across all marine habitats, it is becoming evident that plastics can place increased stress on the ecosystem. High levels of debris in mangroves could lead to a proliferation of pollution-tolerant mangrove species as more sensitive species die off, leading to reduced biodiversity in mangrove ecosystems (UNEP 2017). Considering the increasing prevalence of marine debris in these habitats, there have been relatively few studies on plastic pollution conducted in these habitats (Ivar do Sul et al. 2014).

SEAGRASS

Marine debris obstructs sunlight to seagrass beds and may act as a vector for pathogens that adhere to microplastics (Cole et al. 2011). In the Corn Islands of Nicaragua, shallow seagrass beds are littered with cans, plastic food packaging, and bottles (McDonald and Seid 2014). Derelict fishing gear is particularly damaging to seagrasses because fishing gear can resuspend sediment, disturb the rhizome, and impact the root structure of seagrasses. Other fishing methods, such as spiny lobster traps, have the potential to both flatten seagrasses and shear and abrade them. Additionally, lost traps can continue to inflict damage as they are moved around by storms and waves. Recovery time after damage depends greatly on the species of seagrass (NOAA 2016). Macrofauna living in seagrass beds have consumed microplastics, specifically rayon fibers whose dyes may be harmful to macroinvertebrates living in seagrass beds (Remy et al. 2015). Currently, there is limited research on the impacts of marine debris to seagrasses. Much of the documented impacts to seagrasses are based on reports from community members while impacts to larger marine mammals are reported more frequently than impacts on tropical marine ecosystems (Jimenez, pers. comm. 2018).

CORAL REEFS

Coral reefs are impacted by marine debris via obstruction of sunlight, contamination, ingestion, and entanglement (the latter two stressor pathways are described in detail in Section 5.5.1). Contamination arises from nearshore areas, shipping activities, and adhesion to plastic debris. Despite prohibition of the discharge of any type of persistent solid waste from ships into the Caribbean Sea (Annex V of the (MARPOL) 73.78,), reefs continue to be impacted by solid waste both from ships and land-based sources. The impact on reefs continues given the lack infrastructure and treatment and final disposal facilities, especially in SIDS to adequately manage this waste. Shipping activities and oil production in the Gulf of Mexico and southern Caribbean region have been identified as sources of petroleum and marine debris pollution (Siung-Chang 1997). In a study of coral reefs and marine debris in the Marshall Islands, a significant relationship between coral cover and debris was found, with coral cover and species diversity decreasing as macro-debris cover increases (Richards and Berger 2011).

Waterborne organic pollutants adhere to microplastics (Cole et al. 2011), which may be consumed by reef organisms, including coral (Hall et al. 2015). Additionally, plastic debris can transport the Vibrio bacterium that causes coral disease (Ben-Haim et al. 2003); when corals interact with marine plastic debris, the likelihood of disease increases from 4 percent to 89 percent (Lamb et al. 2018). Carvalho-

Souza et al. (2018) reported ecological disruptions on 418 coral species caused by marine debris; these disruptions included ingestion of plastic by scleractinian coral (reef-building); deprivation of light and oxygen when plastic covers coral; and abrasion from entanglement. Coral will mistake microplastics for plankton in laboratory experiments and ingest microplastics at a similar rate as plankton in natural environments (Hall et al. 2015). The microplastics embed themselves in coral tissue and may impede coral digestion of natural food sources, impairing coral health.

Abandoned fishing gear often breaks sections of branching corals and abrades larger reef-building corals, leading to tissue damage; the damaged tissue is then more vulnerable to pathogens or formation of lesions (Souza et al. 2018). Hook and line gear were responsible for 84 percent of impacts to sponges and cnidarians with tissue abrasion causing partial or total mortality in coral reef and hard bottom sites in the Florida Keys (Gall and Thompson 2015). In the northwestern Hawaiian Islands, recovered derelict fishing gear had 20 percent of its weight attributed to broken coral fragments (Donohue et al. 2001) underscoring the destructive impact of derelict fishing gear. There is currently limited research on community-level effects, though evidence suggests these effects are difficult to quantify rather than that they do not exist (Gall and Thompson 2015).

STRESSES TO KEY FAUNA

PATHWAYS OF MARINE DEBRIS STRESSES

It is increasingly evident that marine debris has a substantial impact on individuals, populations, and ecosystems in the marine environment. As of 2017, more than 800 species had been recorded as directly affected by marine litter (Lachmann et al. 2017). The main stressor pathways in which marine debris impacts fauna is through ingestion or entanglement. According to the Convention on Biological Diversity (CBD 2012), roughly 15 percent of the species affected through entanglement and ingestion are on the International Union for Conservation of Nature (IUCN) Red List. While lethal impacts have been documented in marine animals from interactions with marine debris, the primary impacts of plastic debris in marine animals are mechanical or sub-lethal (Denuncio et al. 2017). Interactions of marine organisms with harmful plastic debris is an increasingly hazardous issue for these organisms. In a decade (2000-2010), fatal entanglement in and ingestion of marine debris by marine animals increased 40 percent (Thompson 2013). The following sections explain the ingestion and entanglement pathways in more detail; the impacts of these pathways on marine mammals, birds, turtles, and fish are discussed in the latter part of this section.

INGESTION

As the amount of plastics in the marine environment grows, so too will the likelihood of marine organisms interacting with plastic via ingestion. More than 200 species of marine fauna are known to be at risk from ingestion of plastic, with evidence that some species exhibit preferences for certain colors or types of plastic while foraging at sea. Small pieces of debris are numerically more dominant among all debris as a result, 40 percent of the world's seabird species, 100 percent of turtle species, and 50 percent of mammals are known to ingest plastic marine debris (Lavers and Bond 2017). These organisms suffer from lethal and sub-lethal effects that inhibit their viability, reproduction, and long-term survival (Lachmann et al. 2017). Potential harms associated with marine debris ingestion include: internal and external wounds; blockage of digestive tracts followed by satiation, starvation, and general debilitation often leading to death; reduction in quality of life and reproductive capacity; and the possibility of absorption and concentration of potentially damaging toxic compounds in plastics from sea water (Gregory 2009). The impact of microplastics is widespread, Jose Enrique Barraza, a local expert in El Salvador stated that studies have shown microplastics to be found in the stomachs of mountain fish in high elevated areas with a low population.

All shapes and sizes of fauna may ingest marine debris, especially microplastics. In many parts of the ocean, the concentration of microplastics outnumbers plankton by up to six times (GIZ 2015), creating serious potential impacts for planktivores. Microplastics have been discovered in 114 aquatic species, more than half of which are common for human consumption (Royte 2018). Microplastics block digestive tracts, diminish the urge to eat, and alter feeding behavior. Furthermore, microplastics concentrate and transfer chemicals that include persistent organic pollutants (POPs) like polycyclic aromatic hydrocarbons (PAHs), PCBs, and dichlorodiphenyltrichloroethane (DDTs) into the tissues of organisms who ingest these particles (Nor et al. 2014). These effects can reduce growth and reproductive output of organisms (Royte 2018). The ingestion of polystyrene particles by zooplankton significantly reduces their nutritional intake (as they can consume up to 40 percent less natural food) as well as their reproductive output (UNEP 2016). In addition, experimental evidence in marine organisms demonstrates the potential for microplastics to be transferred between trophic levels (EFSA 2016). In a study on plastic ingestion of the Acoupa weakfish (*Cynoscion acoupa*) in the Goiana Estuary in eastern South America, plastics are frequently ingested, regardless of season, area, or ontogenetic phase (the ingestion of plastic is enhanced in estuarine systems, mirroring the increased abundance of the contaminant). Sixty-four percent of *C. acoupa* had plastic debris detected in their stomachs during the study; this high frequency suggests a correlation with their high trophic position in the food chain (Ferreira et al. 2016).

Consequences of ingestion of plastic debris appear to depend on feeding habitats. Sea turtles approach and ingest all types of floating debris, including derelict fishing gear (which can increase the likelihood of entanglement). Seabirds that commonly ingest hard, sharp items of prey are better able to tolerate ingestion of hard items of debris than those used to softer prey items. Some species can regurgitate indigestible items and will do so with harmful ingested debris. For those that cannot, such as procellariformes birds, marine debris accumulates in the gut. Physiological effects stemming from plastic ingested by seabirds include obstruction of the gastrointestinal tract and of subsequent passage of food into the intestines, blockage of gastric enzyme secretion, diminished feeding stimulus, lowered steroid hormone levels, delayed ovulations, and reproductive failure (Azzarello, Van Vleet 1987). Microplastic uptake by marine mammals may occur through several mechanisms, such as filter feeding, inhalation at the water-air interface, and secondary ingestion through trophic transfer from prey. It was recently estimated that a single striped dolphin, *Stenella coeruleoalba,* could be exposed to roughly 463 million microplastics through their diet of mesopelagic fish (Lusher et al. 2018). The large amounts of debris in the digestive tract of marine mammals, particularly juveniles, lead to digestive injuries and induced starvation (Ferreira et al, 2016). Fifty-six percent of all cetacean species interact with marine debris and 69 percent of ingested debris is classified as plastic or plastic-derived. Sharp-edged granules of microplastics are capable of internal damage of organic tissues in the digestive tract of various organisms (Nor et al. 2014). Apart from providing zero energy, the presence of plastics in their diets affect how organisms deal with food shortages. For example, many organisms will instinctively decrease metabolic rates when faced with starvation to save energy, but this does not occur when they have consumed plastics (UNEP 2016). Generally, mortality from ingestion of plastic is a growing and serious threat affecting hundreds of marine species (NOAA 2014). The UN (2017) explains that "plastic waste kills up to 1 million seabirds, 100,000 sea mammals, marine turtles and countless fish each year."

ENTANGLEMENT

Entanglement effects from marine debris are largely caused by the high prevalence of abandoned fishing gear, including tangled masses of lost/abandoned trawl net, gillnet, webbing, and monofilament line. Even once discarded, this gear can retain the ability to capture target fish and other species for large periods of time. This phenomenon is known as "ghost fishing" (Gregory 2009). Discarded gear accounts for over half of all macro plastics in the oceans today and is at least four times as likely to impact marine life as all other forms of debris combined (GGCI 2017). While entanglement rates seem to vary across different species/taxa, rates appear to be greater in areas of overlap between high population densities and either human fishing intensity or areas of high debris accumulation (NOAA 2014). Reported problems from entanglement in marine debris such as derelict fishing gear include but are not limited to: wounds (internal and external), suppurating skin lesions and ulcerating sores, drowning and limited predator avoidance (Gregory 2009).

Of all known marine mammal species, over 40 percent have been affected by ghost gear (GGCI 2017). As debris accumulates, especially derelict fishing gear, it can entangle branching species of hard coral, resulting in fragmentation and abrasion and potentially reducing habitat heterogeneity (NOAA 2016). Entanglements in derelict fishing gear were found to have impacted at least 298 reef species. Abandoned fishing gear can break the branches of colonial corals or causing severe lesions on polyps and tissues, and this tissue damage can increase vulnerability to pathogens or animals (Carvalho-Souza et al. 2018). In some derelict nets recovered near the Northwest Hawaiian Islands, 20 percent of their weight was attributable to broken coral fragments (Donohue 2001). In a review of the impact of marine debris on marine life (Gall & Thompson 2015), hook and line gear were responsible for 84 percent of impacts to sponges and cnidarians in the Florida Keys, with tissue abrasion causing partial or total mortality in coral reef and hard bottom sites. Abandoned gillnets can continue to fish until the net breaks down, even after having lost buoyancy. The light material of gillnets is not easily seen by fish and other marine animals. Crab traps and pots are another prominent impact vehicle for marine life. When set, traps and pots are baited, so if they are lost, they continue to attract fish or scavengers. The trapped fish may die, becoming bait for additional fish or other organisms (GGCI 2017).

Animal behaviors related to feeding, play, and nest building often bring individuals into contact with entangling debris. For this reason, certain species, such as sea turtles, are predisposed to entanglement. Fauna that are not able to free themselves quickly have a low chance of survival (Laist 1997). An ensnared sea turtle can be prevented from diving, feeding, or surfacing for breath. Discarded fishing gear such as nets and lines can amputate the limbs of marine fauna, and open wounds can attract predators (Macarenhas et al. 2004). Many sea turtle entanglement cases involve animals that either died due to entanglement, would have died without human intervention, or had gangrenous flippers caused by tightly wrapped lines (Laist 1997). Seabirds become entangled accidentally when seeking natural prey items, such as pelicans plunging for fish near the surface, and entanglements seem to be most common among pelacaniformes and some charadriliformes. Among marine mammals, entanglement in marine debris is most common among pinnipeds and less common in mysticetes and sirenians (Laist 1997). Juveniles and sub-adults of multiple marine mammal species have been found to be more susceptible to marine debris entanglement compared to more agile adults (NOAA 2014). Over 40 percent of all known marine mammal species have been affected by ghost gear (GGCI 2017). There is some evidence to suggest that many individuals can shed their entangling debris. Even in these cases, the lingering effects of entanglement can incur life-long physical problems that may shorten their life spans (NOAA 2014). Entangled animals that manage to get to shore do so at an increased metabolic cost, imposing added food requirements and resulting in more time spent at sea feeding. The likelihood of predation also rises for these individuals because of decreased mobility.

MARINE MAMMALS

Marine debris is increasingly recognized as a significant threat to marine mammals through either entanglement or ingestion, which are described in detail above. Thompson (2013) found that about half of all marine mammal species are impacted by marine debris, over 80 percent of which were associated with plastic. Entanglement is the most common among seals and sea lions, and less common in baleen whales and manatees. The main types of debris identified in entanglement records for marine mammals are trawl nets, gillnet fragments, and monofilament lines (Laist 1997). NOAA (2014) found that for several marine mammal species, juveniles and sub-adults may be more susceptible to entanglement than adults (which are more agile). While there was evidence that some individuals can shed their entangling debris, the effects of entanglement can be life-long, even shortening life spans, which suggests that there may be population-level implications (NOAA 2014). The impacts of ingestion of marine debris by marine mammals can depend on the animal's mode of feeding, such as filter feeding, inhalation at the surface, or secondary ingestion through prey. For example, fur seals and single-striped dolphin were found to mainly uptake plastic via secondary ingestion of prey species, while baleen whales can ingest microplastics through water filtration (Lusher et al. 2018). High levels of ingestion can cause pollutants to bioaccumulate in organisms. For example, fin whales were found to have plastic derivatives in their blubber (Lusher et al. 2018). Marine plastic kills around 100,000 marine mammals every year (UN, 2017). This includes whales, seals, and endangered manatees (NOAA 2014).

SEA TURTLES

A recent study found synthetic particles in every sea turtle sampled, which included turtles of all seven marine species from three ocean basins (Duncan et al. 2018). Further, more than half of the world's sea turtles are expected to have consumed debris (Townsend 2015). Sea turtles are particularly threatened by marine debris due to their feeding and behavior patterns. They often approach and ingest various types of floating debris thinking that it is prey, leaving them prone to entanglement and ingestion. Floating plastic bags can be mistaken for edible jelly fish and end up blocking the esophagus (Gregory 2009). Sea turtles engage in activities like feeding, play, and nesting that can bring them into contact with debris. Once entangled, researchers have observed difficulties in feeding, diving, surfacing to breathe, and other essential behaviors (Mascarenhas, Santos and Zeppelni, 2004; Laist 1997). Nets and lines can also amputate turtle's limbs or leave open wounds that attract predators (Mascarenhas, Santos and Zeppelini 2004). On the coast, plastic debris on beaches creates an actual physical barrier that prevents sea turtle laying attempts (Lavers and Bond 2017). Further, plastic fragments and microplastics can lead to changes in sandy sediments in the intertidal zone, decreasing sub-surface temperatures which can impact the temperature-dependent-sex-determination of sea turtles (NOAA Marine Debris Program 2016).

FISH POPULATIONS

Fish are one of the largest and most diverse animal groups on the planet and as a result, their chances of interaction with plastic marine debris are high (Posatto et al. 2011). Globally, more than 30 percent of fish stocks are overexploited, depleted, or recovering from depletion (UNEP 2016). This decline is exacerbated by the presence of marine debris, which can inhibit the recovery of these ecosystems from other stressors. Marine debris can impact fish populations by decreasing nutrition and causing internal injury, starvation, or death for individuals (NOAA 2018).

The fishing industry itself is a major generator of marine debris. For example, it is estimated that in the Estero de Jaltepeque and the Bahía de Jiquilisco in El Salvador, the major artisanal fishing industry in these bodies have generated approximately 3 million pounds of waste (MARN El Salvador 2014). Field work also revealed that the artisanal fishery industry in Peru contributes significantly to marine debris (see Case Study in Annex C). Marine debris such as derelict fishing gear compromises yields and income from fisheries—an estimated 5-30 percent decline in fish stocks and damage to important marine habitats can be attributed to ghost gear. This creates higher costs for companies and individuals who source fish and contributes to global food losses (GGCI 2017). Coral reefs are popular commercial and recreational fishing grounds and often contain a great deal of derelict fishing gear. Because structurally complex corals are eight times more likely to be affected by plastic, it is likely that microhabitats for reef-associated organisms, such as fish, will be disproportionately affected by the presence of marine litter (Lamb et al. 2009).

Additionally, marine debris can facilitate the transport of potentially harmful alien species that attach to debris. In this way, marine debris can bring a devastating effect to fisheries and local ecosystems (NOAA 2018). Marine species such as bryozoans, barnacles, polychaetae worms, hydroids and mollusks can latch onto marine debris and be dispersed in areas where they are not endemic (Barnes 2002). Some estimates state that global marine species diversity may decrease by 58 percent if introduction of alien species continues worldwide (Derraik 2002).

BIRDS

Entanglement and ingestion of plastics are the most commonly cited pathways of plastic impacts on seabirds. Over 100 species of seabirds that have documented interactions with plastic – via ingestion or entanglement (Gregory 2009); other reports indicate that marine debris impacts one-fifth to one-half of all seabird species worldwide (Laist 1997; Lachmann et al. 2017; Thompson 2013). Physiological effects stemming from plastic ingested by seabirds include obstruction of the gut and of subsequent passage of food into the intestines, blockage of gastric enzyme secretion, diminished feeding stimulus, lowered steroid hormone levels, delayed ovulations, and reproductive failure (Lachmann et al. 2017). Additionally, the amount of plastic ingested by seabirds has been positively correlated with PCBs found in the seabirds' fatty issue (NOAA 2011). Feeding habits influence the impact of plastic ingested by seabirds; some birds have a smaller gizzard and an inability to regurgitate ingested plastics which may lead to internal damage, while the same plastics may not harm other birds (Azzarello and Van Vleet 1987). The density of microplastics in the marine environment in subtropical latitudes increases the hazard of ingestion by planktivores, e.g., 60 percent of 6,136 surface plankton net tows collected buoyant plastic pieces typically millimeters in size (Law et al. 2010). Plantivorous birds are likely to confuse plastic pellets with copepods, euphausiids, and cephalopods.

Along the Pacific coast of South America, Thiel et al. (2018) found six bird species with plastics in their stomachs; the kelp gull had one of the highest frequencies of plastic ingestion. In this same region, oceanic seabirds were "severely affected" by marine plastic ingestion, while continental seabirds were most impacted by plastics entanglement. Seabird entanglements appear to be most common in pelecaniformes (e.g., pelicans and gannets) and a few charadriliformes (e.g., coastal gulls). Seabirds become entangled accidentally when foraging and are trapped by fishing lines and derelict fishing nets (Lachmann et al. 2017; Thiel et al. 2018). The most frequently reported items for seabird entanglement are monofilament line and fishing net, which threatens their survival (Mascarenhas et al. 2004). Other common items include fishing hooks, six-pack yokes, wire, and string.

Habitat, such as mangroves, can be damaged by presence of plastics and therefore, impact breeding, feeding, and nursery habitats of birds (Bulow and Ferdinand 2013). Thiel et al. (2018) noted 12 species using marine litter for nest construction along the Pacific coast of South America; the entanglement and thermal impacts of marine plastics in bird nests is not well-documented. Accumulation of marine debris in mangrove habitats exacerbates existing pressures on these coastal ecosystems from land clearing, aquaculture expansion, over-harvesting, and development as well as reduces important habitat for migrating birds in Latin America and the Caribbean. Furthermore, plastic increases the hazard of entanglement for coastal-nesting birds (Lavers and Bond 2017).

MARINE DEBRIS AND OTHER THREATS TO BIODIVERSITY IN THE REGION

This section corresponds to research question #3: Where impacts are thought to be significant, how do they compare to other threats to biodiversity in the target areas?

KEY POINTS

- Marine debris is a stressor within a multi-stressor scenario that includes conversion of natural habitats, uncontrolled coastal infrastructure development, pollution, climate change, IUU fishing, and invasive species.
- There is not enough information to determine whether marine debris has a more significant impact on coastal and marine biodiversity compared to other threats.
- Marine debris impacts on biodiversity (and our knowledge of these impacts) are likely to increase further due to the drivers of marine debris and growing research in this field.

Marine biodiversity in the LAC region is impacted by a range of factors, including overfishing, coastal development, sedimentation, contamination, climate change, and weak or uncoordinated management of resources, among others. As such, marine debris is a stressor to key fauna and ecosystems within a multi-stressor scenario. For example, drivers such as population growth, increased tourism and higher density population in coastal areas can contribute to multiple threats, including a) land use changes along the coast and in nearshore environments; b) pollution, especially from sewage; c) increased demand for seafood and other food products; and d) increased vulnerability to storms due to loss of coastal ecosystems (CARSEA 2007).

Given the lack of data on population-level and/or habitat-level effects of marine debris, it is difficult to effectively determine whether marine debris has a greater impact on biodiversity than these other factors. Despite the difficulty of weighting threats in this multi-stressor scenario, the literature clearly demonstrates marine debris has deleterious effects on organisms via ingestion, entanglement, contamination, disease introduction, nutrition, and alteration of habitat. It damages ecosystems via abrasion, filtration of light, alteration of hydrologic processes, and suffocation. Furthermore, the impacts of marine debris on biodiversity will likely continue to increase. Since the early 2000s, the number of species that have encountered marine debris was estimated around 260 species, while Gall and Thompson (2015) more recently reported encounters between debris and individuals at 693 species.

Table 3 below provides an overview of the main drivers, threats and stressors to marine and coastal biodiversity in Latin America and the Caribbean. These drivers, threats and stressors overlap, influence, and exacerbate one another. They impact all the key ecosystems and fauna types identified in this paper.

TABLE 2. SUMMARY OF DRIVERS, THREATS, AND STRESSORS TO MARINE BIODIVERSITY

DRIVER	THREAT	STRESSOR
Weak land use planning, regulation,	• Conversion of natural habitats for agricultural	• Erosion and sedimentation • Water quality degraded from pesticides and fertilizers

TABLE 2. SUMMARY OF DRIVERS, THREATS, AND STRESSORS TO MARINE BIODIVERSITY		
DRIVER	THREAT	STRESSOR
and enforcement. (Poor Governance)	expansion, aquaculture, etc.	• Habitat fragmentation and loss • Change in flow dynamics
Poor municipal waste management (Poor Governance) combined with increasing demand for and production of plastic products (Economic forces)	• Garbage and solid waste pollution enter marine habitats	• Entanglement (e.g., sea turtles, marine mammals, birds) • Ingestion of too much plastic can impact digestive tract, feeding and health of marine species • Plastic contamination in marine ecosystems • Dispersal of alien species that outcompete our spread diseases among native species • Physical damage to habitats (e.g., coral reefs, seagrass meadows, mangroves) • Altered community structure due to impacts on reproduction and increased mortality
Insecure tenure, poor enforcement, and lack of ecosystem-based management in the fisheries and aquaculture sector (Poor Governance)	• Illegal, unreported and unregulated (IUU) fishing • Poorly managed aquaculture/ mariculture/fisheries	• Over-exploitation of marine species • Entanglement (e.g., sea turtles, marine mammals, birds) • Ingestion of too much plastic can impact digestive tract, feeding and health of marine species • Plastic contamination in marine ecosystems • Dispersal of alien species that outcompete our spread diseases among native species • Physical damage to habitats (e.g., coral reefs, seagrass meadows, mangroves) • Altered community structure due to impacts on reproduction and increased mortality • Introduction to the marine environment of invasive species and debris

TABLE 2. SUMMARY OF DRIVERS, THREATS, AND STRESSORS TO MARINE BIODIVERSITY		
DRIVER	THREAT	STRESSOR
Population growth, urbanization and increasing tourism	• Uncontrolled coastal infrastructure development • Garbage and solid waste pollution enter marine habitats	• Sedimentation • Habitat fragmentation and loss • Water quality degraded from industrial waste/runoff as well as municipal sewage • Entanglement (e.g., sea turtles, marine mammals, birds) • Ingestion of too much plastic can impact digestive tract, feeding and health of marine species • Plastic contamination in marine ecosystems • Physical damage to habitats (e.g., coral reefs, seagrass meadows, mangroves) • Altered community structure due to impacts on reproduction and increased mortality
Increasing GHG emissions	• Climate change • Increased CO2 in atmosphere	• Increased ocean surface temperatures • Increased frequency and intensity of storms • Ocean acidification • Change in precipitation and timing and quantity of water flows • Sea level rise • Changes in distribution and transportation of marine debris

Outside of marine debris, the other major threats and stresses to coastal and marine biodiversity in the region include the following:

THREAT: UNCONTROLLED COASTAL DEVELOPMENT AND CONVERSION OF NATURAL HABITATS FOR AGRICULTURAL EXPANSION, AQUACULTURE, AND OTHER INDUSTRIES.

Coastal land use change can have devastating impacts on marine habitats and the species that rely on them. Coastal land is increasingly claimed for urban development which can impact sensitive habitats like mangroves, reefs, and seagrasses that harbor fish species vital to both biodiversity and humans (Reis et al., 2016). For example, over the last 25 years, land development for urban areas and tourism has been the main regional cause of mangrove forest loss within the Caribbean (OECS, 2009). Further, if marine or coastal areas are converted to agriculture, sedimentation from these activities can decrease the quality of marine habitats, potentially even killing entire reef systems (Reis et al., 2016).

THREAT: ILLEGAL, UNREPORTED AND UNREGULATED (IUU) FISHING.

Illegal, unreported and unregulated (IUU) fishing contributes to significant biodiversity loss in fisheries around the world. Within the Caribbean, all the major commercial fish, as well as other species, are facing, overexploitation (UNEP, 2016). Use of more sophisticated and efficient fishing technology coupled with open access to the Caribbean Sea leads to overharvest of fish stocks, in part due to lack of regional governance for fisheries (CARSEA, 2007). Overfishing also threatens habitats. For example, overfishing causes the removal of important algal grazers and key nutrients from the reefs; fish contribute nitrogen and phosphorous, which are critical for growth and survival of coral (Ma 2016). Further, IUU fishing can lead to high levels of bycatch. Chile and Peru are home to some of the most southern colonies of sea turtles, but with intensive fisheries in each country, bycatch effects are significant (Alvarez-Varas et al. 2016). A 2018 survey[6] of small-scale fisheries bycatch in the southeastern Pacific (Ecuador, Peru, Chile) found that annual bycatch across harbors was 46,478 turtles (Ecuador: 40,480; Peru: 5,828; Chile: 170). Mortality rates were 32.5 percent (Ecuador), 50.8 percent (Peru), and 3.2 percent (Chile) (Shigueto et al., 2018).

STRESS: POLLUTION, INCLUDING SOLID WASTE, INDUSTRIAL EFFLUENT AND RUNOFF THAT ENTERS MARINE HABITATS.

While marine debris is certainly one form of pollution, other types, such as sewage, agricultural runoff, and industrial effluent also have significant impacts on marine and coastal biodiversity. For example, heavy metal pollution from mining, industry, and untreated sewage can bioaccumulate in the environment, negatively impacting fish and species that consume fish (CEP, n.d.). Latin America and small developing island states are particularly vulnerable to lead pollution due to high numbers of products containing lead that are often inappropriately disposed (CEP n.d.). Sedimentation (mentioned above), particularly from deforestation, can smother marine communities, decrease the amount of sunlight available, physically damage fish, and transport toxic materials absorbed by sediment. The Amazon (Brazil) and Magdalena River (Colombia) contribute significant sediment loads the influence the Wider Caribbean Region (CEP n.d.). Oil spills have devastating consequences for both habitats and fauna, such as destroying seabirds' insulating feathers, killing mangroves and seagrasses, and poisoning sea turtles and marine mammals. The Caribbean has a particularly high oil spill risk due to the 100 refineries in the region and complex shipping network (CEP n.d.).

STRESS: CLIMATE CHANGE.

Changing sea temperatures are having a significant impact on marine ecosystems and species. Higher water temperatures cause coral bleaching (with coral mortality at 70 percent in certain regions), shift

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[6] A total of 765 surveys were conducted: Ecuador: n=379 fishers, 7 ports; Peru: n=342 fishers, 30 ports; Chile: n=44, 6 ports). Survey coverage was 28 percent for Ecuador, 37 percent for Peru and 62.7 percent for Chile.

species' ideal water temperatures to different areas, and alter important characteristics of species such as metabolism, life cycle and behavior (WWF n.d.). Caribbean reefs are particularly vulnerable to climate change due to overlapping human threats and slower recovery rates than other corals (Buddemeier, Kleypas and Aronson 2004). In the Caribbean, over 80 percent of reefs have lost live coral cover in the last 20 years, because of "hurricane damage; disease; coral bleaching; pollution, including sediment run-off from coastal development and agriculture; overfishing, and direct physical damage from boat anchors, fish traps, grounded ships, dredging, curio collection, and dynamite" (Agard and Cropper 2007). For certain marine species, male versus female offspring are determined by temperature, meaning climate change could alter sex ratios and threaten populations more widely. Rising sea levels can also reduce the amount of light reaching marine plants and algae and negatively impact mangroves which are sensitive to sea levels. Increasing storms also have the potential to damage coral and other coastal and marine ecosystems (WWF n.d.). Further, rising levels of carbon dioxide in the atmosphere contribute to ocean acidification which reduces the amount of calcium carbonate available for corals as well as other marine organisms with skeletons and shells (Reef Resilience Network n.d.).

STRESS: INVASIVE SPECIES

Behind habitat loss, invasive species are the next greatest threat to marine and coastal biodiversity globally. When invasive species reproduce, they can out compete native plants and animals and permanently disrupt habitats (NOAA 2018). An example is the invasive Lionfish species in the Caribbean, (which are native to the Indo-Pacific) which pose a grave threat to coral reef ecosystems and fish populations, as they are voracious predators without many predators of their own and multiply quickly (WRI n.d.). Scientists are worried that a similar situation will happen in the Eastern Pacific, where the exotic Cobia Fish has escaped from a mariculture operation in Ecuador (Towers 2016), Invasive species can also introduce and spread new diseases. (NOAA 2018). Coral reefs are particularly susceptible, whereas pollution, including marine debris, and climate change increase the vulnerability of coral reefs to disease and alien species introduced via ship ballast water, Sahara Dust, river effluent, or aquaculture.

EXISTING STRATEGIES, POLICIES AND PLANS FOR ADDRESSING

This section corresponds to research question #4: Where impacts are thought to be significant, how do they compare to other threats to biodiversity in the target areas?

MARINE DEBRIS

This section describes strategies, policies and plans for addressing marine debris, starting at the global level, then the regional level, and finally the country level. Some of the major challenges to implementing successful strategies are also identified.

KEY POINTS

- Marine debris is being addressed at global, regional and local levels with various strategies, policies and plans.
- There is generally consensus that the following strategies are required:
    - Reducing production and consumption of plastics
    - Strengthening solid waste management infrastructure, including plastics recycling
    - Collaboration between the public and private sectors to address the issue
    - Fund additional research into the impacts of marine debris on the environment and biodiversity, as well as which types of interventions are the most successful
    - Encourage innovation and entrepreneurship in plastics alternatives and clean-up

GLOBAL STRATEGIES

There are three key global campaigns and strategies currently in force that aim to mitigate and address the impacts of marine debris around the world. United Nations Environment Programme (UNEP) launched the Clean Seas Campaign in early 2017. The campaign aims to engage governments, the public, civil society, and the private sector under the common goal of addressing marine plastic litter. UNEP also started the Global Partnership on Marine Litter (GPML). The Partnership was launched in 2012 following the recommendation contained within the Manila Declaration. It supports the Global Partnership on Waste Management and aims to protect human health and the environment by reducing and managing marine litter. The partnership is formed between international agencies, governments, NGOs, academia, the private sector, civil society, and individuals. At the Fifth International Marine Debris Conference hosted by NOAA in 2011, the participating members developed the Honolulu Strategy. The Strategy serves as an important framework for a comprehensive global effort to reduce the impacts of marine debris on the environment, economy, and human health. Annex A summarizes the main global strategies in place to combat the issue of marine debris.

REGIONAL STRATEGIES

The key document informing strategy for the wider Caribbean region is the Regional Action Plan on Marine Litter Management (RAPMaLi). The original action plan was developed in 2008 and was updated in 2014. The 2008 plan was an initiative conducted by the United National Environment Programme-

Caribbean Regional Coordinating Unit (UNEP-CAR/RCU) with support from the UNEP's Regional Seas Programme and the UNEP Global Programme of Action. The action plan provides an overview of the issues and case studies focused on different topics, including legislation, education, and solid waste management, for various countries in the region. The plan provides recommendations for addressing the issue in a regionally and locally minded manner (Caribbean Environment Program 2014). Globally, there are 18 Regional Seas programs, with 7 being administered by UN Environment, including the above Caribbean region action plan. The Southeast Pacific and Northeast Pacific regional programs are non-UN environment Regional Seas programs. Although neither of these have yet established an official marine litter action plan.

Regional programs, such as the UNDP and Global Environment Facility (GEF) funded Caribbean and North Brazil Shelf Large Marine Ecosystem project, are increasing recognizing marine debris as a stressor in the project documents (UNDP 2017). The Gulf and Caribbean Fisheries Institute, with UN Environment, has established the Caribbean Node of the Global Partnership on Marine Litter, and this project is currently under development.

COUNTRY STRATEGIES

Many of the countries in Latin America and Caribbean have laws and policies that regulate waste management in the country, but in practice the waste management is severely lacking. For example, in the Bay Islands of Honduras, each island has its designated area for trash collection but oftentimes they are open air pits that are very poorly managed (Drysdale, pers. comm. 2018). Furthermore, of the municipalities located along the coast of Honduras, only one has a waste management facility while the rest have open air pits (Andino and Vasquez, pers. comm. 2018).

Most of the countries in the region have general environmental laws as well as waste management laws. Some countries, such as Guatemala, Honduras, Haiti, and Saint Vincent and the Grenadines have introduced full bans, some on the national level and some at the local level, on styrofoam and plastic bags. In other countries, such as the Dominican Republic, El Salvador, Grenada, Jamaica, and Nicaragua the government or NGOs are driving discussions on potential bans (Caribbean Environment Program, 2014). Table 3 outlines representative programs that are currently being implemented or in specific countries.

TABLE 3. OVERVIEW OF COUNTRY MARINE DEBRIS PROGRAMS AND PROJECTS

PROGRAM NAME	IMPLEMENTER AND/OR FUNDING SOURCE	COUNTRY OR COUNTRIES	DESCRIPTION
Comité Técnico Nacional para la prevención de la contaminación marina	Colombia	Colombia	Founded in 2016, the National Technical Committee for the Prevention of Contamination of the Sea is a multi-sectoral group working to reduce solid waste in the sea.

TABLE 3. OVERVIEW OF COUNTRY MARINE DEBRIS PROGRAMS AND PROJECTS			
PROGRAM NAME	IMPLEMENTER AND/OR FUNDING SOURCE	COUNTRY OR COUNTRIES	DESCRIPTION
Grenada Young Entrepreneurs Project (GYEP)	--	Grenada	Aims to support sustainable businesses within the environmental sector. Promotes the recycling of glass and other materials.
Environmentally Friendly School Initiative	Grenada Solid Waste Management Authority (GSWMA)	Grenada	Program that targets pre-primary, primary, and secondary schools. A 9-month period where participants are involved in projects that touch on various aspects of solid waste management.
Food Vendors Licensing Workshop	GSMW and the Ministry of Health	Grenada	Workshop to promote best practices in waste management for the food service sector.
Plastic Separation Pilot Project	National Solid Waste Management Authority (NSWMA)	Jamaica	This project aims to improve plastic disposal and recycling.
Sandwatch Programme	United Nations Educational, Scientific and Cultural Organization (NESCO)	Saint Vincent and the Grenadines	Encourages youth to monitor the beaches and marine environment.
The Last Straw	Roatan Recycle NOW!	Honduras	An initiative to create awareness of the impacts from single-use plastics.

Plastic bags, fishing nets and gear, balloons, plastic beverage bottles, and plastic utensil items are commonly cited as the most harmful to wildlife, thus, reduction of these plastics is an important step to phase-out these harmful materials. Table 4 outlines the status of styrofoam and plastic bans in the countries of interest.

TABLE 4. OVERVIEW OF STYROFOAM AND PLASTIC BANS IN THE CARIBBEAN AS OF DECEMBER 2018		
COUNTRY	TYPE OF BAN	DESCRIPTION
Colombia	National ban	As of January 2017, Colombia banned single-use plastic bags small than 30x30 cm while also introducing alternatives. In July 2017 the government introduced a tax on single-use plastic bags. The tax will increase annually by 50 percent.
Dominican Republic	Ban in discussion-Public/NGOs	Change.org has sent a petition to the ministry of Environment and Natural Resources. The petition calls for the ban of plastic packing material and use of plastic bags.
El Salvador	Ban in discussion-Government	In June 2018, the National Environmental System (SINAMA) agreed to the development of a strategy to tackle the issue of single-use plastics. The strategy will be obligatory for public institutions and voluntary on a national level.
Grenada	Ban in discussion-Government	The Government has pledged to ban the importation of styrofoam first and then plastic.
Guatemala	Local ban	There are a few municipalities in the country that have banned plastic bags. There is also a bill underway that would ban plastic bags nationally. The bill was submitted to the legislature in November 2017.
Haiti	National ban	Haiti has banned black plastic bags and foam containers via a ban that was introduced in 2013. A previous attempt was made but was not enforced. There are concerns that the 2013 ban will not be well enforced either.
Honduras	Local ban	There are municipalities in the Bay Islands that have banned plastic bags. The ban was implemented alongside an awareness campaign that provided each household with reusable bags. The ban has led to 100 percent elimination in Guanaja, 80 percent in Utila, and 50 percent in Roatan.
Jamaica	Ban in discussion-Government	There is a working group in the process of examining a state motion to ban plastic bags.

TABLE 4. OVERVIEW OF STYROFOAM AND PLASTIC BANS IN THE CARIBBEAN AS OF DECEMBER 2018		
COUNTRY	TYPE OF BAN	DESCRIPTION
Nicaragua	Ban in discussion-Public/NGOs	The National Chamber of Tourism of Nicaragua (Canatur) announced in February 2018 that they intend to promote an initiative to ban plastic bags and promote recycling.
Panama	National ban	As of January 19, 2018, supermarkets, pharmacies, and retailers in Panama will have to stop using plastic bags over the following 18 months, warehouses and wholesalers have longer, 24 months. The law bans the use of polyethylene bags.
Peru	National	As of December 2018, Peru passes a law banning the manufacturing, importation, distribution, and consumption of single-use plastic bags. The ban will be rolled out within three years. The ban also prohibits straws and other non-recyclable plastic products
Saint Vincent and the Grenadines	National ban	The government banned the importation and use of Styrofoam products in early 2018. The government intends to further develop more policies aimed at protecting the environment-including policies aimed at reducing single-use plastic bags.

CHALLENGES

Generation of marine debris is exacerbated by high demand for and production of plastic coupled with either weak waste management infrastructure or lack of physical capacity to process the ever-increasing volume of waste. Jambeck et al. (2015) note that to achieve a global waste reduction of 75 percent of mismanaged plastic, waste management must be improved by 85 percent in the top 35 percent of countries contributing to mismanaged waste. This implies significant investment in waste management infrastructure in low and middle-income countries; however other strategies, such as waste reduction, bans on certain products, and a move toward circular economies[7] are also important strategies to pursue (Löhr et al. 2017). To date, decision makers have been widely unable to use existing laws to combat marine debris because they are uncertain about its nature and extent of its risk to humans and

[7] Circular economies are based on three key concepts: design out waste and pollution; keep products and materials in use; regenerate natural systems.

ecosystems (Rochmann et al. 2016). Given the scale of the marine debris problem, the continued growth in plastic use, and the increasing proportion of microplastics among total debris, collection of marine debris in situ (i.e., floating in the ocean) is currently regarded as a less-effective solution, particularly as it may neglect a substantial proportion of debris – microplastics (CBD 2016).

Although research outlining environmental, social, and economic impacts of marine plastic pollution is growing, few studies have examined policy and legislative tools to reduce plastic pollution, particularly single-use plastics (Xanthos and Walker 2017). Policies to reduce microbeads began in 2014 and interventions for plastic bags began in 1991, however, few studies have documented the effectiveness of these reduction strategies. The existence of these policies indicates that the governments are seeking to address the issue, but these policies are not always enforced, oftentimes because of poor governance structures and lack of human resources. One perspective is the solution is not to develop more laws, but to enforce the existing laws and policies (Jimenez 2018). Poor waste management systems and infrastructure a as an impediment to improving the marine debris situation. Furthermore, a program in Grenada, Belize, Jamaica, and St. Vincent and the Grenadines had success increasing awareness of marine litter via education campaigns; however, there remained a practical disconnect in the ability to prevent waste from becoming marine litter (Matthews and Doyle 2017). This is due in part to the fact that most communities lacked appropriate resources for waste management.

DATA GAPS

The study of marine debris is still a relatively new field. Plastics have only been mass-produced for around 60 years, and because most types of plastics are not biodegradable, the long-term persistence of plastics in the environment is unknown (UNEP 2016). Despite a growing body of work documenting the issue of marine debris and its potential impacts on the marine environment, data linking marine debris to biodiversity loss are scant. Existing studies demonstrate the deleterious impacts of marine debris on key ecosystems throughout the world and these impacts could feasibly be interpreted as undocumented threats and stressors to mangroves, seagrass beds, and coral reefs within Latin America and the Caribbean. However, the literature review identified few papers documenting the direct connection between marine debris and marine and coastal biodiversity.

For example, Law (2017) summarized studies on marine debris impacts as follows: one to five impacts on assemblages of species, three studies correlating population-level impacts of marine debris, and several more at the organism level in the literature, demonstrating the limited evidence of population-level effects of marine debris (Figure 5). More studies have documented impacts of micro to macroplastics and, in some cases, the evidence is correlative, rather than causal, depending on the study (Figure 5).

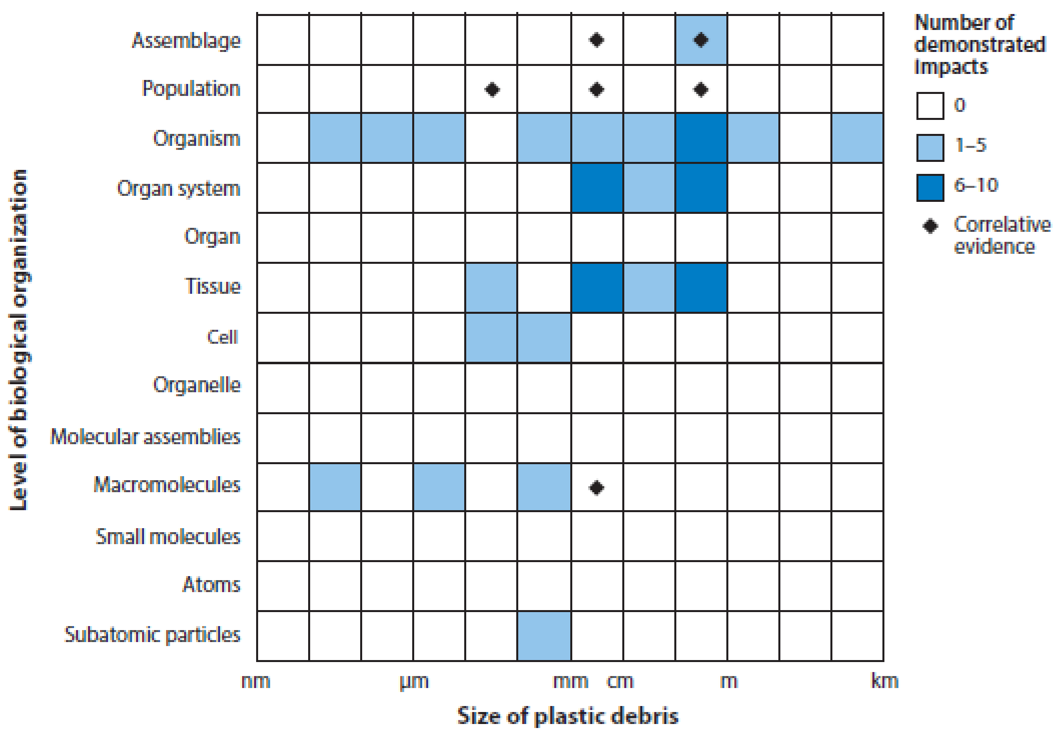

Figure 8. Demonstrated number of impacts of plastic marine debris from the literature based on debris size (x-axis) and level of biological organization (y-axis). Diamonds represent correlative evidence and the shades of blue indicate the number of impacts identified. (Law, 2017).

Significant knowledge gaps remain concerning many aspects of marine debris, particularly in understanding microplastic dynamics in the marine environment and their incorporation into marine food webs. Data gaps include the following:

- Few country-specific studies for target countries
- Few studies linking marine debris impacts and biodiversity
- Limited habitat-level impacts of marine debris
- Lack of population-level impacts of marine debris
- Limited characterization of marine debris pollution in targeted countries
- Invasive species transport by plastics is understudied.

These data gaps make it difficult to assess the potential effects of microplastics on marine biota (CBD, 2016). Toxicity and toxicokinetic data are also lacking for both microplastics and nanoplastics for a human risk assessment (EFSA, 2016). A lack of comparability of microplastic sampling methodologies can hinder the ability of researchers to compare quantitative studies to better determine spatial and temporal patterns of this contaminant (Cole et al., 2011). Regarding microfibers, a key gap in scientific understanding are the total amount of annual microfibers emissions to the environment and the relative contributions of various microfiber transport pathways (NOAA, 2018). Because of the difficulty in conducting observations at sea, many animals that die at sea from entanglement in large debris generally remain unknown.

Few studies have examined policy and legislative tools to reduce plastic pollution, particularly regarding single-use plastics. Although there is considerable evidence demonstrating harmful impacts of plastic debris on individual organisms and many perceived threats to populations, assemblages, and species, there is currently little consensus as to whether these threats have 1) demonstrated ecologically relevant impacts and 2) affect wildlife at population levels. As such, there is a pressing need for robust, quantitative information to predict ecological impacts to species of wildlife that are contaminated with marine debris (Rochman et al. 2016). Given the sustained production of plastics, weak waste management infrastructure in the Latin America and the Caribbean region, and existing studies, the case for the deleterious effects of marine debris on biodiversity is compelling.

Additional Challenges

- Lack of understanding of microplastics dynamics (e.g., sources, sinks, flows and fragmentation rates) in the marine environment
- Incorporation into the food web makes it difficult to assess the potential harmful health impacts on marine biota and humans
- A shortage of infrastructure throughout the region (e.g., technically managed landfills, reliable systems for collection and treatment) means that a substantial proportion of the daily waste that is generated is not collected or contained. (Lu et al. 2013).
- A high degree of recognition and understanding of marine litter issues, but there was a **substantial disconnect** surrounding the local communities' contribution to marine debris (Mathews and Doyle 2012).

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ANNEX A: PROGRAMS FOCUSED ON MARINE DEBRIS

PROGRAM NAME	IMPLEMENTER AND/OR FUNDING SOURCE	COUNTRY OR COUNTRIES	DESCRIPTION
Clean Seas Campaign	UN Environment	Global	UN Environment launched the Clean Seas campaign in early 2017. The aim is to engage governments, the general public, civil society and the private sector under the goal of addressing marine plastic litter.
Convention on Biodiversity	Institutionally linked to the United Nations Environment Programme	Global	Convenes an expert workshop on practical guidance for the prevention and mitigation of the significant adverse impacts of marine debris on marine and coastal biodiversity ad habitats
Global Partnership on Marine Litter (GPML)	United Nations Environment Programme	Global	The GPML was started following the recommendation contained with the Manila Declaration. The partnership was launched in 2012. It supports the Global Partnership on Waste management and aims to protect human health and the environment by reducing and managing marine litter. It is a partnership between international agencies, Governments, NGOs, academia, the private sector, civil society, and individuals.

PROGRAM NAME	IMPLEMENTER AND/OR FUNDING SOURCE	COUNTRY OR COUNTRIES	DESCRIPTION
Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP)	United Nations System, UN Development Programme and International Seabed Society	Global	Working group to assess impacts of marine debris on the environment
Honolulu Strategy	United Nations Environment Programme (UNEP) and National Oceanic and Atmospheric Administration (NOAA) Marine Debris Program	Global	At the Fifth International Marine Debris Conference hosted by NOAA in 2011, the community created the Honolulu Strategy. The Strategy serves as a framework for a comprehensive and global effort to reduce the impacts of marine debris on the environment, economy, and human health.
International Coastal Cleanup (ICC)	Ocean Conservancy	Global	An annual clean-up to remove and record garbage.
International Whaling Commission		Global	Scientific committee to assess the impacts of marine debris on cetaceans

ANNEX B: LIST OF MARINE PROTECTED AREAS

The table indicates the IUCN management category of each MPA, if applicable. The IUCN categories, "classify protected areas according to their management objectives" (IUCN, 2018). The categories are as follows:

- Ia: Strict nature Reserve
- Ib: Wilderness Area
- II: National Park
- III: Natural Monument or Feature
- IV: Habitat/Species Management Area
- V: Protected Landscape/Seascape
- VI: Protected area with sustainable use of natural resources

TABLE C 1. IUCN MANAGEMENT CATEGORY OF EACH MARINE PROTECTED AREA

COUNTRY	MPA	STATUS
Colombia	Corales del Rosario	Status year: 1977. Managed by National Park branch of the Ministry of the Environment and Sustainable Development. IUCN category: II
	El Mono Hernandez	Status year: 2002. Managed by National Park branch of the Ministry of the Environment and Sustainable Development. IUCN category: IV
	Old Providence McBean Lagoon	Status year: 1995. Managed by National Park branch of the Ministry of the Environment and Sustainable Development. IUCN category: II
	Seaflower	Status year: 2005. Managed by National Park branch of the Ministry of the Environment and Sustainable Development. Submitted to UNESCO World Heritage in 2007. Designated SPAW.
	Santuario de Flora y Fauna Ciénaga Grande de Santa Marta (SFF CGSM)	Established 1977. Managed by National Park branch of the Ministry of the Environment and Sustainable Development. Designated SPAW
	Tayrona	Status year: 1969. Managed by National Park branch of the Ministry of the Environment and Sustainable Development. IUCN category: II
Dominican Republic	Arrecifes del Sureste	Status year: 2009. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: IV
	Arrecifes del Suroeste	Established 2009. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: IV
	Bahia de Luperon	Status year: 2004. Managed by Ministry of Environment and Natural Resources. IUCN category: IV
	Boca de Nigua	Status year: 2009. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: V
	Cabo Cabron	Managed by Vice Ministry of Protected Areas and Biodiversity

TABLE C 1. IUCN MANAGEMENT CATEGORY OF EACH MARINE PROTECTED AREA		
COUNTRY	MPA	STATUS
	Cabo Rojo-Bahia de las Aguilas	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: II
	El Morro	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: II
	Estero Hondo	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: Ia
	Francisco Alberto Caamano	Status year: 2009. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: II
	Guaraguao-Punta Catuano	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: VI
	Isla Catalina	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: III
	Jaragua	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: II
	La Caleta	Status year: 1986. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: II. Designated as a Specially Protected Area (Cartagena Convention)
	La Hispaniola	Status year: 2009. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: II
	Laguna Gri-Gri	Status year: 2009. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: III
	Manglares de Estero Balsa	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: II
	Manglares de Puerto Viejo	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: IV
	Parque Nacional del Este	Established 1999. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: II
	Playa Blanca	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: VI
	Playa de Cabo Rojo-Pedernales	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: VI
	Playa Larga	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: VI
	Punta Bayahibe	Status year: 2009. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: III
	Siete Hermanos	Status year: 2004. Managed by Vice Ministry of Protected Areas and Biodiversity. IUCN category: IV

TABLE C 1. IUCN MANAGEMENT CATEGORY OF EACH MARINE PROTECTED AREA		
COUNTRY	MPA	STATUS
Grenada	Molinier-Beausejour Marine Protected Area	Status year: 1999. Managed by Fisheries Division, Ministry of Agriculture, Forestry and Fisheries. IUCN category: II
	Quarantine Point	No Data
	River Sallee Boiling Springs	No Data
	Sandy Island/Oyster Bay	Status year: 2009. Managed by (SIOBMPA) Sandy Island Oyster Bed Marine Protected Area Co-Management Board. IUCN category: II
	Woburn/Clarks Court Bay	Status year: 1999. Managed by the Fisheries Division. IUCN category: II
Haiti	Fort Jacques and Fort Alexandre	Status year: 1968.
	Fort Mercredi	Status year: 1968. IUCN category: V
	La Citadelle, Sans Souci, Ramiers	Status year: 1968. IUCN category: V
	La Visite	Status year: 1983. IUCN category: II
	Lac de Peligre	Status year: 1968. IUCN category: V
	Parc Macaya	Status year: 1983. IUCN category: II
	Sources Puantes	Status year: 1968. IUCN category: V
Honduras	Cayos Cochinos	Status year: 2003. Managed by: Fundacion Hondurena Para la Proteccion y Conservacion De Cayos Cochinos. IUCN category: III
	Roatan	Established 1988. Managed by: Roatan Marine Park. IUCN category: II
Jamaica	Bogue Lagoon Fisheries Sanctuary	Status year: 1979. Managed by: Fisheries Division. IUCN category: IV
	Discovery Bay Fish	Status year: 2009. Managed by: Fisheries Division. IUCN category: IV
	Galleon Fish Sanctuary	Established 2009. Managed by: BREDS: The Treasure Beach Foundation.
	Galleon Harbour Fish Sanctuary	Status year: 2009. Managed by: Caribbean Coastal Area Management Foundation (C-CAM)Ministry of Agriculture & Fisheries. IUCN category: IV
	Middle Morant Cay Nr/Sci R Nature Reserve	No Data
	Montego Bay Marine Park	Status year: 1992. Managed by: Montego Bay Marine Park Trust

TABLE C 1. IUCN MANAGEMENT CATEGORY OF EACH MARINE PROTECTED AREA		
COUNTRY	MPA	STATUS
	Negril Environmental Protection Area	Established 1998. Managed by: National Environment & Planning Agency (NEPA) delegated to Negril Coral Reef Preservation Society (NCRPS)
	Negril Marine Park	Status year: 1998. Managed by: Negril Coral Reef Preservation Society (NCRPS)
	Ocho Rios Marine Park	Status year: 1996. Managed by: National Environment and Planning Agency (NEPA)
	Oracabessa Fish Sanctuary	Status year: 2010. Managed by: Board- Oracabessa Foundation (OBFS), St. Mary's Co-op, Turtle beach, Goldeneye Resort, community members. IUCN category: IV
	Palisadoes/Port Royal Protected Area	Status year: 2005. Managed by: National Environment and Planning Agency (NEPA). Designated as a Ramsar site, Wetland of International Importance
	Port Antonio Marine Park	Established 1993. Managed by: Portland Environmental Protection Association (PEPA)
	Port Maria Marine Park	No data
	Portland Bight	Status year: 1999. Managed by: By status, Natural Resources Conservation Authority (NRCA); By designation, Caribbean Coastal Area Management (C-CAM) Foundation. IUCN category: V
	Priory Marine Park	No Data
	Salt Harbour Fish Sanctuary	Status year: 2009. Managed by: Caribbean Coastal Area Management Foundation (C-CAM). IUCN category: IV
	Three Bays Fish Sanctuary	Established: 2009. Managed by: Caribbean Coastal Area Management Foundation (C-CAM) and Ministry of Agriculture & Fisheries
	Unity Hall Marine Park	No Data
Saint Vincent and the Grenadines	South Coast Marine Park	Established 1987. Managed by: Fisheries Division. IUCN category: II
	Tobago Cays/TCMP	Status year: 1987. Managed by: TCMP Board/ Fisheries Department. IUCN category: II

Data from: http://campam.gcfi.org/CaribbeanMPA/CaribbeanMPA.php

ANNEX C. EXPERTS CONSULTED

EXPERT(S)	ORGANIZATION	COUNTRY	DATE OF INTERVIEW
Maria Lily Zapana; Franco Sandoval Garcia; Ricardo Jimenez; Liliam Morante Torres; Elvis Peralta Roldam	SERNAP; Terra Nuova; GAP; Universidad Nacional San Luis Gonzaga	Perú	November 12, 2018
Eduardo de la Torre and Municipality staff	Municipality of Chincha and Ciudad Saludable	Perú	November 12, 2018
Various staff	FONDEPES (Fondo Nacional de Desarollo Pesquero	Perú	November13, 2018
Sara Purca	Instituto Marino de Perú (IMARPE)	Perú	November 14, 2018
	Associación Unidos por una mejor Chincha	Perú	November 13, 2018
Francesca Accame Mantero	Bioenergia del Peru	Perú	November 20, 2018
Kristal Ambrose	Founder, Bahamas Plastic Movemenet	Bahamas	September 5, 2018
Jimmy Andino, Diana Vásquez	Centro de Estudios Marinos (CEM) Honduras	Honduras	August 31, 2018
José Enrique Barraza Sandoval	Universidad Francisco Gavidia	El Salvador	August 27, 2018
Rainer Christoph	Universidad Francisco Gavidia	El Salvador	August 31, 2018
Ian Drysdale	Healthy Reefs Initiative	Honduras	August 23, 2018
Kitty Edwards	Dept. of Planning and Natural Resources	U.S Virgin Islands	August 29, 2018
Juan Egusquiza Zevallos	Bioenergia del Perú	Perú	November 20, 2018
Juliana A Ivar do Sul	President, Association of Polar Early Career Scientists (APECS)	Brazil	August 28, 2018

EXPERT(S)	ORGANIZATION	COUNTRY	DATE OF INTERVIEW
Nilda Jiménez	Dept. of Natural and Environmental Resources	Puerto Rico	August 30, 2018
Gianina Jimenez	Manager of Sustainability and Institutional Relationships, Coca Cola	Perú	November 14, 2018
Ricardo Jesus Jimenez Vilchez	Terra Nuova	Perú	November 12, 2018
Lilian Morante Torres	GAP	Perú	November 12, 2018
Elvis Peralta Roldan	Univ. Nacional San Luis Gonzaga	Perú	November 12, 2018
Katherine Riquero, General Director for Solid Waste	Ministerio del Ambiente	Perú	November 14, 2018
Hector Soldi	Bioenergia del Peru	Perú	November 20, 2018
Eduardo de La Torre	Ciudad Saludable	Perú	November 12 -14, 2018
Amy Uhrin, Mark Dix, Carlie Herring, Charles Grisafi	NOAA	USA	August 22, 2018
Hernan Velasquez Urbina	Bioenergia del Peru	Perú	November 20, 2018
Franco Sandoval Garcia	RNSIIPG – SERNAP	Perú	November 12, 2018
Maria Lily Zapana	SERNAP	Perú	November 12, 2018