DISCLAIMER: The enclosed document is the outcome of a student project, and does not necessarily represent the views of Sea Education Association or any other individuals referenced or acknowledged within the document.
A MARINE MANAGEMENT PROPOSAL FOR THE SARGASSO SEA
A Marine Management Proposal for the Sargasso Sea
The 2015 SEA Semester: Marine Biodiversity and Conservation class (C-259) would like to express our gratitude to Dr. Tiffany Smythe for her mentorship, dedication, and encouragement throughout the entire process of researching and writing the Marine Management Proposal. We would like to extend a special thanks to Dr. Amy Siuda for contributing feedback on our Management Proposal from a scientist’s perspective. Additionally, we would like to thank Dr. S. Robbie Smith, Dr. Tundi Agardy, Dr. Kristina Gjerde, Dr. Craig McDonald, Christopher Flook, Dr. Tammy Trott, Dr. Kevin Mayall, Noah Chesnin, Dr. Merry Camhi, and Dr. Erik Olsen for sharing their knowledge about marine policy, governance, and stakeholder involvement with us. To Capt. Jason Quilter and the crew of the SSV Corwith Cramer, thank you for giving us the chance to see policy in action in the Sargasso Sea. Finally, we thank Sea Education Association for the incredible opportunity to conduct marine policy research and to apply this research to conservation of the Sargasso Sea, a practical and timely issue. Cover images: © Solvin Zankl.
Table of Contents

1. Table of Contents

2. List of Figures and Tables

3. Executive Summary

4. Introduction

5. Scientific Background
   I. Physical Geography
   II. Bathymetry and Geology
   III. Primary Production
   IV. Ecology

6. Governance and Stakeholder Context
   I. Introduction to the Legal Framework for the Sargasso Sea
   II. Conservation and Management of Areas Beyond National Jurisdiction: International Treaties
   III. Voluntary International Cooperation: The Hamilton Declaration
   IV. Governance of the Bermudian Exclusive Economic Zone
   V. Who Cares about the Sargasso Sea?: A Stakeholder Context
   VI. Methods of Marine Management: Marine Spatial Planning and Marine Protected Areas
   VII. Challenges Associated with the Implementation of MSP and MPAs in Areas Beyond National Jurisdiction
   VIII. Conclusion

7. Biodiversity and Conservation Targets and Priorities
   I. Introduction
   II. Identifying Conservation Targets
   III. Area Assessed for Identification of Conservation Targets
   IV. Habitat Conservation Targets
   V. Sargassum: the Golden Floating Rainforest
   VI. Seamounts: Deep Sea Islands of Biodiversity
   VII. Other Ecosystem Services Provided by Sargassum and Seamount Habitats
VIII. Species Conservation Targets in the Pelagic Region
IX. Stakeholders and Relevant Management Bodies
X. Conclusion

8. Stressors on Biodiversity and Natural Resources
   I. Defining and identifying stressors
   II. Established and emerging approaches to identifying stressors
   III. Major Stressors of the Sargasso Sea
   IV. Climate Change
   V. Plastic Pollution in the Sargasso Sea
   VI. Invasive Species
   VII. Conclusion

9. Fisheries of the Sargasso Sea
   I. Introduction
   II. Fishing in the Sargasso Sea
   III. Fishing in Bermuda
   IV. Fishing Equipment Used in the Sargasso Sea
   V. Current State of Fish Stocks
   VI. High Seas Fisheries Management
   VII. Bermuda Fisheries Management
   VIII. Conclusion

10. Maritime Traffic of the Sargasso Sea
    I. Types of Maritime Traffic
    II. Governance Related to Maritime Traffic
    III. Additional Mechanisms Under the IMO
    IV. Shipping Stressors and Relating Governance
    V. Governance Gaps: Implementation and Enforcement of the IMO’s Regulations by Member States
    VI. Conclusion

11. Recommendations
    A. Background
    B. Recommendations
       I. Management Areas
II. Management Tools and Actions for Designated Management Areas

III. Recommendations by Focus

12. Works Cited

87
List of Figures

Figure 1. Borders of the Sargasso Sea Alliance Study Area are shown in red (Laffoley et al., 2011).

Figure 2. Bathymetry of the Western North Atlantic Ocean, within which lies the Sargasso Sea. The abbreviation “FZ” stands for fault zone (Parson and Edwards, 2011).

Figure 3. An idealized depiction of a Taylor column above the top of a seamount. The down-welling of water from the surface towards the seamount, and then the return of these waters to the surface, serves as a trap for plankton and larvae of fishes and invertebrates. This results in their relatively high populations found around seamounts (White and Mohn, 2004).

Figure 4. Representation of the maritime boundaries set up by the United Nations Convention on the Law of the Sea. This includes what part of the ocean each boundary consists of and the different jurisdictional rights a territory has (Arctic Council, 2009).

Figure 5. A mat of free-floating Sargassum, after which the Sargasso Sea was named (Source: University of Southern Mississippi Gulf Coast Research Laboratory).

Figure 6. Distribution of seamounts in or near the Sargasso Sea (top) and a computer-generated image of a seamount (bottom) (Source: top: WHOI; bottom: NOAA).

Figure 7. Left: Sargassum swimming crab attached to Sargassum. Right: Sargassum pipefish hiding amongst the blades of Sargassum (Source: Solvin Zankl/National Geographic).

Figure 8. Map of Sargassum distribution in the fall and spring (Source: SEA).

Figure 9. Bathymetry map of the Sargasso Sea, showing seamounts that reach within 2000m of the surface in green (Source: SEA).

Figure 10. Atmospheric CO2 since 1960, measured in Mauna Loa, Hawaii. The curve shows a steady increase in atmospheric CO2 coupled with an increase in dissolved CO2 and subsequent decline in ocean pH (Source: NOAA PMEL Carbon Program).
Figure 11. Plastic concentration in the Sargasso Sea. This figure depicts the average concentration of plastics within the Sargasso Sea. Data was obtained using data from satellite imagery, drifters, reanalysis winds, and hydrographic profiles. The black line indicates the contour of the 10-year mean surface circulation. Graphic reprinted with the permission of AAAS (Law et al. 2010).

Figure 12. Discharge provisions of MARPOL Annex V. This chart depicts a simplified version of the discharge provisions of the revised MARPOL Annex V. This figure was taken from MARPOL and is only to be used as a reference, not a substitute for the comprehensive provisions in the revised MARPOL Annex V or the guidelines for implementation. The MARPOL Annex V revisions outlined in this table entered into force on 1 January 2013 (Source: IMO 2013).

Figure 13. Invasion curve depicting costs associated with managing invasive species based on time (Source: North American Invasive Species Network).

Figure 14. Ships take on ballast water to make up for lost weight while not carrying cargo. This results in the intake of organisms from one area (1) when cargo is loaded ships then discharge ballast water, this results in the output of organisms into new environment (3). This exchange of water is the main vector of introduction of non-native and invasive species (Source: NOAA).

Figure 15. Sightings of lionfish from 1985-2014 (Source: Florida Fish and Wildlife Conservation Commission).

Figure 16. Map showing spatial distribution of catches in the Sargasso Sea during the year 2006. The red areas indicate landings of greater than 100 tons, while dark blue indicates a value of zero. Note that Bermuda’s EEZ is almost entirely dark blue. This figure was provided by the Sargasso Sea Alliance (Sumaila et al., 2013).

Figure 17. Map showing the Regional Fisheries Management Organizations (RFMOs) in the Sargasso Sea. (Source: SEA).

Figure 18. Map constructed with data from the Automatic Identification System (AIS), showing traffic volume along established shipping routes (Kaluza et al., 2010).

Figure 19. Map constructed with data from the World Meteorological Voluntary Observing Ships’ Scheme (VOS), showing traffic volume along established routes (NCEAS, n.d.; Halpern et al., 2008).

Figure 20. Map showing shipping routes and volume of traffic (Source: SEA).
Figure 21. A pictorial representation of Annex V under MARPOL describing where one is allowed to dispose of garbage (Source: United States Coast Guard Auxiliary.).

Figure 22. Map showing all resources and uses of the Sargasso Sea (Source: SEA).

Figure 23. Map depicting the areas of the Sargasso Sea marine management plan (Source: SEA).

Figure 24. The steps for establishing increased governance in the Sargasso Sea under a central governance body that can implement a management plan for the Sargasso Sea (Source: SEA).

Figure 25. A schematic for classifying stakeholders by taking into consideration key characteristics of common stakeholder groups. Original graph made with information from Pomeroy and Douvere, 2008.

List of Tables

Table 1. The annexes of MARPOL (IMO 2015).
Executive Summary

The Sargasso Sea, an ocean area in the North Atlantic of great economic and cultural importance, has been internationally recognized as ecologically sensitive. Despite this combination of importance and fragility, very few management efforts exist, mainly due to the area’s location in the high seas beyond national jurisdiction. Sea Education Association (SEA) has worked for over 40 years to better understand the Sargasso Sea by conducting research to facilitate sustainable and responsible management of this sensitive and important habitat. In addition to scientific research, SEA has recently expanded its focus to include policy. This management proposal was compiled by a research team consisting of 20 advanced undergraduate college students working at SEA and focuses on recommendations for better management of the Sargasso Sea. The recommendations are based on three months of work, involving science and policy research, a five-week research cruise through the Sargasso Sea, and interactions with stakeholders, science experts, and policy experts.

Through the recommendations of this management proposal, the research team aims to:

1. Protect and promote conservation of biodiversity and natural resources in the Sargasso Sea by minimizing conflict between human uses and ecosystem health, and encouraging sustainable use of ecosystem services.
2. Facilitate sustainable use and sustainable economic development in the Sargasso Sea for Bermuda and the global economy.
3. Work with stakeholders and within existing and new regional and international legal frameworks to manage the biological, ecological, and human needs of the Sargasso Sea.
4. Take into account future uses of the Sargasso Sea and anticipate changes in the short and long term.

Through the research process, the research team has found that:

The Sargasso Sea lies in the middle of the North Atlantic Ocean, and is bound on all sides by ocean currents. Because the area lies mostly beyond national jurisdiction, with the exception of Bermuda’s Exclusive Economic Zone, any country has the right to extract resources from this area under the “freedom of the seas” doctrine. Many valuable and sensitive animals, including Atlantic bluefin tuna, porbeagle sharks, dolphins, whales, and other top predators, inhabit the Sargasso Sea. Tuna, other tuna-like species, and North Atlantic right whales are important conservation targets. Important habitats include seamounts and aggregations of the unique floating seaweed Sargassum. The ecological communities of the Sargasso Sea are impacted by climate change, plastic pollution, invasive species, fishing, and other stressors. Climate change, in particular, is the most overarching stressor facing the Sargasso Sea; it contributes to ocean acidification, increasing sea surface temperatures, and rising sea levels.

Little progress has been made to manage and protect the Sargasso Sea. Though the international community has shown some interest in protecting this area, most notably through the creation of the Hamilton Declaration and the Sargasso Sea Commission, there is a lack of governing authority that would allow for the effective management and protection of the Sargasso Sea. Care must be taken to include stakeholders in any management planning process, as it helps build a constituency and increases the
likelihood that a spatial management plan will be supported and successful in the long-term. In the case of the Sargasso Sea, these key stakeholders include the nations of Bermuda and the United States, the international fishing and shipping communities, and multiple intergovernmental and United Nations agencies.

Fishing and shipping are vital to the global economy but negatively impact the environment. With the North Atlantic being the most heavily trafficked ocean in the world, the Sargasso Sea could face high levels of environmental stress from commercial shipping, but the specific impacts remain under-researched. The International Maritime Organization (IMO) and the International Convention for the Prevention of Pollution from Ships (MARPOL) provide avenues for managing areas of the Sargasso Sea through different levels of regulation and protection. An example of this regulation is designating an area as a MARPOL Special Area or a Particularly Sensitive Sea Area under the IMO. The Sargasso Sea is fished by nations such as Mexico, Venezuela, Spain, Japan, and the United States which collectively catch thousands of tons of fish from the Sargasso Sea every year, working mainly in the western portion and outside the border of the Bermuda Exclusive Economic Zone. Management falls to various regional fisheries management organizations (RFMOs). There are four RFMOs with jurisdiction over the Sargasso Sea, each protecting a different area or species. None of them, however, completely encompass the entire ecosystem. Overlapping jurisdictions and weak enforcement power have created a fragmented and ineffective system of regulation, a governance challenge that applies generally across this area.

To achieve the four goals, the team has identified several management areas with associated management strategies and makes multiple sea-wide recommendations:

In a buffer zone around the **New England Seamount Chain and the Corner Seamount Chain**, where the ocean floor comes within 2000 m of the water surface, bottom trawling should be prohibited, as bottom trawling is an unsustainable fishing practice that drastically impacts seamount communities. Furthermore, a seasonal closure on most types of fishing should be imposed in order to mitigate impacts of overfishing migratory fisheries and fisheries associated directly with the seamount community.

The **Western Management Area (WMA)**, extending from the western end of the Sargasso Sea to 065°W, excluding Bermuda’s EEZ, should be designated a Special Area under MARPOL Annexes I, II, IV, and V, such that stringent regulations on ship discharge and dumping will apply. A moratorium on *Sargassum* harvesting should be established through the International Commission for the Conservation of Atlantic Tunas (ICCAT), along with Voluntary Reporting Systems for North Atlantic right whales and for *Sargassum* aggregations. Although it is desirable to protect areas of large *Sargassum* aggregations, the data to precisely identify these locations do not currently exist. The signatories of the Hamilton Declaration are urged to support further research in this area.

**Four research** stations for long-term data collection are proposed, to increase our **scientific understanding** of the Sargasso Sea ecosystem. One research station should be located in the New England Seamount Area, one in the Corner Rise Seamount Area, one at approximately 30°N x 074°W, and one at approximately 30°N x 047°W. The signatories of the Hamilton Declaration should support the establishment of these research areas for studying environmental factors and the impacts of human uses, including *Sargassum* harvesting, deep-sea mining, and physical parameters of water quality. Additionally, the signatories should support further research on invasive species in the Sargasso Sea, on the impact of acoustic pollution on the
environment (with particular focus on marine mammals), and on maritime traffic location and density in the Sargasso Sea.

**Climate change** is the most overarching stressor on biodiversity in the Sargasso Sea. Specific recommendations focus on mitigating other environmental stressors to help reduce the synergistic effects of global climate change, since only small volumes of carbon emissions originate in the Sargasso Sea.

To create an **effective governance structure** for the Sargasso Sea, an area beyond national jurisdiction, the Sargasso Sea Commission should work to elevate the Hamilton Declaration to a legally binding agreement, gradually include more nations once this agreement is in place, and ultimately establish a Regional Ocean Management Organization under the United Nations when support is widespread. As a first step, the Sargasso Sea Commission should work to establish a stronger position in each commissioner’s respective government.

To protect **threatened and vulnerable species**, a Sargasso Sea Partnership for Endangered or Threatened Migratory Species should be established under United Nations Environment Programme (UNEP), using the Sister Sanctuary Partnership (Stellwagen Sanctuary and the Bermudian government) for humpback whales as a starting point. The Partnership should include a wide range of vulnerable or threatened marine species found in the Sargasso Sea. Such species are listed by the International Union for Conservation of Nature (IUCN) red list, and include marine mammals (right whales, humpback whales), sharks (whale sharks, tiger sharks, porbeagle sharks), and rays (manta and spotted eagle rays).

To support expanded and more environmentally **sustainable fisheries**, the proposal team encourages the use of fishing techniques that are more targeted towards specific species, and further recommends research into new fishing gear that minimizes bycatch. These recommendations should be implemented through ICCAT and other interested organizations using buyback programs of old gear to incentivize the use of new sustainable technology. Also, the proposal team recommends a satellite-based monitoring system of illegal fishing activity be implemented through the INTERPOL Fisheries Crime Working Group and the IMO. Additionally, the Sargasso Sea Commission should encourage sustainable growth of Bermudian fisheries and aquaculture industries, and an increase in the capture and consumption of locally available species such as yellowfin tuna, wahoo, and the invasive lionfish.

To reduce **plastic debris**, a significant environmental problem in the Sargasso Sea, the Sargasso Sea Commission should explore potential international collaboration for land-based management strategies to minimize plastic input to the Sargasso Sea, since 80% of plastics in the ocean come from land-based sources. Furthermore, Bermuda should implement an effective plastics recycling and reduction program to minimize Bermuda’s plastic input to the Sargasso Sea while serving as a role model for other countries.

To minimize the environmental impact of **maritime traffic**, the signatories of the Hamilton Declaration should work within and with the IMO to increase international environmental standards, make environmental regulations more stringent, and carry out more on-the-ground inspections. These increased environmental standards should include effective waste treatment equipment and equipment that reduces noise pollution. The international community should push for the signing and ratification of the Ballast Water Convention. The Sargasso Sea commission and the signatories should work with the IMO to establish shipping lanes to minimize potential impact on Sargassum. The signatories should also work towards establishing a traffic monitoring agency.
under the expanded Sargasso Sea Commission, as outlined in the Governance section.

To minimize the environmental impact of seabed mining, the proposal team recommends that seabed mining be prohibited in the entire Sargasso Sea. In the future, the International Seabed Authority may conduct impact assessments to determine whether mining would have significant adverse impacts on ecosystems in the water column or on the seafloor, including seamounts. If mining activities are found to have significant adverse impacts, the International Seabed Authority should ensure that mining on seamounts and the seabed continue to be prohibited.
Introduction

Hannah Freyer, Caroline Graham, & Callie Schultz
Introduction

The unique and fragile ecosystem found in the Sargasso Sea is essential for the health of important fish species such as Atlantic bluefin tuna, mahi mahi, and marlin. In addition to supporting global fish markets, this ecosystem provides shelter and food for threatened and endangered species and ten species found only in the Sargasso Sea, as well as hundreds of other migratory bird and fish species. The Sargasso Sea is situated in the North Atlantic subtropical gyre. With the exception of Bermuda, this sea falls outside of any country's jurisdictional boundaries. It is utilized by nations around the world and supplies important resources, including food, for countries such as Bermuda, the United States, and Japan. The numerous human activities that take place in the Sargasso Sea, including fishing, shipping, recreation and research, put increasing pressure on the Sargasso Sea ecosystem and the many organisms that rely on this region.

Even with this influx of human activity in the Sargasso Sea, there is still time to implement effective management measures to ensure the protection of this area and its valuable resources, as well as to mitigate potential conflict between stakeholders. However, those invested in the Sargasso Sea must act quickly and effectively to ensure the successful conservation of this valuable ecosystem.

Sargassum, a floating seaweed circulated by currents throughout the North Atlantic Ocean, forms the basis for these unique ecosystems on the surface of the open ocean (Butler et al., 1983; Casazza and Ross, 2008). In addition to supporting economically important migratory fish species, the Sargasso Sea acts as a nursery ground for other economically important species such as American and European eels and mahi mahi (Laffoley et al., 2011). Regardless of the numerous stressors affecting these organisms, including climate change overfishing, and pollution, little has been done to try to protect this area in order to ensure ecosystem health and maintain the many benefits derived from this ecosystem.

Effective management systems need to be implemented to protect the unique ecosystem of the Sargasso Sea and the species it supports. Although the Sargasso Sea has been designated as an Ecologically and Biologically Significant Area under the United Nations Convention on Biological Diversity, effective protection and management strategies have been difficult to implement due to its location primarily within an area beyond national jurisdiction and the lack of a comprehensive binding management system. International cooperation through the Hamilton Declaration, a non-legally binding agreement that established the Sargasso Sea Commission, has been organized with the intention of protecting the Sargasso Sea. However, there is no substantial international governing framework in place for managing the Sargasso Sea and other areas beyond national jurisdiction.

This document proposes a management plan that addresses the primary challenges concerning the Sargasso Sea.
in order to better manage the region. The goals and specific objectives for this management plan are as follows:

**Goal 1: Protect and promote conservation of biodiversity and natural resources in the Sargasso Sea by minimizing conflict between human uses and ecosystem health, and encouraging sustainable use of ecosystem services.**

Specific objectives are as follows:

1. Reduce the impacts of vessel traffic on Sargasso Sea species and habitats including but not limited to high-density areas of *Sargassum*.
2. Ensure sustainable yield of commercially targeted fish species within the Sargasso Sea, including but not limited to Atlantic Bluefin tuna, taking into consideration scientifically defined catch limits.
3. Reduce the input of land-based plastic pollution from Bermuda into the Sargasso Sea.
4. Minimize ship discharges and the dispersal of other shipborne pollutants in the Sargasso Sea.
5. Promote scientific research, including long-term ecological monitoring of specific areas of concern, within the Sargasso Sea.

**Goal 2: Facilitate sustainable use and sustainable economic development in the Sargasso Sea for Bermuda and the global economy.**

Specific objectives are as follows:

1. Promote sustainable new and expanded human uses that do not threaten the ecosystem health of the Sargasso Sea.
2. Develop sustainable fisheries of a broad range of species and find ways to promote use of underutilized fishery resources.
3. Increase sustainable economic opportunities for Bermudian fisheries and seafood industries within and beyond the Bermuda Exclusive Economic Zone.

**Goal 3: Work with stakeholders and within existing and new regional and international legal frameworks to manage the biological, ecological, and human needs of the Sargasso Sea.**

Specific objectives are as follows:

1. Facilitate coordinated management of the Sargasso Sea in the short term by convening regularly for meetings, under the auspices of the Sargasso Sea Commission, with interested countries, international competent authorizes such as RFMOs, and partners.
Introduction

2. Facilitate coordinated management of the Sargasso Sea in the mid- to long-term by using the consensus developed around the Hamilton Declaration and the Sargasso Sea Commission to develop a regional seas agreement and implementing organization.

3. Work toward long-term coordinated management of the Sargasso Sea by exploring the creation of a new regional ocean management organization, established through a legally-binding international treaty under the auspices of the United Nations.

4. Build a constituency for responsible management of the Sargasso Sea through the engagement of stakeholders and the public.

Goal 4: Take into account future uses of the Sargasso Sea and anticipate changes in the short and long term.
Specific objectives are as follows:

1. Promote scientific research on existing and proposed future human uses and the sustainable use of genetic resources.

2. Implement proactive management approaches that consider the potential effects of environmental changes and new and emerging human uses.

In order to realize these goals and objectives, specific areas of the Sargasso Sea have been selected for management based on ecological, human use, and political criteria. From an ecological perspective, the planning team selected areas for management based on the presence of Sargassum and seamounts that were within 2000 meters of the ocean surface. These were both important considerations in the designation of the Sargasso Sea as an Ecologically and Biologically Significant Area. The human use criteria included the consideration of high-density shipping and fishing activities, and the economic value of the areas based on fishery landings. Finally, the planning team considered areas for management based on their location in the high seas, while recognizing Bermuda’s ongoing conservation efforts within their own Exclusive Economic Zone.

This proposal is part of an ongoing effort by Sea Education Association to better understand the Sargasso Sea, from both a scientific and a policy perspective, in order to effectively influence the conservation and management of this critical area in the North Atlantic Ocean. Prior to developing this proposal, twenty students of Sea Education Association Class C-259, Marine Biodiversity and Conservation, conducted extensive research on current international and Bermudan marine policy and governance, met with national and international marine policy and management experts, and conducted scientific research on a five-week research cruise across the Sargasso Sea. The content of this proposal was developed through a series of workshops in which all twenty C-259 students participated in a consensus-based planning and decision-making process. This process replicated the challenging interdisciplinary, collaborative nature of real-world marine conservation planning and policy processes.

The intended audience for this proposal is the Sargasso Sea Commission and other interested stakeholders and decision-makers. This document includes a scientific background, context for governance and stakeholder involvement, biodiversity and conservation targets and priorities, biodiversity conservation stressors and issues, as well as information on fishing and shipping activity in the Sargasso Sea. It concludes by defining specific marine management areas and recommends management measures for these specified areas in the Sargasso Sea. This management plan will ultimately be presented to the Sargasso Sea Commission, Sea Education Association partners, and other interested parties for their consideration in future management of the Sargasso Sea.
Scientific Background

Anthony Daley, Helena McMonagle, & Katarina Rolf
Scientific Background

The Sargasso Sea lies within the North Atlantic Subtropical Gyre, a major ocean circulation pattern, making it an important part of the world ocean. It is the only sea in the world that is bounded not by land, but by ocean currents. The Sargasso Sea has played an important role in our understanding of the world’s oceans since research began in this region in the 1870s with the HMS Challenger (Roe et al., 2011). For one, the world’s most abundant photosynthesizing organism, a bacteria of the genus Prochlorococcus, was discovered in the Sargasso Sea (Chisholm et al., 1988). Additionally, early findings of deep sea organisms and deep ocean eddies were made in the Sargasso Sea (Swallow, 1971). This region is also home to one of the oldest running marine time series, Hydrostation S, which has been collecting oceanographic data since 1954 and has contributed significantly to our understanding of how our oceans are changing over time.

Named after the genus of the free-floating seaweed, Sargassum, that occurs throughout the region, the Sargasso Sea was recently designated by the Convention on Biological Diversity as an Ecologically or Biologically Significant Area (EBSA)(NOAA, 2014). This distinction was given due to the unique combination of its physical, chemical, geological, and biological oceanographic features. These features work together to make the Sargasso Sea a particularly unique, productive, and biodiverse ecosystem that is worthy of prioritization in marine conservation efforts (Roe et al., 2011). This broad scientific background section is designed to provide context and meaning to the Marine Management Proposal for the Sargasso Sea that will be introduced in later sections of this document. For the purposes of this scientific synthesis, the same borders of the Sargasso Sea that were agreed upon by the Sargasso Sea Alliance’s “Summary Science and Supporting Evidence Case” will be used (Figure 1, Laffoley, et al., 2011).

Physical Geography

Five main currents bound the Sargasso Sea on four sides. The Gulf Stream creates the boundary for the Western Sargasso Sea; the North Atlantic Drift borders the north Sargasso Sea, the Canary Current the east, and both the North Equatorial Current and the Antilles Current to the south (Figure 1). The Canary Current is more diffuse and variable than the other four currents bordering the Sargasso Sea, making it more difficult to use as a hard boundary in conservation efforts. The eastern boundary is therefore considered to be to the west of the Mid-Atlantic Ridge in the western basin of the Atlantic Ocean (Figure 1).

These currents move in a clockwise, rotation around the Sargasso Sea. Due to the spinning of the Earth, overall movement of the water is directed in towards the middle of the gyre, which is explained by the physical process of Ekman transport. The cold water mass from the northern Sargasso Sea and the southern warm mass of water converge in the center of the Sargasso Sea causing downwelling. This movement creates a high rate of accumulation within the Sargasso Sea for anything that is picked up by the currents. This includes Sargassum, a floating seaweed discussed in the earlier section, as well as debris such as plastic (for further information, see Biodiversity).
Scientific Background

Stressors). These currents can trap pollutants for periods of up to 50 years (Maximenko et al., 2011).

Within these large boundaries, the Sargasso Sea is also influenced by rings and eddies (Roe et al. 2011). A ring forms when a meander of the Gulf Stream pinches off and moves independently as an eddy. The currents bordering these rings move at relatively high speeds, reaching up to 1 knot and effectively isolate both the water and the organisms inside. Cold water rings have a cyclonic circulation that can last within the Sargasso Sea for years (Cormillon et al., 1986).

There are also smaller mode water eddies, called mesoscale eddies, that form in the Sargasso Sea. They form in midwater and rotate below the surface with diameters from tens to hundreds of kilometers wide. These different types of eddies create localized areas of upwelling and downwelling, impacting the upper layers of the Sargasso Sea by mixing surface and deep water. These areas of upwelling impact water salinity, nutrient content, and heat, which in turn create areas of high biological productivity.

An additional physical feature of the Sargasso Sea is the Subtropical Convergence Zone (STCZ, 20°N - 30°N). Here, northern and southern surface waters converge and create distinct temperature fronts within the upper 150m of the water column in fall to spring seasons (Katz 1969). This frontal area forms two or three bands every year and creates a dynamic seasonal feature of the Sargasso Sea. When this convergence occurs, water from both sides entrains into these fronts, creating strong eastward countercurrents or frontal jets (Mied et al. 1986). This pattern of convergence contributes to the accumulation of both plankton and debris and is relatively nutrient rich compared to the rest of the nutrient poor Sargasso Sea.

Bathymetry and Geology

The Sargasso Sea primarily lies above the abyssal plain, between the continental slope of the eastern seaboard of North America to the Mid Atlantic Ridge, a spreading ridge system at the eastern edge of the North American tectonic plate. The bathymetry of the Sargasso Sea is characterized by several important features including the Hatteras, Nares, and Sohm Abyssal Plains, the Blake Spur, Kane, and Atlantic fault zones, the Mid Atlantic Ridge, and several groups

Figure 2. Bathymetry of the Western North Atlantic Ocean, within which lies the Sargasso Sea. The abbreviation “FZ” stands for fault zone (Parson and Edwards, 2011).
of seamounts (Figure 2). The bathymetry of the Sargasso Sea was created through rifting, break-up, and seafloor spreading, with the exception of the seamounts that were formed by volcanic activity. Today, the region experiences little to no earthquake activity and no volcanic activity (Parson and Edwards, 2011).

Seamounts are dramatic bathymetric features formed on the seafloor by underwater volcanoes that have become extinct (Epp and Smoot, 1989). Seamounts can be circular or elliptical in shape (Epp and Smoot, 1989). Over 800 seamounts have been found in the North Atlantic (Epp and Smoot, 1989), many of which are within the Sargasso Sea. These include the New England seamount chain and Corner Seamounts, created 103–82 million years ago and 70–75 million years ago, respectively, by the same hotspot (Parson and Edwards, 2011). These seamounts fall within the high seas regions of the Sargasso Sea, while the Muir seamount chain, Bowditch seamount, Crescent seamount, Argus Bank, and Challenger Bank seamounts fall within Bermuda’s Exclusive Economic Zone. In fact, the island of Bermuda itself was created by extinct volcanoes, though it is not considered a seamount (Parson and Edwards, 2011). The height that the seamounts of the Sargasso Sea rise above the abyssal plain varies, with the Corner Seamounts rising as high as 4000m from the seafloor and some of the New England and Corner seamounts sitting as low as 1km below the surface of the ocean. Seamounts are known to host particularly biodiverse and productive ecosystems, due to the Taylor Columns that form around them (White and Mohn, 2004, Figure 3). Taylor Columns are eddies that can form around seamounts. They accumulate small fish, larvae, and plankton, which provide a food source for a variety of species living attached to or nearby the seamount itself (White and Mohn, 2004). The currents that surround seamounts are crucial to the biological resources that are found associated with them (Smith, 2014).

Though the abyssal plain of the Sargasso Sea remains relatively understudied, some deep sea minerals have been discovered within and on the ocean floor. Minerals of industrial interest that have been discovered include manganese nodules, cobalt-rich crusts, gas hydrates, polymetallic sulphides, and hydrocarbons (Roe et al, 2011). There is also little information regarding the impact that mineral extraction would have on biological resources on the seafloor (Smith, 2014), a topic that would need to be researched further in order to understand how mining could affect seamount and abyssal plain ecosystems.

Primary Production

The Sargasso Sea surface waters have low nutrient levels and are classified as oligotrophic. However, despite these low nutrient levels, it is a high net annual primary production rate that parallels levels found in some of the world’s most productive regions (Steinberg et al. 2001). This productivity is attributed to a number of factors including the location of the Sargasso Sea in the subtropics, the production of carbon in surface waters by photosynthesis, and differences in phytoplankton assemblages as well as associated nitrogen fixation. The annual net community production, which is defined as the balance between primary production and plankton respiration, in the Sargasso Sea’s euphotic zone can be significantly higher than in some sub-polar regions. The Sargasso Sea’s net primary production has been estimated to be three times as high as one of the world’s most recognized productive sea areas, the Bering Sea (Emerson et al. 2001). However, the majority of the primary production in the Bering Sea is channeled directly into harvestable resources whereas bacteria recycle the Sargasso Sea primary productivity.

The Sargasso Sea plays a key role in global carbon sequestration. The ocean uptake of carbon dioxide has increased proportionally with the release of anthropogenic carbon dioxide into the atmosphere. The oceans of the world sequester a large quantity of carbon dioxide from the atmosphere through a combination of chemical and physical processes. These processes move dissolved inorganic carbon from surface waters into deeper water through ocean current movements. The particulate matter eventually sinks to the deep ocean, a process referred to as a biological pump. The biological pump and other
Scientific Background

processes are major factors for controlling the carbon dioxide concentration in the atmosphere and have a significant impact on the global climate system.

Ecology

The Sargasso Sea is a unique region in the North Atlantic where *Sargassum* – a completely open ocean type of seaweed – is distributed and used as a means of habitat for many kinds of different organisms (Winge, 1923; Parr, 1939; Butler et al. 1983). There are two species of *Sargassum* which act as foundational species for a diverse range of associated sessile and mobile flora and fauna. Age of *Sargassum* can be determined by coloration; younger *Sargassum* are yellow or yellow-green and older *Sargassum* are darker in coloration, brown with brittle inner branches (Stoner and Greening, 1984). The *Sargassum* community is especially unique because the habitat is holopelagic – living in the open ocean for their entire life cycle – where some species depend directly on the *Sargassum* itself for habitat or otherwise; whereas other species, mainly large predatory fishes, have a more indirect dependence on the habitat that *Sargassum* provides by feeding on smaller fishes that inhabit the seaweed.

A relatively recent review of the animals that inhabit *Sargassum* show a large range of animal types and a high number of different species: *Sargassum* supports small and large colonial organisms, fungi, greater than 100 species of invertebrates, over 100 species of fishes and four kinds of sea turtles (Coston-Clements et al., 1991). The *Sargassum* community should be noted for its endemic species as well as the large amount of organisms in the Sargasso Sea on the IUCN Redlist for Threatened and Endangered Species. In the Sargasso Sea, there are at least ten endemic species, which cover a number of different taxa (Laffoley et al., 2011). Many of the endemic species from this region exhibit camouflage and plant-part mimicry as a means to hide from predators (Hacker and Madin, 1991). One of the endemic species, the slender *Sargassum* shrimp, also happens to be the most abundant invertebrate and possibly the most abundant macro organisms in the Sargasso Sea (Stoner and Greening; Huffard et al. 2014). On a smaller scale, but not any less important, is the plankton community in the Sargasso Sea. The greatest abundance of plankton groups falls within the subtropical convergence zone (Anderson et al., 2011).

Since this gyre takes up a large part of the North Atlantic Ocean, the complexity of the system needs to be taken into consideration. This complexity is expressed in the temporal, geographical and seasonal variation of *Sargassum* and the associated species that depend on their mobile habitat (Fine, 1970; Gower and King, 2011; Huffard et al., 2014). Aggregation of *Sargassum* is not found everywhere in the North Atlantic gyre; there are plenty of areas where *Sargassum* is void at any given moment. Below the surface, open ocean species are found opportunistically feeding or migrating. *Sargassum* was named an essential fish habitat and a number of ecologically and

Figure 3. An idealized depiction of a Taylor column above the top of a seamount. The down-welling of water from the surface towards the seamount, and then the return of these waters to the surface, serves as a trap for plankton and larvae of fishes and invertebrates. This results in their relatively high populations found around seamounts (SourceWhite and Mohn, 2004).
economically species spawn in the Sargassum (NMFS, 2003). Commercially important species that spawn or breed in the Sargasso Sea include, but are not limited to, White and Blue Marlins, European and American eels and tuna species (Pendleton et al., 2014). Many of these commercially important fish species have evolved over time to cross great expanses as part of their life strategy.

Migratory species like the Bluefin Tuna, for example, dive to great depths (>1000 m) and frequently make trans-Atlantic trips from the Gulf of Mexico in the United States to the Mediterranean Sea in Europe (Block et al., 2001). Open ocean species are generally not roaming the ocean randomly, rather they are frequenting hotspot areas in the oceans where biological activity is booming in an otherwise dispersed habitat (UNEP, 2006). Great examples of productivity hotspots in the open ocean are seamounts – regions of the seafloor that rise up closer to the surface resembling underwater volcanoes. The interaction between the water column and these fixed benthic habitats generate a unique community including fishes, corals, sponges, sea squirts, hydroids and anemones (UNEP, 2006). Diversity and endemism – meaning that species are unique for their geographic location – are especially high between and among different seamounts in the Sargasso Sea (Shank, 2010). One of the most important indices of ecosystem health is the measure of biological diversity (Cowen et al., 2007). Biodiversity, as an ecosystem function, is a major concern for Sargassum and seamount communities in the face of climate change.

VI. Anthropogenic Impacts – Climate Change and Marine Debris

The Sargassum community is currently of particular importance due to the declining measures of biodiversity and evenness when compared to the 1970’s (Huffard et al., 2014). There have been shifts in the abundance of certain species, but overall the Sargasso Sea is subject to a great deal of variation due to its size and complex processes that occur throughout the open ocean (Fine, 1970; Huffard et al., 2014). Sargassum has been named a critical habitat for a number of fishes, many of them migratory, in terms of important biological and economic views (Moser et al., 1998). Migratory species are particularly vulnerable to climate change impacts as they rely on productive seasonal habitats which are geographically separated from each other (Robinson et al., 2009). The open ocean is large and diffuse; however, it has been looked at as a dump for all wastes in the past and anything that is released into the ground or atmosphere eventually finds its way into the great world ocean.

With climate change knocking on our door, conservation and management strategies need to be rethought in order to tackle the world’s most powerful threat. There is limited evidence of climate change impacts in the Sargasso Sea according to the Bermuda Atlantic Time-series Study (BATS), (Lomas, 2011). On the other hand, we can look at this as an opportunity to protect the Sargasso Sea while it remains relatively healthy rather than try and combat the effects of climate change after they have started devastating life forms and habitats.
The Sargasso Sea lies beyond the jurisdictional boundaries of any nation, with the exception of Bermuda. As an Area Beyond National Jurisdiction (ABNJ), the Sargasso Sea is governed by the “freedom of the seas” doctrine, which gives any nation the right to extract resources from this area, with some limitations. Since all nations have access to this area and its resources, the governance of the Sargasso Sea falls onto the international community as a whole and the stakeholders, organizations, or individuals that benefit from or have an interest in the ecosystem services of the area. The key stakeholders in the Sargasso Sea include the nations of Bermuda and the United States, the international fishing and shipping communities, and multiple intergovernmental and United Nations (UN) agencies. Despite several international treaties through the United Nations, including the UN Convention on the Law of the Sea, the UN Fish Stocks Agreement, and the UN Convention on Biological Diversity, that call for the protection and management of ABNJs like the Sargasso Sea, little progress has been made to manage and protect this area. Even though the international community has shown some interest in the protection of the Sargasso Sea, through the creation of the Hamilton Declaration and the Sargasso Sea Commission, there is a lack of governing authority that allows for the effective management of the Sargasso Sea through the implementation of management tools such as Marine Spatial Planning (MSP) and Marine Protected Areas (MPAs). These management tools can act as effective frameworks for designating specific areas of management to address points of concern relating to the ecology and human uses of the Sargasso Sea.

Hannah Freyer, Caroline Graham, Sabrina Hutchinson, & Mareike Duffing Romero
Introduction to the Legal Framework for the Sargasso Sea

The Sargasso Sea is of interest to many stakeholders, including many nations of the world, but is located beyond national jurisdictional boundaries where there is no one established governing body. With increasing use of the Sargasso Sea, there is an increased need to bring nations together to create a comprehensive legal framework for the sustainable use of the Sargasso Sea. Governance of the Sargasso Sea is shared between the government of Bermuda and the international community. Although many nations have an interest in the Sargasso Sea, the United States, United Kingdom, Monaco, Azores, and Bermuda have taken the initiative to collaborate to create an agreement known as the Hamilton Declaration, which demonstrates their interest in protecting the Sargasso Sea. However, the Hamilton Declaration is not legally binding, and the Sargasso Sea Commission, created under the Declaration, does not have the authority to implement and enforce laws. In addition, there are several international treaties such as the United Nations Convention on the Law of the Sea (UNCLOS), the United Nations Fish Stocks Agreement, and the Convention on Biological Diversity, which are relevant to the Sargasso Sea and attempt to address the need for management in Areas Beyond National Jurisdiction (ABNJ). However, these agreements and governance mechanisms currently lack the authority to collaboratively create and enforce a legally-binding management regime for the Sargasso Sea.

Marine Areas Beyond National Jurisdiction represent nearly half of the planet’s surface and are the largest reservoir of biodiversity (Gjerde et al., 2012, Rochette et al., 2014). The designation of these areas as ABNJ comes from the United Nations Convention on the Law of the Sea, which is the basis of all maritime law. Areas Beyond National Jurisdiction consist of two zones: the high seas and the “Area.” As defined in UNCLOS, the high seas refers to the water column found beyond a nation’s Exclusive Economic Zone (EEZ), which extends 200 nautical miles beyond a nation’s coastline. The “Area,” also defined in UNCLOS, includes the seabed or ocean floor beyond the limits of national jurisdiction, since nations have a right to claim up to 350 nautical miles of their extended outer continental shelf (Molenaar et al., 2009, Rochette et al., 2014). In addition, the “Area” and its natural and mineral resources (liquid, solid or gaseous) are described by UNCLOS as the...

![Figure 4](https://example.com/figure4.png)

**Figure 4.** Representation of the maritime boundaries set up by the United Nations Convention on the Law of the Sea. This includes what part of the ocean each boundary consists of and the different jurisdictional rights a territory has (Source: Arctic Council, 2009).
“common heritage of mankind,” meaning that all of the world’s nations have the right of access to extract these resources for human use (Rochette et al., 2014) (Figure 4).

**Conservation and Management of Areas Beyond National Jurisdiction: International Treaties**

Since the Sargasso Sea lies in an area of the ocean considered an Area Beyond National Jurisdiction, with the exception of Bermuda’s Exclusive Economic Zone, the regulations governing this area come from international policies formed by the United Nations. Since there is a significant array of international activities in this area, ranging from commercial tuna fishing to whale conservation, it is critical to understand what effect international policies have had or not had on the Sargasso Sea, as well as the potential for these policies to instigate changes in the management and use of this area. The three main international treaties that specifically discuss the use of the high seas and ABNJs are the United Nations Convention on the Law of the Sea (1982), the United Nations Fish Stocks Agreement (1995), and the United Nations Convention on Biological Diversity (1992). Even though each of these international agreements includes statements calling for the protection and management of ABNJs, like the Sargasso Sea, they have had minimal effects on the successful management of activities in the Sargasso Sea and the protection of this important ecosystem.

The United Nations Convention on the Law of the Sea, which was developed during the third United Nations Conference on the Law of the Sea (1982), entered into effect in 1994 and has since been the basis for all international ocean governance agreements and treaties. This treaty has been ratified by 167 nations, not including the United States, and sets up a system of regulation and governance for the ocean through clearly defined international boundaries. Beyond countries’ EEZs, which extend 200 nautical miles from the coastline, lies the high seas, an area that is reserved for peaceful purposes and defined by the “freedom of the seas” doctrine. This doctrine was codified under UNCLOS and has since been the basis for the international community’s approach towards places like the Sargasso Sea, which are open access ocean areas for all nations. One central challenge for effective governance comes from the idealistic view that has dominated ocean governance throughout history that the ocean is an inexhaustible resource. This view has led to the exploitation of resources, such as Atlantic bluefin tuna by the International Commission for the Conservation of Atlantic Tuna, and is an increasing concern with growing fisheries in ABNJs (Cullis-Suzuki and Pauly, 2010; Webster 2011). Since ABNJs are common property, every nation has equal rights to the resources in these areas and no nation can prevent any other nation from also taking these resources (Rayfuse et al., 2008). Under UNCLOS, both coastal and landlocked countries have freedoms that include, but are not limited to, navigation, fishing, and scientific research. UNCLOS also declares that all nations have a responsibility to conserve the living marine resources of the high seas through national regulations and international cooperation, but the convention lays no solid groundwork for taking action with regards to this responsibility (Maes, 2008).

The conservation and protection of living resources in the high seas, mentioned in UNCLOS, is largely based on the idea of “flag state responsibility” and some form of international cooperation, which has proven to be vague and ineffective in the conservation of the living resources of the Sargasso Sea. The idea of flag state responsibility means that countries are responsible for ships bearing their flag whether they are inside their own national jurisdictional boundaries or outside of them. This concept has been insufficient in preventing the major loss of living resources in areas like the Sargasso Sea for a variety of reasons, including a lack of incentive for nations to limit their resource extraction.
Governance and Stakeholder Context

(Hannesson, 2011). Apart from flag state responsibility, UNCLOS briefly remarks on the need to facilitate international cooperation through regional or sub-regional organizations, however, there is no framework laid for the establishment of such organizations under UNCLOS. Overall, UNCLOS did not set up a way in which nations can be held accountable for their actions in the high seas and only generally states that environmental protection is a goal without implementing any specific environmental protection provisions. This is a major issue limiting the effectiveness of this treaty (Global Ocean Commission, 2014). Therefore, under UNCLOS, the Sargasso Sea faces serious threats to the persistence of its valuable ecosystem and the many resources associated with it.

With regards to activities in the high seas, the next convention to follow UNCLOS was the United Nations Agreement for the Implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (UN Fish Stocks Agreement), which facilitated important steps in the conservation of a few select living resources in the high seas that are of commercial interest. This international agreement states that nations have an obligation to cooperate at an international level to ensure the conservation of straddling and highly migratory fish stocks. At the center of these efforts are Regional Fisheries Management Organizations (RFMOs), which are created through separate treaties by different signatories that have a particular interest in certain species in a specified area (FAO Fisheries and Aquaculture, n.d.). The RFMOs relevant to the Sargasso Sea include the International Commission for the Conservation of Atlantic Tuna (ICCAT), the Western Central Atlantic Fisheries Commission (WECAFC), the Northwest Atlantic Fisheries Organization (NAFO), and the North Atlantic Salmon Conservation Organization (NASCO). (See Human Use: Fisheries section for further details.) The purpose of such organizations is to effectively facilitate international cooperation in the conservation and sustainable use of straddling stocks and highly migratory species through international regulations governing sustainable catches. While the UN Fish Stocks Agreement established more concrete steps for conserving certain, commercially valuable species in the Sargasso Sea and other Areas Beyond National Jurisdiction, it lacks an overall approach to conserving and protecting marine resources in these areas (Örebech et al., 1998).

Significant gaps in the United Nations Fish Stocks Agreement, as well as the failed implementation of certain aspects of the agreement, have prevented meaningful progress in the conservation of commercially-valuable living marine resources in Areas Beyond National Jurisdiction such as the Sargasso Sea (Ardron et al., 2008; Cullis-Suzuki and Pauly, 2010). While the UN Fish Stocks Agreement is an important step towards protecting certain living resources, nations and intergovernmental organizations formed in response to this treaty lack the legal capacity and/or will to limit catch numbers and to close off certain areas to fishing for conservation purposes (Ardron et al., 2008). The UN Fish Stocks Agreement also specifically covers straddling and highly migratory fish stocks, which excludes species whose range fall entirely within the ABNJ portion of the Sargasso Sea. Additionally, this treaty was established for the conservation of commercially-fished species and does

Key Numbers

<table>
<thead>
<tr>
<th>Country</th>
<th>Lands over Annual USD of Fish in the Sargasso Sea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>20 million USD</td>
</tr>
<tr>
<td>Mexico</td>
<td>18.9 million USD</td>
</tr>
<tr>
<td>US</td>
<td>2.3 million USD</td>
</tr>
</tbody>
</table>

The United Nations Convention on the Law of the Sea, which is the basis for all maritime law, codifies the “freedom of the seas” doctrine, giving nations open access to Areas Beyond National Jurisdiction, like the Sargasso Sea, and its many resources.
Governance and Stakeholder Context

not include the conservation of other species, such as whales and sea turtles, that are threatened by current activities in the Sargasso Sea (Laffoley et al., 2011). These policy gaps and the failure of nations and intergovernmental organizations to take sufficient and effective measures to ensure the sustainable use of commercially-valuable living marine resources in the Sargasso Sea still needs to be addressed.

Another attempt to address issues concerning the conservation and sustainable use of living marine resources in the Sargasso Sea, and other ABNJ's, is the United Nations Convention on Biological Diversity (CBD). The three main goals of this convention are the conservation of biological diversity, the sustainable use of the components of biodiversity, and the fair and equitable sharing of the benefits from genetic resources. While the CBD focuses primarily on the conservation of biodiversity and marine genetic resources in areas under national jurisdiction, it also has implications for areas like the Sargasso Sea since it encompasses the conservation of biodiversity in all ecosystems (Global Ocean Commission, 2014). Additionally, the CBD sets up a list of criteria for defining “Ecologically and Biologically Significant Areas” (EBSAs) in the oceans. These criteria include: the uniqueness or rarity of the area, the special importance of the area for life history stages of species, and the importance of the area for threatened, endangered or declining species and/or habitats, among others. In 2012, the Sargasso Sea was recognized as an EBSA, an important first step in international recognition of this area.

While the Convention on Biological Diversity has the most potential for working towards the conservation and protection of the Sargasso Sea, there are still significant flaws with this international treaty that prevent it from being entirely effective. For example, even though the Sargasso Sea has been designated as an EBSA, there has been little to no progress towards designing management strategies in order to protect this area because the CBD does not offer a clear way forward after the initial designation of EBSAs (Dunn et al., 2014). Also, the CBD is reliant on voluntary action and international political will; however, many nations lack the incentive and political will to take action towards the conservation of open-access resources (Global Ocean Commission, 2014). The CBD, like all international agreements regarding Areas Beyond National Jurisdiction, has very limited authority to impose and enforce regulations in international waters, preventing significant progress towards the conservation and protection of the Sargasso Sea (Hannesson, 2011).

As of January 2015, the United Nations is in the process of planning for the establishment of a legally binding High Seas Biodiversity Agreement, which would include the regulation of the Sargasso Sea and other ABNJ's. This idea was first proposed at the Rio+20 summit in Brazil, and the UN Ad Hoc Working Group is currently working on developing this idea with the following main points in mind: area-based management tools, environmental impact assessments, marine genetic resources, capacity building, and technology transfer. However, this will likely take many years to develop (Deen, 2015; Gjerde, 2015).

In addition to the three main international treaties that broadly discuss the use of the high seas and Areas Beyond National Jurisdiction, there are other international treaties, agreements, and organizations that play a significant role in specific activities in these areas, such as shipping. For example, the International Maritime Organization (IMO), established in 1948, governs and maintains a management and regulatory framework for international shipping, including shipping occurring in ABNJ's (IMO, n.d.). (See Maritime Traffic section for further details.) This is just one example of an international organization and agreement that regulates activities in ABNJ’s to a certain extent but is still limited in its capacity to manage activities in places like the Sargasso Sea.

These international organizations and treaties are intended to govern Areas Beyond
Governance and Stakeholder Context

National Jurisdiction. However, there are still significant gaps in the governance of ABNJs, including the lack of participation and cooperation among states and sectoral organizations responsible for implementing relevant legal regimes for the management of ABNJs (Rayfuse et al. 2008). In addition, the current governance of ABNJs is incomplete: some regions either don’t have management agreements or have partial agreements that are yet to come into force (Ban et al. 2013). Despite all of the international governance frameworks, organizations, and agreements that pertain to the protection and management of the Sargasso Sea as an Area Beyond National Jurisdiction, there is still a significant need to address gaps in these preexisting and fragmented international management frameworks. In 2014 the Sargasso Sea Commission was created as an effort to increase international collaboration regarding the Sargasso Sea.

Voluntary International Cooperation: The Hamilton Declaration

The Hamilton Declaration is a non-binding international agreement that outlines a framework for collaboration between existing organizations; it was signed in 2014 by the Azores, Bermuda, Monaco, the United Kingdom, and the United States. By signing, the signatories agreed to collaborate on pursuing conservation initiatives. The declaration also designated the Sargasso Sea Commission (SSC), whose main goal is “to exercise a stewardship role for the Sargasso Sea and keep its health, productivity, and resilience under continual review.” The SSC is charged with the task to “use the best available science and apply an ecosystem approach and the precautionary approach when appropriate.”

The Sargasso Sea Alliance (SSA), established in 2010 through the leadership of Bermuda’s government, was responsible for drafting the Hamilton Declaration. The Alliance had three main goals: to build an international partnership to secure recognition of the ecological significance of the Sargasso Sea and the threats it faces; to use existing regional, sectoral, and international organizations to secure a range of protective measures for all (or parts) of the area in order to address key threats; and to use the process as an example of what can and cannot be delivered through existing institutions in Areas Beyond National Jurisdiction. In 2012, the SSA published a supporting evidence case and summary science report, *The Protection and Management of the Sargasso Sea*, and is responsible for pushing the recognition of the Sargasso Sea as an Ecologically and Biologically Significant Area under the United Nations Convention on Biological Diversity.

Through the signing of the Hamilton Declaration, the SSA was effectively replaced by the SSC, which adopted the SSA’s goals. The commissioners were appointed by the Bermudian Government through a consultation process with governments who support the Hamilton Declaration, and are mainly scientists and those committed to conservation. Through the Hamilton Declaration, the Commission adopted more powers, than those previously held by the SSA, including the ability to develop proposals that the signatories may submit and/or support in the international arena to further the protection of the Sargasso Sea.

Governance of the Bermudian Exclusive Economic Zone

In addition to Bermuda’s role in spearheading the Sargasso Sea Commission, the island’s government and stakeholders have taken initiative to improve conservation efforts within their own waters. Bermuda is a British land territory in the Sargasso Sea. Though their internal government functions largely independently from the United Kingdom with Governor George Fergusson as acting representative of the Queen of England, they are still required to seek approval when making any major government decisions (The World Factbook: Bermuda, 2014). Within the Bermudan government the Sustainable Development Department is responsible for making decisions regarding Bermuda’s unique culture, environment and heritage, including, but
Governance and Stakeholder Context

not limited to, their marine territory. Bermuda has jurisdiction out to 200 nautical miles off of their coast, which is the expanse of their Exclusive Economic Zone. Throughout the island’s history, the people of Bermuda have had close ties with the surrounding Sargasso Sea, whether it is for shipping needs, tourism business, food, and more. The Bermudan government has been implementing conservation efforts for protecting and preserving marine areas directly surrounding the island throughout their history. Some key environmental laws passed in the Bermuda government include the Coral Reef Preserves Act of 1966, the Fisheries Act of 1972, and the Protected Species Act of 2003 (Mayall, 2015). Since 2010 there have been two new initiatives by non-governmental groups in Bermuda, the recently proposed Bermuda Blue Halo project (2010), which proposes new marine conservation measures for portions of Bermuda’s waters, and a coastal marine spatial planning project (2014), which is in the pre-planning phase. Marine protected areas (MPAs) and marine spatial plans (MSPs) will be discussed later in this section.

The Blue Halo project aims to create the largest marine protected area in the Atlantic Ocean and would encompass a majority of Bermuda’s Exclusive Economic Zone including the entire area between 50 nautical mile and the 200 nautical mile area of the EEZ (The Pew Charitable Trust, 2015). The project was led by the Pew Environmental Group and their Bermudian staff, Chris Flook and LeeAnne Hinton, who were formerly funded by Pew and have no direct affiliation with the government. The Government of Bermuda Sustainable Development Department document The Future of Bermuda’s Exclusive Economic Zone (2013) suggests that a marine reserve or marine protected area surrounding the entire island could be beneficial for supporting conservation efforts in the Sargasso Sea, while simultaneously taking into account the human needs for the area. Due to political uncertainty and ambiguity about the restrictions this project may have on the economy, this project remains in the proposal stage (Flook, 2015). Although there are many issues revolving around the Bermuda Blue Halo, a marine protected area such as this project proposes would be a significant departure from any conservation initiatives currently in place.

A second more recent marine conservation initiative, led by a new group of conservation minded Bermudians interested in protecting the marine space surrounding their island, is the development of a coastal marine spatial plan. Unlike the Blue Halo Project, this plan only incorporates the territorial waters of Bermuda, up to 12 nautical miles offshore. The spatial plan aims to clearly map marine uses and resources into zones that would support Bermuda’s economic, social, and conservation goals (Mayall, 2015). This project is still in pre-planning and not yet at the official planning stage, but it has the potential to bring Bermuda one step further in establishing conservation efforts in the Sargasso Sea.

Who Cares about the Sargasso Sea?: A Stakeholder Context

Bermuda, due to its dependence on the Sargasso Sea, is a key player in the conservation of the area; however, Bermuda is not the only entity with a vested interest in this area. These entities, referred to as stakeholders, can be defined as anyone (person, agency, corporation, government, etc.) that has an interest in or is affected by the area of interest. Identifying and engaging stakeholders in any policy making process is difficult; however, the lack of governance in the high seas exacerbates the problem. One of the main hurdles in improving management is determining who cares, the level to which people hold stock in various ocean activities, and engaging those people or groups.

The involvement of stakeholders throughout the marine conservation planning process is integral to the success of any policy
Governance and Stakeholder Context

making project through their empowerment, ability to provide invaluable information, and ability to facilitate learning (Jentoft, 2007). Stakeholders often have political and/or economic power over a particular resource, which is why they are vital to the management process. However, it is also important to involve stakeholders because they tend to have a better understanding of the complexity of the ecosystem of interest, the human influence on that ecosystem, and current areas of conflict. Additionally, stakeholder involvement provides the opportunity to allow for mutual understanding, explore ideas cooperatively, and ensure the long-term availability of resources held within the system of interest. Perhaps most importantly, open discussion between stakeholders could possibly foster discussions of new options or solutions that may have not been considered otherwise (Pomeroy and Douvere, 2008).

Resource management research has shown that citizen and group participation is vital and needs to be encouraged, as it makes the planning process effective, equitable, and legitimate, provided those involved fairly represent their constituents and are capable of making decisions in the best interests of their respective groups (Buanes et al., 2005). Stakeholder involvement also builds buy-in, or lasting support, which can be helpful beyond the planning process – stakeholder buy in increases stewardship, and may reduce enforcement costs. Stakeholder involvement early in the process can also reduce legal costs in the events of backlash, reduce conflict, and save time on the entire project by decreasing obstacles that may have been raised had they not been consulted (Olsen et al., 2014). Essentially, stakeholders are more likely to support the resulting decision after being included and having participated in a democratic management planning process (Dalton, 2005).

The first step in stakeholder engagement is identifying the key stakeholders that should be involved. One approach is stakeholder analysis, which can be defined as “an approach for understanding a system by identifying the key actors or stakeholders in the system, and assessing their respective interest in that system” (Grimble and Chan, 1995). Additionally, it is a tool used to gain insight into the complexity and compatibility problems between stakeholders and objectives. Importantly, it differentiates stakeholders based on their attributes and case-specific criteria, which may include their relative power and interest, the importance and/or influence they have, or the networks and coalitions to which they belong (Ramirez, 1999). One of the main benefits of stakeholder analysis is that groups of stakeholders can be divided into categories that are as specific as needed for the project, as it is imperative that all groups have a voice, and excluding or lumping groups together could lead to complications down the line (Pomeroy and Douvere, 2008). Ideally, the group of stakeholders consulted will represent a wide array of all key players, including resource users, managers, experts, specialized knowledge holders, and citizens (Tallis et al., 2010).

The following stakeholders have been identified in the Sargasso Sea using stakeholder analysis; additionally, they have been prioritized in terms of their involvement in the Sargasso Sea. These key stakeholders include the citizens and government of Bermuda, United States fishing and scientific interests, the international fishing and shipping communities, scientific research and education institutions, and multiple intergovernmental and United Nations agencies.

Bermuda holds a unique and significant role in the Sargasso Sea as the only nation that borders and has national jurisdiction within its waters. There has been research into the economic

**Important Definitions**

**Stakeholders:**
anyone (person, agency, corporation, government, etc.) that has an interest in or is affected by an area

**Stakeholder analysis:**
an approach for understanding a system by identifying the key actors or stakeholders in the system, and assessing their respective interest in that system
Governance and Stakeholder Context

effects and benefits to Bermuda that are derived directly and indirectly from the Sargasso Sea (e.g. Hallett, 2011). Bermuda – both its government and its citizens - are stakeholders with strong economic incentives for supporting and maintaining a healthy ecosystem in the Sargasso Sea. They benefit from ecosystem services including reef tourism, commercial and recreational fishing, and scientific research (Hallett, 2011). Tourism is Bermuda’s second largest industry based largely on coral reef dives, both snorkeling and SCUBA. Bermuda’s coral reefs are healthier and more vibrant than most Caribbean reefs, drawing international tourists (Hallett, 2011). The Sargasso Sea plays a key role in maintaining a healthy reef ecosystem, providing a constant influx of nutrients, continual current flushing, and sustaining grazing fish to keep the coral free of algae. Another study estimated the total value of tourism and recreational use of the reefs at 434 million USD per year (Sumaila, Vats, & Swartz, 2013).

The Sargasso Sea supports fish stocks that are commercially and recreationally fished by many countries from the Atlantic region, and across the world (Sumaila et al., 2013). Only recently, though, has Bermuda’s commercial fishing industry begun to grow, with a shift from fishing the reefs to the open ocean (Hallett, 2011). Fishing from pelagic stocks and preserving the populations of reef fish helps maintain healthy reefs, while connecting the Bermudian people with the Sargasso’s pelagic ecosystem. Perhaps more well known than Bermuda’s commercial fishing is its recreational fishing. Bermuda holds annual fishing tournaments that draw people from all over the world and generate a large amount of revenue to the local charter fishing industry and general tourism industry (Hallett, 2011). Therefore, both Bermuda’s recreational and commercial fishermen and associated businesses are key stakeholders in the Sargasso Sea.

The international fishing community is another key stakeholder in the Sargasso Sea, as the North Atlantic has the highest levels of commercial shipping in the world (Roberts, 2011). The main types of vessels found in the Sargasso Sea include cargo ships, cruise liners, military vessels, and recreational boats and yachts. Cargo ships are especially essential for the quality of life on Bermuda, which relies on a strong shipping presence to deliver a wide range of goods and services. Some of the largest shipping companies present in the Sargasso Sea include, but are not limited to, Maersk Lines and the China Ocean Shipping Company. The cruise line industry, particularly Carnival Cruise, is a major element of maritime traffic in the area, particularly between the U.S. and Bermuda. Being a cruise line destination is vital for Bermuda, as it relies on the tourism industry for nearly a third of its gross domestic product (van Beukering, 2015). The United States Coast Guard, United States Navy, and the British Navy have a strong presence in the Sargasso Sea as defenders of trade and national waters. While data on military activity and presence is difficult to come by, it is necessary to list them as stakeholders, as their actions directly affect the Sargasso Sea. Last, recreational boating plays a large role in the Sargasso Sea. Bermuda is a popular destination for many yachters, and is the destination of the biennial Newport Bermuda Race, hosted by Cruising Club of America and the Royal Bermuda Yacht Club through the Bermuda Race Organizing Committee.

Sargasso Sea fish per year (over 20 million USD) catching yellowfin tuna, albacore, and Spanish mackerel (Sumaila et al., 2013). Mexico catches the most fish, with a landed value of 18.9 million USD (Sumaila et al., 2013). The yearly economic value of U.S. landed fish from the Sargasso Sea is estimated at 2.3 million USD (Sumaila et al., 2014). The most highly sought-after fish species in the Sargasso Sea include tuna species, despite the declining populations of some of these, particularly Atlantic Bluefin Tuna. Given the economic value of fish coming from the Sargasso Sea, the world’s commercial fishermen and fishing industries are important stakeholders.

The international maritime community is another key stakeholder in the Sargasso Sea, as the North Atlantic has the highest levels of commercial shipping in the world (Roberts, 2011). The main types of vessels found in the Sargasso Sea include cargo ships, cruise liners, military vessels, and recreational boats and yachts. Cargo ships are especially essential for the quality of life on Bermuda, which relies on a strong shipping presence to deliver a wide range of goods and services. Some of the largest shipping companies present in the Sargasso Sea include, but are not limited to, Maersk Lines and the China Ocean Shipping Company. The cruise line industry, particularly Carnival Cruise, is a major element of maritime traffic in the area, particularly between the U.S. and Bermuda. Being a cruise line destination is vital for Bermuda, as it relies on the tourism industry for nearly a third of its gross domestic product (van Beukering, 2015). The United States Coast Guard, United States Navy, and the British Navy have a strong presence in the Sargasso Sea as defenders of trade and national waters. While data on military activity and presence is difficult to come by, it is necessary to list them as stakeholders, as their actions directly affect the Sargasso Sea. Last, recreational boating plays a large role in the Sargasso Sea. Bermuda is a popular destination for many yachters, and is the destination of the biennial Newport Bermuda Race, hosted by Cruising Club of America and the Royal Bermuda Yacht Club through the Bermuda Race Organizing Committee.
Governance and Stakeholder Context

There are a number of international governing authorities that are key stakeholders in the Sargasso Sea. These include but are not limited to the International Maritime Organization, the International Commission for the Conservation of Atlantic Tuna (ICCAT), the North Atlantic Fisheries Organization (NAFO), and the International Seabed Authority (ISA). Each body has different regulatory responsibilities. The IMO, under the United Nations, is the authority for the safety, security and environmental performance of international shipping. ICCAT, a Regional Fishery Management Organization under the United Nations, is the regulating body on catch limits of Atlantic tuna and tuna-like species (ICCAT, 2014). NAFO is the RFMO for all other fisheries in the North Atlantic, and provides scientific advice to member nations with the goal of ensuring the conservation and management of fish stocks in the region. The ISA is the regulating body over all proposed and current seabed mining or exploration within ABNJs. Seabed and seamount mining has already been proposed globally, with contracts issued to nations interested in the Mid-Atlantic Ridge. The ISA is a significant stakeholder in the Sargasso Sea, with a role to play in the protection of its unique ecosystems. The ISA claims responsibility for regulating “deep seabed mining and [...] ensuring that the marine environment is protected from any harmful effects which may arise during mining activities, including exploration” (ISA, 2014). Additionally, the ISA works to minimize marine pollution caused by mining activities, and prioritize conservation of natural resources (ISA, 2014).

Many nations in the international community recognize the important ecosystem that is the Sargasso Sea, and acknowledge the scientific value of the area. In 1954, American scientists established the first open ocean monitoring station, Hydrostation “S,” off the southeast shore of Bermuda. This data collection station is the longest running in the world, earning international interest, especially in relation to the effects of global climate change on marine systems (Hallett, 2011). Additionally, the U.S. government agency National Oceanic and Atmospheric Administration (NOAA), through studies with Duke University, is conducting ongoing research into Sargassum communities. Some other United States research institutes are also interested in the Sargasso Sea, and have contributed significantly to the pool of knowledge on Sargassum. These include but are not limited to the American Association for the Advancement of Science (e.g. AAAS, 2015), Sea Education Association (e.g. Sehein, Suida, Shank, and Govindarajan, 2014), and Woods Hole Oceanographic Institute (e.g. Sehein et al., 2014). The contributions of the international scientific community will be critical in understanding the ecosystem of the Sargasso Sea and the implementation of an effective management plan.

Methods of Marine Management: Marine Spatial Planning and Marine Protected Areas

In order to successfully implement a management plan for the Sargasso Sea, it is critical to take into consideration the current fragmentation of governance and the wide array of stakeholders in the Sargasso Sea. Even with the Sargasso Sea Commission and Hamilton Declaration to support conservation efforts in the area, as well as existing international ocean governance regimes discussed above, there are insufficient mechanisms available to support comprehensive marine conservation. Marine spatial planning, a well established management tool, can be used as a framework to provide guidance for management of marine areas such as the Sargasso Sea in order to accomplish a wide range of environmental, economic and social objectives (Gjerde, 2015).

One marine management tool that can be implemented through a marine spatial planning process is the designation of marine protected areas, which are coastal or offshore marine areas specifically designated and managed to protect the ecosystems within its boundaries. MPAs play dual roles: they both protect the ocean and have a socioeconomic purpose – to maintain or enhance a resource base for human use (Jentoft et. al, 2007). Designation of MPA networks is another common
Governance and Stakeholder Context

Marine spatial planning is a powerful process that facilitates inter-organizational and international collaboration for marine management. Additionally, it provides guidelines for how marine spaces should be used, including the regulations that are necessary for accomplishing management goals and objectives. By designating specific areas for management through the MSP process, the challenges associated with management in each area can be specifically addressed, allowing governing bodies and regulatory organizations to create region-specific guidelines for the ecological integrity and sustainable anthropogenic uses of the area. While MSP typically requires governmental authority in order to be implemented, often the bodies that propose MSP are not affiliated with governments, and include non-governmental organizations (NGOs), universities, and international agencies, such as the United Nations (UN). These bodies can use MSP to provide a framework for high seas management and to potentially address many of the gaps in current international maritime governance, such as in the Sargasso Sea.

Challenges Associated with the Implementation of MSP and MPAs in Areas Beyond National Jurisdiction

Even though MPAs, MSP, and other similar area-based management approaches are popular tools in regulating and managing Areas Beyond National Jurisdiction, there are various challenges in implementing these. For example, Gjerde and Ruska-Domino (2012) identified these challenges as follows:

a. A lack of a global process to implement and enforce legal approaches to manage the open ocean;
b. A lack of a consistent global institution in charge of ensuring conservation and ecosystem-based management take place;
c. A lack of systematized procedures assessing the environmental impacts of either regulated or unregulated human activity;
d. A lack of a regional body dedicated to the promotion of ocean conservation in Areas Beyond National Jurisdiction;
e. A lack of an international advisory body for providing scientific and technological knowledge in order to create adequate approaches for the management of Areas Beyond National Jurisdiction.

Furthermore, scientists and policy makers often don’t have a good communication system to share valuable knowledge regarding the scientific, legal, policy, and stakeholder aspects for the implementation of management areas. The governance of ABNJs is fragmented, since some regions have an agreement on how to regulate human activities while others do not (Ban et al. 2013). This makes it harder to implement the necessary legal regimes for marine protected areas within Areas Beyond National Jurisdiction. The fact that there is no one single governmental body that has the authority to establish and implement MPAs or MSP processes within Areas Beyond National Jurisdiction is a major obstacle in MSP and the establishment of MPAs, which could protect valuable biodiversity (Game et al. 2009). All of the above-mentioned challenges have thus far impeded the ability to establish, implement, and enforce the management of ABNJs; it is important to address these if the ultimate goal is to better manage the Sargasso Sea.

Despite all of these challenges, it has been recommended by authors such as Gjerde and Ruska-Domino (2012) that creating a network of marine managed areas could be a solution to improving the protection of ABNJs. Additionally, authors have recommended the creation of a centralized Regional Ocean Management Organization, which would be in charge of implementing and enforcing management measures in ABNJs, like the Sargasso Sea (Gjerde and Ruska-Domino, 2012).
Governance and Stakeholder Context

Conclusion

In conclusion, the wide array of stakeholders and the fragmented governance mechanisms that currently regulate the Sargasso Sea, an Area Beyond National Jurisdiction, make it difficult to implement a management plan to conserve this important area. Although there are international treaties (UN Convention on the Law of the Sea, UN Fish Stocks Agreement, UN Convention on Biological Diversity), organizations (Regional Fisheries Management Organizations, International Maritime Organization, International Seabed Authority), and agreements (Hamilton Declaration) that govern the use of the Sargasso Sea to an extent, there is still significant progress that must be made to consolidate these fragmented governance mechanisms and create a clear authority that can implement a comprehensive management plan for the Sargasso Sea.

Marine spatial planning is a management approach that can help provide a clear framework for regulations and governance based on ecological and anthropogenic needs. The implementation of MSP in the Sargasso Sea is a challenging task due to the lack of clear authority for the area and the many stakeholders involved, which include but are not limited to Bermuda, the United States, Japan, Mexico, international fisheries, the international shipping community, and the scientific community. It is for these reasons that this proposal takes a marine spatial planning approach to identify management areas, including the creation of marine protected areas in the Sargasso Sea.
This section of the Management Proposal deals with the identification of important ecological features to consider as conservation targets. This process of identification and prioritization must be done in order to shape marine management. In this Proposal, these important ecological features are defined as conservation targets, and include both habitats and specific species. In this section, research-based methods of defining conservation targets are discussed first. Second, the area of the Sargasso Sea that is considered in the identification of conservation targets is outlined and explained. Next is a discussion of the habitat and species conservation targets that have been chosen as top priority for conservation in the Sargasso Sea. Finally, the identified conservation targets are connected with stakeholders to promote stakeholder engagement in conservation management. The chosen habitats for management are Sargassum aggregations and seamounts, while the chosen species are tuna and tuna-like species and right whales.
I. Introduction

This section of the Management Proposal deals with the identification of important ecological features in the Sargasso Sea to consider for conservation. This process of identification and prioritization must be done in order to shape marine management. In this Proposal, these important ecological features are defined as conservation targets, and include both overall habitats and specific species.

This Proposal first describes the process of using research-based methods of defining conservation targets. Second, the area of the Sargasso Sea that will be considered in the identification of conservation targets is outlined and explained. The Proposal then discusses the habitat and species conservation targets that are most important to consider for conservation in the Sargasso Sea. Next, the identified conservation targets are connected with stakeholders to promote stakeholder engagement in conservation management. Finally, conservation targets that are given specific protection under the Management Proposal will be explained. These targets were chosen based on several criteria. They are ecologically important, threatened or impacted by humans, and there are enough data available about their abundance, distribution, and life history that management areas and strategies specific to protecting those targets could be designed. The selected habitat targets given protection under the Management Proposal are Sargassum aggregations and seamounts, and the selected species are tuna and tuna-like species and the North Atlantic right whales.

II. Identifying Conservation Targets

Conservation planning for marine management is an important process that needs to be well thought-out and many questions need to be answered before a management plan is developed. An effective marine conservation plan requires defining and determining targets and, ultimately, what exactly the targets for the management area should be. An effective practice is to look both at past successes of marine management areas and previous examples of management areas that failed. By using a multifaceted approach, the proposal team
established targets in order to create a successful management proposal for this region of the northwest Atlantic Ocean. One of the most important initial steps in defining conservation targets is gathering data and performing research to get an understanding of the biological and physical processes of the area of concern. Only after enough sound research has been done can a management proposal be put forth. To promote a successful management area with conservation as a priority, there needs to be a foundation of conservation science in order to create a complete and successful management plan, otherwise policymakers and resource managers will make misguided decisions (Agardy et al., 2003).

After scientific research is completed, conservation planners need to decide whether to focus on direct species or have a broader target, like an entire habitat, for example. More recently there has been a shift from species-specific management regimes to habitat or ecosystem-based management (Grumbine, 1994; Arkema et al., 2006). It is arguably more rational to use entire habitats as conservation targets because organisms that are targeted are not living in a box by themselves; animals are connected to their environment and other organisms that live in it. In the case of highly migratory species, on the other hand, there needs to be a species-based approach for management because it is not feasible to create a management plan for such a large area, such as the entire Atlantic Ocean. Fundamentally, without the main goal of maintaining healthy ecosystem function, successful natural resource management is not possible.

A comprehensive study on designing marine management areas touches on connectivity, critical areas, representation, spread, replication, size, and shape as important features for maintaining ecosystem health through the creation of management and protection areas (McLeod et al., 2009). Another study suggests using species assemblages as “surrogates” to represent high priority areas for marine management planning (Ward et al., 1999). For deep ocean habitats, surrogates like biogeography, geomorphology and substrate need to be taken into great consideration, as well as the attributes discussed above (Howell, 2010). Ecological research is the basis of any conservation measure and it should be used to inform design of the management plan.

Representation is a key ecological aspect to consider when planning a conservation-based management area (De Santo, 2013). For a diverse ecosystem, at least 30% of each habitat type should be represented (McLeod et al., 2009). In addition to representation, replication is significant for an effective marine management area. Three or more replicates of each marine type should be represented, but it is a good idea to have the replicates spread out far enough to reduce effects of a disturbance event in the chance that there is one (McLeod et al. 2009). Shape and size need to be considered as well when creating an effective plan. Size should be determined by specific management objectives that are unique to each ecosystem; management areas must be large enough to protect the array of habitat types and ecological operations, but small enough to realistically and sufficiently protect and manage the entire complement of biodiversity in the system (McLeod et al., 2009). A comprehensive study done by Wood et al. (2009) found that 80% of MPAs already created are either too small or too large, and at least half of the world’s MPAs are both small and isolated and thus not effective at protecting marine populations from fishing efforts and other extractive processes.

By identifying conservation targets beforehand, management time and effort can be spent in an effective manner, so no time is wasted on scientific studies that should have been done prior to the creation of the plan. Systematic planning relies on spatially explicit data that are often lacking in areas of concern for conservation, as well as socioeconomic data which are needed to determine the feasibility of outcomes for the management area (Ban et al., 2009). An implicit, but perhaps the most valuable, benefit of identifying targets in advance is that it is possible to determine the right stakeholders to communicate with in order for the most successful management plan to be developed and implemented. Following research
Biodiversity and Conservation Targets

and stakeholder involvement is a process of prioritization based on feasibility and data availability on specific targets.

Commercial fishing, shipping, research and numerous other human uses are occurring in the open ocean at all times. The best tool to find a balance between human use and conservation of ocean habitats is by creating marine spatially planned areas (Ardron et al., 2008). The methodology of identifying conservation targets is crucial for effective management, successful and sustainable ecosystems, and maximum conservation and ecosystem services. For more effective ecosystem-based management, various sorts of management areas, which are unique based on the goals and objectives of any given proposal, need to be created (Agardy et al., 2011; Gaines et al., 2010). A well-considered marine management area will allow some human use, such as beneficial fisheries, while leading to effective conservation.

III. Area Assessed for Identification of Conservation Targets

In order to identify and prioritize conservation targets for the Sargasso Sea, the region of study must first be defined. In this report, the Sargasso Sea shall be defined using the same borders as the study area boundaries decided upon by the Sargasso Sea Alliance, which became the Sargasso Sea Commission once the Hamilton Declaration was signed. When deciding on boundaries, the Sargasso Sea Alliance took into account ocean currents, sea surface temperature, political boundaries such as EEZs, and remote satellite and research ship detections of Sargassum (Figure 1) (Ardron et al., 2011). The Sargasso Sea Alliance Study Area is bounded by the four major ocean currents that make up the North Atlantic Gyre, and excludes the Bermuda EEZ. Though the Bermuda EEZ is not excluded entirely from considerations regarding conservation targets, targets located exclusively within this EEZ and not in other areas of the Sargasso Sea (e.g. coral reefs) are not the focus of this section. The Hamilton Declaration explains that the boundaries of the Study Area were also decided upon based on the

1 This report is part of a series of scientific and technical reports on the Sargasso Sea. These reports can be accessed on the Sargasso Sea Commission website.

---

Did you Know?

Right whales are no longer hunted in the north Atlantic. Today, the most serious threats to North Atlantic right whales are death or injury from fishing gear entanglement and from ship collisions off the eastern coast of North America.
bathymetry of the seabed (Hamilton Declaration, 2014), as will also be discussed in this section.

**IV. Habitat Conservation Targets**

Within these boundaries of the Sargasso Sea Study Area, the Proposal team first identified habitat conservation targets and species conservation targets. This discussion will focus on the habitats and species that were prioritized based on background research, and based on the conservation targets that were stressed in the proposal to classify the Sargasso Sea as an Ecologically and Biologically Significant Area (EBSA) (McKenna and Hemphill, 2014). The designation of an EBSA does not mean any legally binding management. However, identification of high priority areas for conservation is the first step in an incremental process that can lead to focused research and monitoring efforts, and ultimately recommending management areas and tools for conservation (Convention on Biological Diversity, 2012), as is done in this Management Proposal. The Convention on Biological Diversity, an international organization tasked with certain High Seas management responsibilities, has the authority to approve EBSAs. Members of this organization review scientific reports that provide supporting evidence making a case for an EBSA, and then decide whether to approve the request (Convention on Biological Diversity, 2012). The criteria that must be met for an area to become an EBSA include uniqueness, importance to endangered species, fragility, biological productivity, and biological diversity of the area (Convention on Biological Diversity, 2012). The scientific report that was submitted on behalf of the Sargasso Sea Alliance proved that the Sargasso Sea sufficiently met these criteria to be named an EBSA.

Two specific habitats were emphasized as being the highest priorities for conservation in the scientific report that was submitted to the Convention on Biological Diversity (Roe et al., 2011). The first of these is Sargassum aggregations, which are areas where individual clumps of *Sargassum* weed have come together to form a larger patch of floating weed (Figure 5). The second highest priority habitat for conservation, according to this scientific report, is seamounts, which are extinct, underwater volcanoes that create elevated areas of the seabed (Figure 6) (Epp and Smoot, 1989). As the purpose of this section is to identify and discuss habitats in the Sargasso Sea that are of high priority for conservation, these two habitats, *Sargassum* aggregations and seamounts, will be discussed in...
Biodiversity and Conservation Targets
detail, particularly as their importance relates to the
biodiversity of species that rely on them. This
section will then review other potential
anthropogenic uses and ecosystem services of
these two habitats that are not specifically related
to conserving biodiversity. The discussion on
habitat conservation targets and ecosystem
services will be followed by a discussion of species
conservation targets.

V. Sargassum: the Golden Floating Rainforest

Sargassum aggregations, especially when
clumped together into enormous Sargassum mats
(Figure 5), have been described as “floating golden
rainforests” for the rich and diverse community of
organisms they support out in the open ocean
(Laffoley et al., 2011). There are two species of
Sargassum that create the structure for this floating
ecosystem: Sargassum natans and Sargassum
fluitans (Roe et al., 2011). Both are holoplanktic,
meaning they spend their entire life cycle floating
in the open ocean. This makes them unique
compared to all other seaweeds. As open ocean
seaweeds, Sargassum aggregations build up
relatively high nutrient levels in what is otherwise
a low nutrient environment (Roe et al., 2011). These
nutrients are closely cycled within the Sargassum
ecosystem, as much of the nutrient content
produced as waste products by associated
organisms of the Sargassum is used up by the
Sargassum itself (Roe et al., 2011). More than 100
species of invertebrates, 280 species of fish, four
species of turtle, and 23 species of seabird rely on
Sargassum at some point during their life cycle
(Hallett, 2011). In this way, Sargassum aggregations
act as oases of life in what would otherwise be an
ocean desert.

These aggregations support a variety of
species. This includes ten endemic species,
meaning they are found only in the Sargasso Sea.
The community of organisms that live in
Sargassum rely on the solid surface and nutrient-
rich environment that this open ocean seaweed
provides (Roe et al., 2011). Some of the species that
are found only in this environment include the
Sargassum swimming crab, Sargassum pipefish,
Sargassum shrimp, and Sargassum snail (Figure 7)
(McKenna and Hemphill, 2014). Sargassum also
provides a spawning ground for many species, such
as the commercially important European eel and
American eel (Laffoley et al., 2011). The European
eel, a commercially fished species that has recently
been classified as critically endangered by the
International Union for Conservation of Nature,
have been found to migrate 5000 kilometers (3107
miles) to the Sargasso Sea from Europe (Jacoby and
Golluck, 2014; Aarestrup et al., 2009). When these
eels arrive at the Sargasso Sea, they rely on the
Sargassum community for a spawning site (Roe et
al., 2011). The Sargasso Sea is also a spawning site
for white marlin, porbeagle sharks, and
commercially important dolphinfish (also known as
mahi-mahi) (White Marlin Biological Review Team,

Figure 7. Top: Sargassum swimming crab
attached to Sargassum. Bottom: Sargassum
pipefish hiding amongst the blades of
Sargassum (Source: Solvin Zankl/National
Geographic)
Sargassum also provides protection for sea turtles during their vulnerable life stages as small hatchlings and juveniles (Laffoley et al., 2011). Many turtle species have been found to use Sargassum as a nursery, a place for feeding and hiding as they grow into adults. These include green turtles, hawksbill turtles, loggerhead turtles, and Kemp’s Ridley turtles, many of which are classified as endangered or critically endangered by the International Union for Conservation of Nature (IUCN) Red List (IUCN Marine Turtle Specialist Group, 1996; IUCN Marine Turtle Specialist Group, 2008). It is important to note that some of these IUCN classifications may not have been updated recently to reflect more contemporaneous distributions of Red List species.

Sargassum also supports many species that do not live exclusively within its structure. Tunas, one of the top three most highly consumed types of seafood in the U.S. by weight each year, rely on the Sargasso Sea as highly productive feeding grounds during their trans-Atlantic migrations (Roe et al, 2011; U.S. Census Bureau, 2011). In fact, the International Commission for the Conservation of Atlantic Tuna (ICCAT) has recognized the importance of Sargassum as habitat for tuna, and has requested that countries report any activities that may affect the abundance of Sargassum (Roe et al, 2011). Seabirds, such as white-tailed tropicbirds, masked boobies, and bridled terns also rely on the productive surface waters of the Sargassum community to feed on during their...
Biodiversity and Conservation Targets

migration routes across the Atlantic (Haney, 1986). In fact, seabirds have been found in densities up to 32-43 times greater in areas that have Sargassum than in areas that do not (Haney, 1986). In summary, for a variety of endemic, commercial, endangered, and migratory species, Sargassum provides an important habitat. Therefore, areas of the Sargasso Sea with high Sargassum abundance should be top conservation priorities for the sake of preserving the rich biodiversity they support.

For the purposes of this proposal, two datasets were used together in order to determine the geographical locations of high-density areas of Sargassum. The first dataset was provided in a report by Dr. Amy Siuda of Sea Education Association, and was published as part of the Sargasso Sea Alliance Science Report Series (Siuda, 2011). This part of the report series presents a dataset on seasonal distribution of Sargassum density over the past twenty years, which has been collected using net tows aboard Sea Education Association vessels. The second dataset was published by Dr. Jim Gower and Dr. Stephanie King (2011) in the journal *International Journal of Remote Sensing Letters*. These data were collected using satellite imagery of Sargassum collected between the years of 2002 and 2008. The aggregate of the two datasets is used in the mapping of seasonal Sargassum density in this Management Proposal (Figure 8). These are considered the best available scientific data characterizing Sargassum distribution in the Sargasso Sea.

VI. Seamounts: Deep Sea Islands of Biodiversity

As previously mentioned, Sargassum is not the only habitat emphasized as a high priority habitat for conservation in the scientific report submitted to the Convention on Biological Diversity, which argued that the Sargasso Sea meets the criteria for an EBSA. The second habitat that was stressed in this report is seamounts (Roe et al., 2011). Seamounts are circular or elliptical bathymetric features created by volcanoes (Epp and Smoot, 1989). There are thought to be roughly 800 seamounts in the North Atlantic alone and more recent estimates predict that there are more than 100,000 seamounts worldwide (Epp and Smoot, 1989; UNEP, 2006). Some seamounts rise as little as 100 meters above the seafloor, while others can tower 3000 meters or more above the seabed (UNEP, 2006), like underwater mountains that never break the sea surface. There are several groups of seamounts that lie within the Sargasso Sea (Figure 6). Within Bermuda’s EEZ alone are the Muir Seamount chain, Crescent seamount, and Bowditch seamount (Hallett, 2011). Other seamounts that lie within the Sargasso Sea study area are the New England Seamounts and the Corner Rise Seamounts (Roe et al., 2011). The Management Proposal creates specific management for these two sets of seamounts (Figure 9). If the boundaries of the Sargasso Sea were to be defined more broadly to extend further east into the Canary current, the seamounts that surround the Azores could also be considered within the Sargasso Sea.

Seamounts significantly increase the biodiversity on the seafloor (Shank, 2010). They are able to support these particularly biodiverse communities for two major reasons: for the hard substrate they provide to organisms in the open ocean, and for the localized upwelling of water they create that washes nutrients from the seabed up towards the surface (Seidel, 2010). These nutrients stimulate an explosion of planktonic and small organism growth, which can then feed larger animals like as whales, sharks, and tunas (Seidel, 2010). Seamounts act as deep sea islands of biodiversity, making their protection particularly vital (Seidel, 2010). These islands also act as stepping stones for organisms that disperse across the otherwise relatively barren deep sea (UNEP, 2006). About 670 species have been found in the Corner and New England seamount chains alone, including commercially important fish species like the orange roughy and other deep sea species such as the Basketwork eel (Moore et al., 2004; Roe et al., 2011). 2

---

2 Data from Natural Earth, a source for free vector and raster map data for use with GIS, was used for the mapping of seamounts in the Sargasso Sea for the proposal.
Seamounts often support complex sponge and coral communities, including some species that are found nowhere else in the world and others that are protected species (Laffoley et al., 2011). They also provide a habitat for unique fish, sea squirts, hydroids, and sea anemones. Seamounts also act as a feeding ground for a variety of visitors such as tunas, swordfish, sharks, rays, eels, whales, sea turtles, seabirds, and orange roughy (UNEP, 2006). These species are economically important, particularly in terms of fishing or ecotourism (Pendleton et al, 2015).

Unfortunately, many seamounts in the Sargasso Sea have been damaged severely by bottom trawling (Roe et al., 2011). Deep sea fish in this area have been commercially exploited since 1976 (Roe et al., 2011). These fish stocks, such as the orange roughy, are especially slow to recover from impacts like overfishing and habitat destruction by bottom trawling because deep sea fish are long lived, they take many years to reach sexual maturity, and they produce few offspring when they do reach sexual maturity (Roe et al, 2011). The threat of bottom trawling to seamounts is discussed further in the Fisheries section of the Management Proposal.

While 30 different species of cetacean have been found in the Sargasso Sea, the direct association of each of them with seamounts remains to be seen. That being said, some studies (e.g. National Marine Fisheries Service, 2010) have already pointed to the importance of seamounts to sperm whales and humpback whales. The North Sargasso Sea and Gulf Stream are some of the highest density areas of sperm whales (National Marine Fisheries Service, 2010). Sperm whales appear to prefer steep depth gradients, which seamounts provide, and they are likely feed in areas above seamounts (Roe et al, 2011; National Marine Fisheries Services, 2010). Also, a recent paper that has yet to be published suggests that humpback whales use seamounts in the Sargasso Sea as feeding and aggregation sites before heading north for the summer (Laffoley et al, 2011).

VII. Other Ecosystem Services Provided by Sargassum and Seamount Habitats

In addition to their importance to a variety of organisms, Sargassum and seamounts are valuable resources to human society. These habitats of the Sargasso Sea provide a variety of ecosystem services, many of which will become increasingly important to society in the future. Sargassum provides two important ecosystem services that relate to the earth’s atmosphere. The first is carbon sequestration, and the second is oxygen production. The Sargasso Sea, with its relatively high productivity for being in the open ocean, has been found to be three times more productive than the Bering Sea, which is often described as one of the world’s most productive oceans (Roe et al, 2011). Since biological productivity leads to the absorption and storage of carbon dioxide from the atmosphere, the productivity of the Sargasso Sea acts as a carbon sink. In this way, Sargassum growth mitigates the rising carbon dioxide level in the atmosphere that is contributing to global warming (Pendleton et al, 2015). Secondly, the oceans provide nearly half of the oxygen in the earth’s atmosphere (UNEP, 2006), making the Sargasso Sea an important contributor to the global oxygen supply.

One potential threat to the long-term health of the Sargassum habitat is Sargassum harvesting. Currently, Sargassum is harvested for use as a fertilizer, but there is potential for other uses of Sargassum such as for biofuels and cosmetics (Pendleton et al, 2015). It has also been used in the past as cattle feed (Laffoley et al., 2011). Though Sargassum harvesting is managed in certain parts of the U.S. Exclusive Economic Zone, it is not regulated in the High Seas (South Atlantic Fishery Management Council, 2002; McHugh, 2003).

Seamounts provide us with important ecosystem services as well, beyond the more familiar service of supporting commercial fisheries (discussed in the Fisheries section of this proposal). Two of these are bioprospecting and deep sea mining, which are projected to become more and more relevant to the economy, science, and international relations in the future (UNEP, 2006;
Biodiversity and Conservation Targets

Van Dover, 2011). Bioprospecting is the search for, and exploitation of, valuable genetic resources of the seabed beyond national jurisdiction (Arico and Salpin, 2005). For example, gene sequences found in organisms in the deep sea that perform a useful function are relevant in the fields of medicine, bioremediation, agriculture, aquaculture, and biofuel development (Arrieta et al., 2010). As seamounts host an extremely rich diversity of organisms, many of which are still unexplored, genetic resources are another reason to conserve seamount habitats so that those genetic resources are not lost (Arico and Salpin, 2005).

In terms of mining, the seabed of the Sargasso Sea contains a variety of valuable resources such as polymetallic sulphides, manganese nodules, hydrocarbons, and others that could be commercially mined in the future (Roe et al., 2011). While the mining industry is not currently exploiting deep sea resources in the Sargasso Sea (Roe et al., 2011), doing so will likely become feasible in the future as demand increases and technology for deep sea extraction of minerals advances (UNEP, 2006). In fact, both Russia and China have already applied for exploration licenses to mine polymetallic sulphides in the Mid-Atlantic Ridge, which lies along the eastern border of the Sargasso Sea as it is defined by the Sargasso Sea Alliance (Parson and Edwards, 2011). Deep sea mineral extraction is expected to inevitably lead to the severe disturbance of deep sea ecosystems, such as those on seamounts (UNEP, 2006). Therefore, even though mining is not currently as high a concern for seamounts as other current human uses, mining regulations set by international bodies like the International Seabed Authority (ISA) will become essential for the protection of seamount habitats in the future (UNEP, 2006).

VIII. Species Conservation Targets in the Pelagic Region

Having designated conservation habitats, this document will now identify and explain a few species conservation targets within the Sargasso Sea. Many organisms living in the open ocean, or pelagic region, of the Sargasso Sea directly affect other areas beyond the Sargasso Sea. As migrating species travel through an area they interact with and influence many different environments (Enticknap, 2011). This creates a network of species living in the Sargasso Sea that can have broad impacts on the oceans adjacent to or near the Sargasso Sea. If management strategies are not implemented in the Sargasso Sea to mitigate the impacts of human activities, many of the migrating species that use the area to rejuvenate--benefiting from the food source provided by the Sargassum community--could be negatively impacted and may not be as successful in completing their migrations. Given the interconnectedness of the marine system, it is possible that altering migration routes can have substantial impacts on the ecosystems at both ends.

One category of species that are important conservation targets in the Sargasso Sea, and not mutually exclusive with migrating species, is top predators. Example of top predators in the Sargasso Sea include dolphins, sharks, and large species of tuna, such as the Atlantic bluefin tuna. If these species were to be removed, their absence would likely disrupt and drastically change the surrounding ocean ecosystem. This is due to a variety of processes collectively called trophic dynamics. Trophic dynamics is a term used to describe how different levels of the food web interact and affect each other. It is usually illustrated as a pyramid with plants and other primary producers--organisms that make food from sunlight--on the bottom of the pyramid, and top predators on the top of the pyramid. Removing important stages in the trophic pyramid can cause catastrophic devastation for the habitat and disrupt the broader food web, changes which are more broadly defined as trophic cascades.
Biodiversity and Conservation Targets

Top predators control the populations of all other organisms below them in the pyramid through a process called top-down control. In top-down control, the top predator directly controls the population of the next predator down, which directly controls the population of the organism below it. For example, in kelp forests, sea otters feed on sea urchins, which in turn feed on kelp, which lie at the base of the pyramid. In areas where sea otters have been hunted to extinction, the sea urchins no longer have anything controlling their population growth. This causes their populations to grow, and collectively, they consume kelp at a much faster rate than they would if there were sea otters around. The increase of kelp consumption causes large barrens in the kelp forests where none of the kelp-supported life can grow (Estes, 1974).

The effects of trophic cascade can also happen in a pelagic system such as the Sargasso Sea. Large predators like Atlantic bluefin tuna, dolphins, and porbeagle sharks feed on smaller forage fish like sardines and anchovies (Eticknap 2011). The forage fish feed on zooplankton, which in turn feed on phytoplankton. If the large predators were to be removed, the baitfish (such as sardine and anchovies) populations would increase. There would be nothing controlling their population size, and they could consume zooplankton at a much higher rate. Without zooplankton, there would be nothing to keep the population of phytoplankton in check. The phytoplankton populations could then explode. These explosions of phytoplankton growth are called algal blooms, and they lead to significant oxygen depletion (such as can occur during algal blooms known as red tides). In extreme cases, these trophic cascades could ultimately result in a decrease of life in the pelagic system, and the transformation of the environment into one where many fish cannot survive (Ramcharan 1996).

Therefore, top predators play an important ecological role and should be protected and considered in conservation management. The species listed above are representatives of the top predator community in the Sargasso Sea; however, there is not enough data on their life histories, distribution, and total numbers to include them in this management proposal. Given this fact, the Proposal encourages the protection of the Sargasso Sea's top predators.

Additionally, the life histories of shark and dolphins provide further evidence of the need for protection. Both sharks and dolphins have very low reproductive rates, meaning that they produce offspring very infrequently. This is due to many factors, including a low number of offspring produced in each birthing event, long gestation periods, and high ages of sexual maturity. Most sharks and dolphins produce very little offspring per breeding event. Dolphins usually only have one calf at a time, and porbeagle sharks only produce four pups on average per year, giving birth to these pups in the Sargasso Sea (Connor, 2000; Francis, 2000; Campana et al., 2010). Dolphins and sharks both have long gestation periods of almost a year.

Did You Know?

When Christopher Columbus sailed to North American in 1492, he wrote the first written account we have of Sargassum seaweed. He and his sailors recognized the seaweed as a sign of shallow waters, and thought they were going to run aground. Little did they know that Sargassum spends its entire life cycle in the open ocean!  

Chart from Christopher Columbus' journal
(Jensen, 2002; Shirihai, 2006). This long gestation period means that each organism is only producing offspring once a year or less. Porbeagle sharks mature between the ages of six to 11 if male and 12 to 18 if female; each individual thus has to live for a very long time before being able to create more offspring (Jensen, 2002). In that time, a shark can die from predation from other sharks, entanglement with fishing gear, or disease, thus not reaching the age necessary to reproduce. The same is true of dolphins, with females maturing between the ages of five and 13 and males maturing between the ages of nine to 14 (Wells, 2002).

Because of the above life history traits, it takes a very long time for species like dolphins, right whales, and sharks to increase their populations. As such, when their populations begin to decline, it is very difficult for them to bounce back. This means they should be afforded as much protection as possible, in order to prevent their populations from falling to levels dangerously close to extinction. Both sharks and dolphins are already threatened by human activities such as fishing, which will be discussed further in the Fisheries section of this Proposal.

Not all large marine animals are top predators. The role that right whales play in the environment is very different from that of the top predators discussed above. As ecosystem engineers, right whales influence the environment considerably, providing the proper ecological condition for the survival of many organisms. Right whales do this in a few different ways, not least of which is through their excrement. Whale feces contain a high concentration of nutrients from the food they eat. Since they are so large, whales release these nutrients into the ocean in huge quantities. One right whale can excrete up to 15.9 kg of feces per day (Roman 2010). The feces then float throughout the ocean on the surface, providing an influx and recycling of nutrients for other animals to live off. The nutrients in the feces come from the krill deep in the ocean that the whales feed on, providing a means of bringing nutrients that sank due to gravity back to the surface (Roman 2010).

The second way that whales provide a large concentration of nutrients to the ocean is as whale falls. When whales die, they sink to the bottom of the ocean. Once they land on the seafloor, they are scavenged by a wide variety of organisms that live on the bottom of the ocean, in this case recycling nutrients from the surface to the deep ocean (Little 2010).

With regard to management, right whales are an easily-supported conservation target. Besides their key ecological role, right whales and other whales are also of interest to the general public, and conservation policy regarding whales often enjoys public support. Despite this fact, and because right whales’ life history traits are similar to those of sharks and dolphins discussed above, right whale populations are very low, and thus listed on the IUCN Red List (Reilly, 2012). This Management Proposal acknowledges the ecological significance of North Atlantic right whales, and their status on the IUCN Red List, and have suggests management of North Atlantic right whales to protect them from negative human impacts.

Similar to the right whales, other species of concern have ecological importance beyond their role in augmenting biodiversity. Sea turtles play three major roles in the ocean. As primary grazers of seagrass beds, they help keep seafloors at a reasonable level, preventing them from becoming overgrown (Wilson, 2010). Overgrown seagrass can block currents and provide habitat for molds (Wilson, 2010). They also eat jellyfish, helping to control those populations and prevent jellyfish from growing out of control, a growing concern among marine scientists, particularly in warming oceans (Wilson, 2010). Finally, turtles provide food to many species through a variety of methods. Their young become prey for fish and land animals. Their shells host benthic animals, like barnacles, and turtles are known to stop at reef cleaning stations where fish can eat the parasites off of them (Wilson, 2010). In this way, sea turtles provide a role that no other organism fills. Unfortunately, most sea turtles are included on the IUCN Red List, and further efforts for their conservation should also be investigated (Wilson 2010).
Biodiversity and Conservation Targets

As mentioned above, Atlantic bluefin tuna are top predators, keeping other species in check. However, they are also extremely important to humans for commercial reasons. They are the number one fished species in Japan, and 90% of their stocks have been depleted since the 1970s (Collette, 2011). More broadly, canned tuna species make up the third most highly consumed seafood in the United States by weight, with shrimp and salmon taking first and second most highly consumed, respectively (National Marine Fisheries, 2011). This proposal recommends the protection of all tuna and tuna-like species, including Atlantic bluefin tuna that live in the Sargasso Sea, all of which can be regulated under ICCAT.

This proposal focuses on North Atlantic right whales and tuna and tuna-like species because each of these species has a significant ecological role in the marine ecosystem, as described above. The proposal does not include dolphins, sharks, turtles, or other species of concern due to lack of data, but does recommend they be investigated further for possible inclusion in future management plans.

IX. Stakeholders and Relevant Management Bodies

Identifying conservation targets is important not just for understanding what to protect or manage in a marine conservation plan, but also for the engagement of stakeholders. It is critical for the success of ocean conservation that the stakeholders are invested in conservation, and key way of engaging stakeholders is by connecting them with the predetermined conservation targets. For this proposal the conservation targets discussed above have been associated with the stakeholders described in the Governance section. These stakeholders include the people of Bermuda, the international fishing community, relevant international regulatory bodies, and the scientific community. Some of these stakeholders have already shown support for ocean conservation, or interest in the conservation targets, while others still need encouragement. The conservation targets outlined in the sections above are suggested here as points of interest to stakeholders. This is followed by suggestions of other conservation targets that can be used as a means of engaging with stakeholders.

The first conservation target considered is Sargassum habitat. As mentioned in previous sections (see section V. above, “Sargassum: the Golden Floating Rainforest”), Sargassum supports a community of small and large organisms, as unique as the Sargassum frog fish and as charismatic as juvenile sea turtles. Though Sargassum consists of floating clumps of seaweed in the open ocean, it has the potential to engage stakeholders, and build support for conservation initiatives; the Sargasso Sea fish stocks rely heavily on Sargassum mats or areas of high Sargassum concentration to for juvenile growth. Certain research institutes and government agencies such as Duke University, the Sea Education Association (SEA), the National Oceanographic and Atmospheric Administration (NOAA), and others have demonstrated their interest in studying Sargassum, supporting the case for Sargassum as a conservation target. Some example studies include the role of Sargassum in life-cycles of pelagic fish (Casazza et al., 2010), genetic studies of Sargassum community fauna (Sehein et al., 2014), and the potential use of Sargassum as a biosorbent of heavy metals (AAAS, 2015). United States policy reflects this interest in Sargassum; the U.S. South Atlantic Fishery Management Council has already restricted Sargassum harvesting in parts of its EEZ off the eastern seaboard, suggesting a broader interest in supporting conservation of this unique ecosystem (South Atlantic Fishery Management Council, 2015).

The next key habitat in the Sargasso Sea is seamounts. As underwater mountains, these seamounts encompass a broad range of depths that allows for considerable biological diversity along the depth gradient (see discussion above). These seamounts provide pristine ecosystems for oceanographic, biological, and geological research; the scientific community is engaged in research and understanding of seamounts, and their
Biodiversity and Conservation Targets

ecological conservation (Shank, 2010; Cho, 2008). Additionally, seamounts are potential sites for acquiring mineral resources. The ISA acknowledges the potential environmental impacts of seabed and seamount mining, and they include “conservation management” in their responsibilities. The ISA is a strong supporter of conservation and research towards the effects of mining and exploration (though only in their areas of potential claims), and can be considered an engaged stakeholder in regard to conservation of seamounts.

While encouraging stakeholders to care about Sargassum and seamount habitats can be a challenge, engaging stakeholder using species targets, particularly charismatic megafauna, is often considered more feasible though less effective for conservation (Agardy, Notarbartolo di Sciara, and Christie, 2011). In Bermuda, a significant tourist attraction are cetaceans (whales and dolphins), and other charismatic megafauna (primarily sharks). As such, these targets provide easy ways for individuals to connect and engage with the ocean environment. Additionally, a number of these species utilize the Sargasso Sea for pupping, such as sharks, and nursing, such as whales (Campana et al., 2010; Hallett, 2011).

Two conservation targets are related to fisheries: tuna and tuna-like species, and Sargassum. Tuna species are the most heavily fished species in the Sargasso Sea, and some populations are in decline. The fishermen, processors, distributors, and other members of the international fishing community are key stakeholders in Sargasso Sea fisheries and depend on its resources. It is crucial for these major tuna-fishing nations, including Japan, the United States, and Mexico, to acknowledge the need for conservation of these heavily fished species, especially if fishing practices are to continue in a sustainable manner. In addition to the commercial fishing industry, Bermuda’s recreational tournaments rely on pelagic and coastal fish stocks. These recreationally targeted fish, primarily marlin, are another key conservation target, as well as a way to engage recreational fishermen in the bigger picture of Sargasso Sea management. Furthermore, to maintain open ocean fish stocks, it is vital to protect juvenile pelagic fish habitat, which as mentioned previously, are Sargassum aggregations.

At the regulatory level, ICCAT is another key stakeholder, but has often been criticized for increasing tuna catch limits, even as the tuna populations continue to decline (Sumaila, Vats, and Swartz, 2013). However, ICCAT is still an invested and powerful stakeholder in the Sargasso Sea. Moreover, they have recognized the significance of Sargassum habitat to juvenile fish (Roe, 2011), which is an incremental step towards tuna conservation.

Shifting from discussing targets considered for management in the Proposal to other potential conservation targets, sea turtles are another target useful for engaging stakeholders. Sea turtles, like many pelagic fish, occupy the Sargasso Sea as juveniles, hiding within Sargassum clumps and feeding off the Sargassum community of smaller organisms (Inter-American Convention, 2014). While ICCAT has been scrutinized by environmental groups for not prioritizing tuna conservation (Sumaila et al., 2013), ICCAT has shown that it may consider sea turtles as a conservation target. Though ICCAT has held meeting to discuss regulations around bycatch of sea turtles (ICCAT, 2014), they have been slow to act in creating a conservation plan for sea turtles. Though sea turtles are not considered in this Proposal as conservation targets, they remain a species of ecological concern, and may be utilized in opening the door to discussing conservation efforts with ICCAT in the future.

Another potential conservation target not identified above pertains directly to Bermuda, and

Did You Know?

Seamounts are dormant underwater volcanoes. There are roughly 800 seamounts in the North Atlantic, and over 100,000 seamounts worldwide.

Two conservation targets are related to fisheries: tuna and tuna-like species, and Sargassum. Tuna species are the most heavily fished species in the Sargasso Sea, and some populations are in decline. The fishermen, processors, distributors, and other members of the international fishing community are key stakeholders in Sargasso Sea fisheries and depend on its resources. It is crucial for these major tuna-fishing nations, including Japan, the United States,
Biodiversity and Conservation Targets

greatly influences the tourism and fishing industries: coral reefs. This Proposal has excluded reefs from its discussion of conservation targets as they fall almost exclusively within Bermuda’s EEZ, which is not the focus of this Proposal. That said, this document hopes to encourage support for conservation of coral reefs as they are threatened by a number of factors, including climate change as a major stressor (Hoegh-Guldberg et al., 2007), which will be discussed further in the Stressors section of the Proposal. However, given that much of Bermuda’s tourism relies on healthy coral reefs, it follows that Bermuda should invest in continuing and encouraging support for the conservation of reefs. These coral reefs provide the opportunity for Bermudians and tourists to engage as stakeholders in the Sargasso Sea.

X. Conclusion

Defining and identifying conservation targets prior to drafting a management plan is extremely important and will aid in the creation of a successful marine management plan. Scientific studies are needed to determine targets and support rationale for the specifics of a management plan. The methods of identifying and prioritizing conservation targets are different for each habitat type. It can be extremely difficult to obtain enough information for a system like the open ocean, as it contains so many factors of ecological and socioeconomic importance. After an applied, well-reasoned process, the proposal team came to an agreement on the conservation targets of the Sargasso Sea. These targets include high density Sargassum aggregations, seamounts, tuna or tuna-like species, and right whales, all of which have limited existing management in place for their protection in the Sargasso Sea. Other conservation targets in the Sargasso Sea include porbeagle sharks, dolphins, and other endangered or threatened species on the IUCN Red List, but these are not included in the proposal due to the lack of data on these species. In regards to stakeholders, further education to engage individuals and entities with conservation targets is the next and necessary step towards successful ocean management and conservation.
Stressors on biodiversity and natural resources are an important consideration when discussing management of the Sargasso Sea. Although stressors itself is a term that can be broadly defined, there are three overarching stressors on biodiversity and natural resources that are the top priority in the Sargasso Sea: climate change, plastic pollution, and invasive species. We also acknowledge fishing and shipping as stressors on biodiversity and natural resources, however these issues are highly complex and will be discussed as independent sections. Climate change, in particular, is the largest and most overarching threat facing the Sargasso Sea, resulting in ocean acidification, increasing sea surface temperatures, and rising sea levels. Plastics pose significant health threats to organisms living both in the Sargasso Sea and outside of it, and also contribute to the introduction of invasive species. The presence of invasive species in the Sargasso Sea would be extremely detrimental to biodiversity and health in this unique ecosystem. Each of these variables has increased tremendously over the past century with no signs of decline, and immediate action must be taken by policy makers and the public in order to mitigate the negative impacts of these stressors on the marine environment.
Stressors on Biodiversity and Natural Resources

In order to promote conservation of biodiversity and natural resources, it is important to understand and mitigate potential stressors of these resources. Biodiversity acts as a crucial indicator of ecosystem health, yet there are many elements of biodiversity in a marine ecosystem. This results in two major challenges in making progress toward the goal of protecting and promoting conservation of biodiversity and natural resources: 1) a reliable and robust method of identifying these stressors, drawing from both established and emerging innovative approaches, and 2) development and implementation of proper management strategies to respond to these stressors.

Defining and identifying stressors

Stressors are identified as anything reducing or with the immediate potential to reduce biodiversity (Coll et al. 2010). Broadly defined, a stressor can refer to a range of events or processes on a varied temporal scale. In one sense, a stressor is defined as a major event, where a given system may undergo a significant reduction in species richness and abundance, such as clear cutting of a forest. By contrast, large scale geologic patterns, such as the slowing of thermohaline circulation over hundreds of years (causing global cooling) are also stressors to biodiversity. Additionally, the definition of stressors on biodiversity will change based on the area of interest. A smaller area is more vulnerable to local extinctions and reductions in species richness and abundance, while a larger area is more resilient to minor impacts (Raup, 1985). Stressors on biodiversity can have a variety of impacts. For example, some stressors may target a specific species or ecological niche, reducing biological diversity through species extinctions and loss of species richness. On the other hand, stressors can also target specific habitats, leading to the loss of habitat and loss of species abundance.

It is important to recognize that while some stressors clearly fall into one of the categories listed above, the scope and impact of most stressors is more difficult to define. Furthermore, the Sargasso Sea has similar stressors to other open ocean systems like it, but in the same way that certain characteristics of the Sargasso Sea will be unique, certain stressors to the Sargasso Sea will be unlike any other system (Coll et al., 2010; Game et al., 2009).

Established and emerging approaches to identifying stressors

Traditionally, policymakers have turned to the experts in the field as the primary source of identifying stressors. One example is the global study done by Halpern, Selkow, Micheli, and Kappel (2001), which identified the use of expert survey as the primary method of identifying stressors. The survey allowed the creation of an expert consensus on the identification and prioritization of global oceanic stressors. The idea of relying on expert knowledge is logical, as these experts undoubtedly will have the greatest knowledge and insight on a given system. Halpern et al. (2001) found that surface temperature increases, followed by destructive fishing and organic pollution, pose the most immediate stress on biodiversity in the global marine system.

However, there are very significant issues with strictly relying on expert consensus to identify and prioritize stressors. Returning to the difficulty of defining a stressor, it can then be understood why the results of a global survey, such as Halpern et al. (2001), cannot be applied to a more specific area. Although these conclusions still carry weight, distinctions between global stressors and stressors to smaller regions, such as the Sargasso Sea, must be made in addition to a prioritization based on specifics of the Sargasso Sea. This prioritization will require a new ecosystem-specific approach to stressors, rather than a global analysis of greatest impacts.

The first step in Sargasso Sea-specific prioritization of stressors is developing an intricate understanding of key players in this
Stressors on Biodiversity and Natural Resources

system. Key players are broadly defined as any aspect of the system that will directly affect the functioning and the amount or frequency of ecosystem services provided (Sherr and Sherr, 1994). The process of selecting and identifying key players of a system is a highly complex process on its own, and has therefore been discussed more in-depth in the “Conservation Targets and Priorities” section.

Major Stressors of the Sargasso Sea

A review of the scientific and technical literature to date indicates that there are five major stressors in the Sargasso Sea. This list is not comprehensive, but focuses on the most immediate and highest priority stressors to the Sargasso Sea:

- Climate change
- Plastic pollution
- Invasive species
- Fisheries
- Maritime traffic

Of these stressors, global climate change should be regarded as the greatest stressor on biodiversity and natural resources. Climate change has the most overarching impacts, on the greatest scale, and with currently the least number of immediate solutions available. Climate change will affect not just the Sargasso Sea, but will affect all systems both connected to and beyond the Sargasso Sea. For these reasons, climate change is a major stressor on biodiversity.

Plastic pollution, a rapidly growing issue, is also identified here as a major stressor on biodiversity. Plastic pollution in particular poses a great stress on the biodiversity in the Sargasso Sea because of its detrimental effects and longevity. Plastics, slow to break down, have a wide range of impacts, from direct harmful ecological effects to human health risk by independent consumption.

Finally, invasive species impose an important stressor on biodiversity and natural resources in the Sargasso Sea. Invasive species are identified as a particular danger because of the difficulty surrounding the prevention of invasion, in addition to the great difficulty of mitigating the effects of an invasive species once it is established in the system. Although there are few known invasive species in the Sargasso Sea, identified invasive species such as the lionfish pose significant danger to ecosystems colonized. Immediate action will be required to prevent further colonization of invasive species, in addition to reducing the impact of established invasive species.

Both shipping and fishing create measurable and identifiable stress on biodiversity and natural resources in the Sargasso Sea. However, these subjects are highly multidimensional, and must be handled and understood as such. For this reason, there are separate discussions on the impacts and effects of shipping and fishing included in this Management Proposal (see the Fisheries and Maritime Traffic sections).

There are other stressors to the Sargasso Sea that are not discussed here, because they do not present the most immediate danger to biodiversity in the Sargasso Sea, but must still be acknowledged. These include seabed mining, and Sargassum harvesting. Seabed mining and the harvest of other natural resources such as Sargassum, while not currently taking place in the Sargasso Sea, would both be major issues for the preservation of biodiversity and natural resources should they evolve. It is therefore also important to consider how this list may change in the future. For further discussions of these topics see the Conservation Targets section.

Other considerations when discussing stressors

Creating effective management strategies to mitigate the impacts of these stressors is complex. When discussing mitigation and management strategies, other factors are at play. For successful implementation of management measures, development of realistic and attainable goals should be made a top priority as well (Halpern, Selkow, Micheli, and Kappel, 2001). Just as management cannot be completed overnight, management goals and strategies for mitigating stressors should reflect achieving easily attainable goals first, while moving towards more challenging and long term goals.
Climate Change

Human activities have released large quantities of carbon dioxide into the atmosphere. The burning of fossil fuels, such as coals and oils, has raised atmospheric carbon dioxide levels from 280 parts per million to 404 parts per million in the last 150 years, increasing CO2 concentrations by one third since the Industrial Revolution (Tans, 2015). This increase in carbon dioxide contributes to Earth’s natural greenhouse effect, a warming phenomena that results when gases in the atmosphere trap heat radiating from Earth. Although the greenhouse effect heats up the Earth, thereby supporting life, the recent influx in carbon dioxide has had adverse effects, such as increased global temperatures, reductions in ice cover, and rising sea levels. The growing threat of climate change has caused the United Nations to establish several bodies that evaluate and address these stressors.

Over the past two centuries, the global oceans have absorbed one third of the carbon dioxide in the atmosphere (Beman et al., 2011; Laffoley et al., 2011; Lomas, Bates, Buck, & Knap, 2011). As a consequence, ocean chemistry has drastically altered and the oceans are becoming more acidic, a process called ocean acidification (see figure 10)(Huffard, Von Thun, Sherman, Sealey, & Smith Jr., 2014). Although this is a global issue, one region that is highly significant is the Sargasso Sea.

There are only four research stations that have studied carbon dioxide concentrations in the oceans long enough to illustrate the reality of ocean acidification. Each month, water samples are collected at 35 depths, from 0 to 4,200 meters (13,780 feet), during four-five day cruise tracks around each research station. The concentrations of carbon in these samples are then analyzed to determine the ocean’s’ acidity (Bell, 1997). Of these four stations, three are located in the Sargasso Sea, two in the northwestern Sargasso Sea, and one in the northeast, in the Canary Current. The two research stations in the northwest include the Bermuda Atlantic Time-series Study and Hydrostation “S,” which began sampling in 1988 and 1974 respectively. The northeastern station is the European Station for Time-series in the Ocean Canary Islands (ESTOC), and was initiated in 1994. The locations of these stations in the Sargasso Sea make this area one of the most critical regions for understanding global ocean acidification and the far reaching consequences it poses (Laffoley et al., 2014).

Numerous organisms are affected by ocean acidification; however, organisms that produce shells and skeletons made of calcium carbonate are most at risk (Cheryl, 2010). These organisms use carbonate ions found in seawater to build their shells and skeletons, and include oysters, clams, mollusks, and hard corals, the latter of which form the stony foundation of reef ecosystems (Huffard et al., 2014; Lomas et al., 2011). As seawater absorbs more carbon dioxide, the increased acidity causes carbonate ions to be relatively less abundant. Therefore, this decrease in carbonate ions makes it difficult for these organisms to build and maintain their shells.

In the Sargasso Sea, ocean acidification is especially problematic for the deep-sea corals that grow among seamounts and the coral reef ecosystems of Bermuda. These corals are ecosystem engineers and foundation species that build extensive habitats that support high levels of biodiversity. Increased acidity will reduce the corals’ ability to successfully function within the ecosystem, by making the corals more susceptible to temperature change, disease, and storm damage. Although coral communities can remain on weakened, eroding corals, studies show that...
Stressors on Biodiversity and Natural Resources

Reef surfaces, which are normally rough and irregular, become flatter with ocean acidification. This creates a loss in habitat diversity, which leads to declines in overall biodiversity (Kleypas and Yates, 2009).

Ocean acidification also threatens other communities in the Sargasso Sea. Bryozoans, for example, are small marine invertebrates that live on Sargassum seaweed and secrete a calcium carbonate exoskeleton. Studies show that increased acidity can contribute to a reduction in bryozoan coverage on this seaweed (Huffard et al., 2014). If this coverage on Sargassum is reduced, the seaweed does not sink as easily when it ages. The reduction of sinking Sargassum causes a decline in the rate of food supplied to the deep sea, which affects fish and invertebrate scavengers who consume the fallen seaweed (Huffard et al. 2014). Additionally, a majority of the organisms associated with surface level Sargassum are not calcifying, however many are negatively impacted by ocean acidification. Studies have found that the exoskeletons of crab and shrimp larvae begin to weaken if they are exposed to increased acidity for prolonged periods of time (NOAA, 2015). This is problematic for the Sargasso Sea as many of its crab and shrimp species are only found in this region, and act as a food source for many ecologically and economically important species.

Models provided by the Intergovernmental Panel on Climate Change (IPCC) estimate that surface ocean pH will decrease from 8.2 to as low as 7.7 over the next century; which corresponds to approximately a 215% increase in acidity (Laffoley et al. 2011). Additionally, scientists project that main reef-building organisms, such as stony corals, will calcify 10-50% less, relative to pre-industrial rates, by the middle of the century (Kleypas and Yates, 2009). Despite these negative effects and predictions, the photosynthetic activity of Sargassum in the Sargasso Sea can buffer the boundary layer from low-pH conditions (Huffard et al. 2014). This suggests that Sargassum may fair better than other organisms as ocean acidification increases.

A second threat posed by climate change to the Sargasso Sea is increased sea surface temperatures (SST's). Due to the greenhouse effect, as carbon dioxide concentrations increase, atmospheric and sea surface temperatures follow...
Stressors on Biodiversity and Natural Resources

Annual average global atmospheric temperatures have increased by about 1.5°C (2.7°F) to 2°C (3.6°F) since 1901 (Climate, 2013; EPA 2014). Additionally, from 1901 to 2013, sea surface temperatures have risen at an average rate of 0.07°C (0.13°F) per decade, and have been higher during the past three decades than at any other period since observations began in 1880 (EPA, 2014).

Two species found in the Sargasso Sea that are heavily affected by increased sea surface temperatures are the American and European Eels. Around the 1970’s, researchers and fisheries managers began noticing a decline in American and European Eel recruitment (Bonhommeau, Chassot, & Etienne, 2008; Friedland, Miller, & Knights, 2007). Because both eel species utilize only the Sargasso Sea as a spawning ground, several studies were conducted to determine a cause for the decline. In these studies, long-term sea surface temperatures were analyzed, in order to investigate long-term regime shifts and variations (Friedland et al. 2008). Sea surface temperatures in the Sargasso Sea have been monitored at Hydrostation “S” of Bermuda’s Biological Station since 1955. Results showed that temperatures in the Sargasso Sea could be categorized into three distinct phases. The first, cold phase occurred between 1960 and 1970, with temperatures averaging 21.4°C (70.52°F). Following this phase, however, sea surface temperatures began to increase to about 22°C (71.6°F) until 1999, after which temperatures in the Sargasso Sea increased higher than 22°C (Bonhommeau et al., 2008). Researchers found that marine production decreases as sea surface temperatures increase, due to warmer waters inhibiting vertical mixing, and reducing the upward nutrient supply (Richardson and Schoeman, 2004). This shift in sea surface temperatures around 1970 marked the beginning of changes in the Sargasso Sea environment, and indicates a strong and significant negative relationship between sea surface temperatures, primary production, and eel recruitment. This indicates that the Sargasso Sea has gradually been increasing in surface temperatures, and that temperature is the main governing factor influencing eel recruitment (Bonhommeau et al., 2008; Friedland et al. 2008).

Increasing sea temperatures also negatively impact corals. Corals have a symbiotic relationship with microscopic algae, known as zooxanthellae, which live in their tissues. Corals provide this alga with a protected environment, as well as compounds needed for photosynthesis. In exchange, the algae produce oxygen, help the corals remove waste, and supply the coral with food products necessary for calcium carbonate production (NOAA, 2015). When corals are stressed by changing conditions, however, the symbiotic algae is expelled, causing the corals to turn completely white in a process called coral bleaching. Without their algae, the corals lose their major source of food, becoming more susceptible to starvation and disease. Warmer water temperatures can result in coral bleaching, and although a major bleaching event has yet to be documented in the Sargasso Sea, mass bleaching events have been documented in other locations worldwide. For example, in 2005 the United States lost half of its Caribbean coral reefs in one year, due to a massive bleaching event (NOAA, 2015).

As sea surface temperatures increase, one trend that may occur is a northward/poleward range shift in species distribution. Climatic regimes influence species distribution, often through species-specific thresholds such as temperature and precipitation tolerance (Walther et al. 2002). Already, scientists have discovered many marine fish species moving towards the poles to escape warming ocean temperatures (Poloczanska et al. 2013). While this response may benefit some species, many species and habitats in the Sargasso Sea are unable to make this shift. These include reef building corals that surround Bermuda, as well as cold-water corals that live on seamounts. The latitudinal distributions of these corals are limited by various factors, however habitat availability is first and foremost (Walther et al. 2002). The lack of viable habitat north of the Sargasso Sea makes it impossible for cold-water corals to leave their seamounts. As a result, corals in the Sargasso Sea may have increased mortality.
Stressors on Biodiversity and Natural Resources

As increased ocean temperatures push them past their thresholds.

As climate change continues and atmospheric temperatures further increase, sea levels are expected to rise, which will pose another significant problem for the Sargasso Sea and its various ecosystems. There are two primary ways sea levels will rise: the warmer climate will cause ice over land to melt, and warmer oceans will cause seawater to expand (NOAA, 2014). Studies show that sea levels changed little between the years CE 0 and 1900 (NOAA, 2014). Since 1900 however, scientists have determined that global sea levels have been steadily increasing at a rate of at least 1.02 to 2.54 millimeters (0.04 to 0.1 inches) per year (NOAA, 2014). Recent satellite evidence indicates that the rate of sea level rise has increased since 1992 to 3.05 millimeters (0.12 inches) per year (NOAA, 2014).

While surface ecosystems, such as Sargassum, will not be affected, sea level rise could have detrimental effects on corals, the island and people of Bermuda, and tidal habitats such as mangroves. For the time being, most coral reefs throughout the Sargasso Sea should be able to adapt to sea level rise, because coral growth rate exceeds the current rate of sea level increase. However, as the rate of sea level rise increases, it is unlikely that corals will keep pace, and many may struggle to adapt to deeper waters (GBRMPA, 2011).

Sea level rise also poses a threat to the island and people of Bermuda. As oceans rise, low-lying areas will experience more frequent flooding, with very low-lying areas potentially being submerged completely. Additionally, Bermuda may face increased erosion along its coasts, which would negatively affect many of its coastal houses and towns (EPA, 2014).

Last, rising sea levels threaten Bermuda’s mangroves, which act as nursery habitats, protection for inland sites, sediment traps to sustain offshore water quality, as well as resources for medicines, firewood, and food. As sea levels increase, mangroves are subject to increased stressors, such as sediment erosion, inundation stress, and increased salinity (Ellison, 1994). This is especially problematic for mangrove ecosystems in Bermuda, which are restricted in their inland distribution by human development. Recessions of mangrove forests in Bermuda can lead to increased lagoon environments and a loss of the resources and services these forests have to offer. In fact, with the increasing rate of sea level rise, Bermuda has already seen a recession in their mangrove forests (Ellison, 1994).

Managing global climate change as a stressor is difficult given the systems-level nature of the problem. No single country is responsible for climate change, and no country can tackle this issue single handedly. As a result, managing global climate change requires global, regional and local scale initiatives. On a global scale, countries must focus their policy initiatives on greenhouse gas reductions to mitigate the problem. Regionally and locally, however, policy must focus on ways to adapt to the impacts of global climate change on people organisms and the environment.

Currently, the primary global framework to address climate change through the reduction of greenhouse gases is the United Nations Framework Convention on Climate Change (UNFCCC). This is an international treaty to cooperatively consider what can be done to limit average global temperature increases and resulting climate change. Within the UNFCCC is the Kyoto Protocol, which was adopted in December 1997 (UNFCCC, 2014). This protocol is a pact that commits signatory countries to reduce their greenhouse gas emissions by 5% of 1990 levels between 2008 and 2013, the first commitment period (Sciermeier, 2012; UNFCCC, 2014). Out of 192 parties associated with the UNFCCC, 82 signed and ratified the Kyoto Protocol. Following the end of the first commitment period, the Doha Amendment was created, establishing the second commitment period. This will run from 2013 to 2020, with the goal of parties reducing greenhouse gas emissions by 18% of 1990 levels (UNFCCC, 2014).

Following the end of the first commitment period, the Kyoto Protocol reached some success, with signatory countries reducing emissions by 16%. However, due to non-party countries such as the United States, India, and China, worldwide...
Stressors on Biodiversity and Natural Resources

emissions surged by 50% since 1990. Despite this, by combining and committing countries worldwide to reduce emissions, the Kyoto Protocol laid the groundwork for more ambitious future efforts (Schiermeier, 2013; UNFCCC, 2014). Since the establishment of the Doha Amendment in 2012, the United States and China, two of the world’s largest polluters of greenhouse gasses, have planned to reduce emissions by 28% of 2005 levels by 2025 (White House, 2015). Hopefully, with the combined effort of these two major emitters along with the signatories of the Kyoto Protocol, global greenhouse gas emissions will see a serious reduction by 2025.

While greenhouse gas reduction negotiations take place on a global scale, the potential impacts of climate change on the Sargasso Sea require regional and local action to occur at the same time. These management strategies must focus on adapting to the impacts of climate change on the marine environment. Currently, no such policies are in place for the Sargasso Sea, however there are several strategies that could be implemented to help this ecosystem. First, other stressors to the Sargasso Sea (i.e. plastics, invasive species, shipping, etc.) must be reduced. Reduction of these stressors will help establish a healthier ecosystem that can endure and potentially adapt to the effects of climate change. Next, as ocean temperatures increase, areas must be established that take into consideration the poleward shifts in species distribution. While not all organisms and ecosystems in the Sargasso Sea can travel north, policy must be established to help protect these organisms in their new territories. Last, regional and local policy should prioritize the mitigation of stressors to ecosystems and species that cannot undergo poleward range shifts, such as corals and seamounts, as these are most at risk. Implementing these, as well as global policies, can help mitigate the stressor that climate change has become for the Sargasso Sea.

Plastic Pollution in the Sargasso Sea

Plastic pollutants in marine systems are putting increasing amounts of pressure on their inhabitants. Gyres are particularly at risk due to the circulation patterns of plastics in the ocean (Eriksen et al. 2014). Currently, several frameworks exist on both national and international levels to try and address the issue of plastic pollution in the marine environment. Still, these measures insufficiently target a small portion of ships traversing the world’s oceans with inadequate enforcement.

Some countries have taken initiative to fund and support research projects investigating the impacts of marine plastics on the environment. However, there is ample evidence to demonstrate the harmful properties of plastic and its impact on marine inhabitants. Researchers predict that if prompt action is not taken, marine systems will face significant threats to ecosystem stability and functionality (Jambeck et al. 2015; Law et al. 2010). Policy makers need to take immediate action either through the development of an international treaty that regulates plastic waste or agree to work on smaller, regional levels that directly target the largest consumers of plastic and the biggest threats to polluting the oceans: people on land.

Current Pressures Introduced to Systems

The global distribution of plastics in the oceans has only recently begun to be fully understood. These plastics include plastic bags, plastic bottles, plastic-based fishing line and netting, balloons, small pieces of plastic called microplastics that have been broken down over time by sun and currents,, and even small plastic beads from certain brands of face wash. It is widely known that microplastics are globally distributed (Eriksen et al. 2014; Law et al. 2010). All plastics of all sizes are found in all parts of the ocean (Eriksen et al. 2014).

The major accumulation zones are in the five large subtropical gyres located in the North Pacific, better known as the Great Pacific Garbage Patch; the South Pacific; the Indian Ocean; the South Atlantic; and the Sargasso Sea in the North Atlantic Ocean (Cózar et al. 2014; Eriksen et al. 2014). This includes southern hemispheric gyres, which were previously speculated to have less plastic accumulation than the northern
hemisphere due to smaller populations on their coast. After two studies surveyed the oceans for plastic distribution, they found that the estimated amount of surface plastics is an order of magnitude smaller than the actual amount (Cózar et al. 2014; Eriksen et al. 2014). There is additional speculation that there is an additional large sink of plastics that are currently unaccounted for in the world’s oceans, which would bring the plastic concentration up even more (Cózar et al. 2014). The increase in marine plastic concentration globally could have substantial negative consequences for the organisms living in the world’s oceans.

The most significant stressor introduced by plastics is negative health impacts on organisms both inside and outside the Sargasso Sea (Rochman et al. 2013). As plastics break into smaller pieces, their potential for infiltration into a food web becomes significantly higher (Browne et al. 2008). Laboratory and field studies have found that invertebrates, fish, and microorganisms ingest microplastics. Although little research has been done to look at the specific health impacts in all of these organisms, humans and mussels are adversely impacted by the ingestion of plastics. Particles of plastic have been shown to disrupt important cellular processes necessary for the maintenance of the organism’s health and degrade tissues (Browne et al. 2008).

Along with immediate health risks from actual ingestion, plastics themselves are made up of hazardous ingredients (Rochman et al. 2013). The United Nations’ Globally Harmonized System of Classification and Labeling of Chemicals found that more than 50% of the chemical ingredients in plastic are harmful. Plastics also have the potential to pick up other pollutants (Teuten et al. 2009). Pesticides and organic pollutants classified by the US Environmental Protection Agency (EPA) as ‘priority pollutants’ are consistently found on plastic waste at concentrations 100 times those found in sediments and one million times those found in seawater (Rochman et al. 2013). These ‘priority pollutants’ are classified due to their toxicity or persistence in organisms in food webs, which requires special regulation by government agencies. Rochman et al. found that 61% of priority pollutants listed by the European Union and 78% listed by the EPA are associated with plastic debris. These pollutants include ingredients in plastic and other pollutants absorbed from the environment. The larger impact of these pollutants remains relatively unknown. However, the known immediate and long term consequences of plastic accumulation in the global oceans are too severe to be left unnoticed.

This directly applies to the Sargasso Sea with a study conducted in 2010 by Law and coauthors. Previous studies looking at the direct effects of plastic on ocean fauna have focused on larger pieces of plastic, finding that marine organisms are susceptible to entanglement and ingestion leading to injury or death (Gregory 2009). However, Law et al.’s study focused on the impacts of microplastics and their distribution in the Sargasso Sea. A research vessel collected 6,136 surface samples between 1986 and 2008. 60 percent of these samples contained buoyant plastic that was just millimeters in size, ranging from the size of an ant to a mosquito (Law et al. 2010). The region of the highest convergence of microplastics in the Sargasso Sea is the subtropical convergence zone, which is widely thought to be a hotspot for biodiversity within the area (see figure 11). Law et al. found that this high accumulation of plastics had led to ingestion by organisms of all sizes, dispersal of nonnative organisms, and the concentration and transport of contaminants to species in the ecosystem.

The main issue with both the global perspective on marine plastic pollution and the scientific data investigating this problem is that there is rarely an acknowledged connection between the terrestrial world and the aquatic world. Several studies have focused on the mechanism of transport of plastics in the oceans and what they do when accumulation occurs, but
very few studies focus on what areas are most at risk for polluting the oceans (Jambeck et al. 2015; Law et al. 2010). Furthermore, even less is known about the vectors of plastic introduction from land-based sources to the oceans (Rochman et al. 2013). A study done in 2015 by Jambeck et al. suggests that more researchers need to link global data on economic status, population density, and global waste to better address the problem of plastics pollution in marine systems. Jambeck and co-authors determined that the factors having the largest impact on the amount of plastic waste generated by any country are the population size and the quality of waste management. This study stipulates that if plastic waste is not managed on a global level immediately, the amount of plastic circulating in the oceans will increase further by an order of magnitude.

Figure 11: Plastic concentration in the Sargasso Sea. This figure depicts the average concentration of plastics within the Sargasso Sea. Data was obtained using data from satellite imagery, drifters, reanalysis winds, and hydrographic profiles. The black line indicates the contour of the 10-year mean surface circulation. Graphic reprinted with the permission of AAAS (Source: Law et al. 2010).
Stressors on Biodiversity and Natural Resources

The global community’s ability to regulate all sources of marine pollution (Boyle 1985; Craig 2005).

The main current international convention regulating plastic pollution in marine systems is the International Convention for the Prevention of Pollution from Ships (MARPOL) Annex V 73/78 (see figure 12). This treaty was signed into force on 31 December 1988. It is designed to reduce and eliminate all forms of garbage from ships introduced to marine systems (Rochman et al. 2013). Garbage in this protocol was defined as all kinds of food not including fish, domestic and operational waste. It strictly prohibits the dumping of plastics into marine systems from ships travelling through the high seas and EEZs of nations party to the treaty. However, the treaty does allow for the implementation of stricter regulations regarding the discharge of certain types of wastes in areas classified as Special Areas under Annex V.

<table>
<thead>
<tr>
<th>Type of garbage</th>
<th>Ships outside special areas</th>
<th>Ships within special areas</th>
<th>Offshore platforms and all ships within 500 m of such platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food waste comminuted or ground</td>
<td>Discharge permitted ≥3 nm from the nearest land and en route</td>
<td>Discharge permitted ≥12 nm from the nearest land and en route</td>
<td>Discharge permitted ≥12 nm from the nearest land and en route</td>
</tr>
<tr>
<td>Food waste not comminuted or ground</td>
<td>Discharge permitted ≥12 nm from the nearest land and en route</td>
<td>Discharge prohibited</td>
<td>Discharge prohibited</td>
</tr>
<tr>
<td>Cargo residues 1 not contained in wash water</td>
<td>Discharge permitted ≥12 nm from the nearest land and en route</td>
<td>Discharge only permitted in specific circumstances and ≥12 nm from the nearest land and en route</td>
<td>Discharge prohibited</td>
</tr>
<tr>
<td>Cargo residues 1 contained in wash water</td>
<td>Discharge permitted</td>
<td>Discharge only permitted in specific circumstances and ≥12 nm from the nearest land and en route</td>
<td>Discharge prohibited</td>
</tr>
<tr>
<td>Cleaning agents and additives 1 contained in cargo hold wash water</td>
<td>Discharge permitted</td>
<td>Discharge only permitted in specific circumstances and ≥12 nm from the nearest land and en route</td>
<td>Discharge prohibited</td>
</tr>
<tr>
<td>Carcasses of animals carried on board as cargo and which died during the voyage</td>
<td>Discharge permitted as far from the nearest land as possible and en route</td>
<td>Discharge prohibited</td>
<td>Discharge prohibited</td>
</tr>
<tr>
<td>All other garbage including plastics, domestic wastes, cooking oil, incinerator ashes, operational wastes and fishing gear</td>
<td>Discharge prohibited</td>
<td>Discharge prohibited</td>
<td>Discharge prohibited</td>
</tr>
<tr>
<td>Mixed garbage</td>
<td>When garbage is mixed with or contaminated by other substances prohibited from discharge or having different discharge requirements, the more stringent requirements shall apply</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 12.** Discharge provisions of MARPOL Annex V. This chart depicts a simplified version of the discharge provisions of the revised MARPOL Annex V. This figure was taken from MARPOL and is only to be used as a reference, not a substitute for the comprehensive provisions in the revised MARPOL Annex V or the guidelines for implementation. The MARPOL Annex V revisions outlined in this table entered into force on 1 January 2013 (SOURCE: IMO 2013).
The treaty requires that vessels of 100 gross tonnage and above or containing crews of 15 or more develop a garbage management plan, which includes a written management plan aimed at “minimizing, collecting, storing, processing and disposing of garbage” (MARPOL Annex V, regulation 10.2). Vessels weighing 400 gross tonnage and above or consisting of crews of fifteen or more are further required to keep a garbage record book (MARPOL Annex V, regulation 10.3). These books contain the date, time, and position of the ship when discharge is eliminated, the description of the garbage eliminated, and the estimated total amount eliminated from the ship. This regulation was introduced in order to help local officials better keep track of the waste eliminated from larger vessels. It was designed to be advantageous to the ship during waste checks – when personnel can accurately account for the waste disposal that occurred during their voyage, it is less likely that they will be penalized for wrongful or incorrect disposal of garbage. Although local officials are intended to regulate garbage disposal, there is little enforcement beyond what countries party to the treaty are willing to do.

Many nations throughout the world also have targeted policies that address plastic pollution in the oceans. However, much like the London Convention and MARPOL Annex V, many of these policies target sea-based sources of plastic pollution rather than land-based sources. The lack of international policy that directly addresses plastic regulation on land is becoming a large problem that the world cannot turn away from. From the scientific standpoint, the adverse impacts of plastics on marine organisms are clearly identified (Teuten et al. 2009). However, the vector of pollution has yet to be clearly defined by researchers. The closest scientists have come to outlining the mechanism of pollution was through a meta-analysis of economic, population, and waste statistics to determine the common
Stressors on Biodiversity and Natural Resources

Recent research makes it clear that plastics are a global threat to ecosystem functionality. Microplastics put a significant amount of pressure on the organisms that live there either directly through entanglement or suffocation or indirectly through ingestion and buildup of toxins over time. The lack of clear policy targeting plastic waste management on land is the key issue with current international policy. Utilization of regional management in conjunction with international management will help achieve global standards for plastic waste management in the oceans.

Invasive Species

One of the pressures on many ecosystems is the movement of non-native species into new habitats, through either natural range expansion or human interference. Invasive species are non-native species that rapidly colonize new areas, which results in effects detrimental to biodiversity, human health, livelihoods, local cultures, and national economies (Burgiel, Fotte, Orellana, and Perrault, 2006). Colonization by these organisms is a serious problem because their negative impacts require constant population management for maintaining healthy ecosystems (See figure 13) (Occhipinti-Ambrogi, 2007). It is for this reason that a combination of further research and effective management is crucial to define the potential input sources and to design management strategies for preventing potential invasions before they occur. Once an invasive species moves into an area it is nearly impossible to eradicate, therefore management of invasive species must be proactive and must start at the source.

Known Mechanisms of Introduction

The foremost problem when handling invasive species is not necessarily controlling populations, but understanding how the invasive species arrived in the first place; this requires consideration of the potential vectors of invasion. While marine invasion ecology is a relatively new field, scientists have identified several common vectors of introduction. These vectors include, but are not limited to, spread associated with biofouling (IMO, 2002) and ballast water from ships (see figure 14)(AAPA, 2013; Burgiel et al., 2006; IMO 2015), accidental releases from
Stressors on Biodiversity and Natural Resources

personal aquaria or aquaria trade (Padilla and Williams, 2004; Schofield, 2009), and transportation of non-native species via plastic pollutants carried by ocean currents (Eriksen, 2014). While these vectors do not encompass all modes of transportation of non-native species, they are the most relevant in the case of introduction of marine invasive species in the Sargasso Sea.

Potential colonizers of the Sargasso Sea

Invasive species pose a serious threat to biodiversity in the Sargasso Sea. Sargassum, the main substrate of the Sargasso Sea, supports communities of both biologically and economically important organisms (Laffoley et al., 2011). Not only does Sargassum provide habitat that supports species found nowhere else in the world, but it also serves as a nursery and feeding ground for many migratory species, such as tuna, swordfish, American eel, and whales (Coston-Clements, 1991). Currently, there are no known invasive species in Sargassum communities throughout the Sargasso Sea; however this does not mean that invasive species may not spread into the sea in the future, nor that they do not create stress on this ecosystem.

Bermuda and its invasive species

As the only major body of land within the Sargasso Sea, Bermuda plays a critical role in the potential introduction of invasive species. While the Bermudian government identifies several invasive species existing on the island, there is only one marine invasive currently known in Bermuda’s EEZ: the lionfish.

Indo-Pacific lionfishes (Pterois volitans and Pterois miles) are the first marine fish invaders in the greater Caribbean region (Hackerott et al., 2013). Lionfish are responsible for a decline in native fish biomass on Caribbean reefs (Green et al., 2012), since the document of their spread in the early 21st century (see figure 15)(Mumby, Harborne, and Brumbaugh, 2011). The coral reefs of the Caribbean provide many ecosystem services to Caribbean residents and visitors, and without these services, Caribbean nations will suffer. Additionally, should the lionfish invade Sargassum communities, there would most likely be a similar pattern in terms population declines of native species. However, most research regarding lionfish focuses on the current impacts of lionfish on coral reefs, and so the Sargasso Sea is not a top priority. However, this unique open water ecosystem could provide a method of dispersal or act as a nursery for juveniles, by acting as a stepping stone from the eastern coast of North America to Bermuda via the Gulf Stream, and the threat to biodiversity is crucial to consider.

The Lionfish Task Force is an entity of the government of Bermuda that represents all the stakeholders relevant to the lionfish invasion. Its primary mission is contributing to both the control and management of the invasive lionfish in Bermuda (Gleason, Gullick, and Bermuda Lionfish Task Force, 2014). The Task Force’s management plan provides a clear outline of the lionfish issue in Bermuda as well as management
Stressors on Biodiversity and Natural Resources

solutions, such as shallow and deep water culling, lionfish fishery, biological control and removal incentives (Gleason et al., 2014).

The Task Force could also provide key insight into potential management strategies for handling lionfish in the Sargasso Sea, through its experience in handling the current invasion. The Task Force represents a body of people committed to the lionfish issue and therefore could be crucial allies in organizing and implementing international policy, such as a new treaty or agreement, to control the invasive lionfish.

Currently, the focus of invasive ecology is on managing ecosystems that have already experienced population booms, also known as the post-invasion phase. However, once a species reaches the post-invasion stage, it is often too late for management measures to help control that species. This set of factors may make management of invasive species prove to be one of the most difficult tasks of this generation. This also puts the Sargasso Sea in a unique position as developing effective proactive management plans could help to preserve the biodiversity and unique species of this unique area before further colonization of invasives.

Current Policy

The accidental transport of organisms through ships’ ballast water is a primary means of the introduction of invasive species. Currently, there is no international legally-binding regulation of ballast water; therefore, this should be the primary focus in the development of management plans, both for the Sargasso Sea and beyond. The main body with the means of enacting international policy around ballast water is the International Maritime Organization (IMO), a specialized agency of the United Nations, whose responsibility is to develop and maintain rules and regulations regarding all the factors that influence shipping (IMO, 2015). The IMO enacts, ratifies, and enforces conventions regarding ocean law such as the Ballast Water Convention. Until the development of the Ballast Water Convention (BWC) in 2004, an international treaty not yet entered into force due to lack of sufficient signatories, there had been no global strategies outlining management practices regarding ballast water. The BWC lays out several clear objectives for all the signatories. These objectives include the enhancement of regional cooperation monitoring, the gathering and sharing of data regarding ballast water, the willingness to participate in regular inspections, and the creation of effective enforcement practices for management of ballast water (Firestone and Corbett, 2006). The convention also mandates that each ship flying the flag of a signatory nation must have an approved, ship-specific, Ballast Water Management Plan (BWMP). Out of all aspects of the convention, Firestone and Corbett (2006) outline what they describe as the “most important aspect of the BWC,” the concentration-based ballast water performance standards. These standards set a precedent for ballast water treatment and are important to think about in regards to the volume of ballast water being discharged into ocean waters.

While the original convention was drafted in 2004, it has still not taken effect as a legally-binding international treaty. Unlike many conventions, the BWC requires a total of both 30 states and 35% of the world’s shipping body in tonnage to sign the convention before implementation begins. Currently, there are 44 nations who have signed the Convention, however they do not account for 35% of the world’s total shipping tonnage (IMO, 2015). Thus, under the guidelines to ratify the convention and despite the critical need for regulation, ballast water management remains outside the bounds of the IMO.

Conclusion

As stated earlier, it is important to acknowledge that the stressors highlighted here are the largest and most pertinent stressors on biodiversity in the Sargasso Sea. This is not a comprehensive list. These three stressors, climate change, plastic pollution, and invasive species, have been discussed in depth because of their current impact, potential future impact, and potential for mitigation. Additionally, fisheries and maritime traffic are also significant stressors which are discussed in separate sections of this...
Stressors on Biodiversity and Natural Resources

Management Proposal. Collectively, these five issues are the stressors of highest priority for direct and immediate action.

Additionally, these stressors are of even larger concern when occurring together. While individually these stressors are significant concerns, the greatest concern of the Sargasso Sea arises from the cumulative impacts of climate change, plastic pollution, and invasive species introduction. Climate change, a large overarching pressure on all life in the Sargasso Sea and elsewhere, can reduce the resilience of any ecosystem to other stressors, creating a synergistic magnification of both plastic pollution effects and invasive species potential. Likewise, plastic pollution has been shown to vastly increase the potential for non-native species colonization, which can in turn reduce the biodiversity of an area and affect the resilience of a system to climate change. When these cumulative impacts are paired with cumulative impacts of fishing and shipping, the results are a significant loss of biodiversity and natural resources.

While climate change, plastic pollution, and invasive species may be the largest stressors to the Sargasso Sea currently, the research team recognizes that future stressors may supersede these stressors in the Sargasso Sea. As an example, seabed mining, or the harvesting of other biological resources, have not been discussed in depth in this section, as they currently are not major stressor on the biodiversity in the Sargasso Sea. However, if in the future there is an increased potential or interest in pursuing seabed mining or harvesting of new natural resources, these could possibly become major stressors on biodiversity, and would need to be accounted for in future assessments of the Sargasso Sea. Moving forward, it will be vital that these stressors be incorporated into the greater discussion of the management of biodiversity and natural resource stressors in the Sargasso Sea.

At present, five major stressors place pressure on the biodiversity and conservation of natural resources in the Sargasso Sea: global climate change, plastic pollution, invasive species, fisheries, and maritime traffic. Each of these requires an immediate action or plan for management, ranging from direct input reduction, such as with plastics, to indirect treatment, such as adapting to climate change. By prioritizing and organizing these stressors in a logical way, effective and efficient action can be taken, and only through this efficiency can stressors in the Sargasso Sea be effectively mitigated and managed.
The Sargasso Sea is utilized by nations across the globe as a major source of fish for global fish markets. Countries such as Mexico, Venezuela, Spain, Japan and the United States catch thousands of tons of fish from the Sargasso Sea every year, mainly from the western portion and outside the border of the Bermuda EEZ. Targeted species include tuna, marlin, and wahoo. The main types of fishing gear used in the Sargasso Sea to pursue these species are longlines, gillnets, and purse seine nets, all of which have the potential to be environmentally damaging. However, because the Sargasso Sea lies primarily within an area beyond national jurisdiction, no one nation has jurisdiction over fisheries management in the Sargasso Sea. Instead, management falls to various regional fisheries management organizations (RFMOs). There are four RFMOs with jurisdiction over the Sargasso Sea: the International Commission for the Conservation of Atlantic Tunas (ICCAT), the North Atlantic Salmon Conservation Organization (NASCO), the Northwest Atlantic Fisheries Organization (NAFO), and the Western Central Atlantic Fisheries Commission (WECAFC). Each protects a different area or species; however, none of them encompass the entire ecosystem. Overlapping jurisdictions, and weak enforcement power have created a fragmented and ineffective system of regulation, and future management must seek to address this issue.
Human Uses: Fisheries

Introduction
The Sargasso Sea is utilized by many nations as a major source of fish for global markets. Mexico, Venezuela, Spain, Japan and the United States are the largest fishing powers in the region, concentrating mainly in the western Sargasso Sea and just outside the border of the Bermuda EEZ (Sumaila, 2013). Some of the most commercially important species in the Sargasso Sea are a few species of tuna, including Atlantic bluefin tuna (ABT), marlin, and wahoo (Laffoley et al., 2014). The Atlantic bluefin tuna fishery is highly regulated to support growth and recovery of the stock, following decades of excessive fishing (Collette et al., 2011a). However, because the Sargasso Sea is primarily an area beyond national jurisdiction, no one nation has jurisdiction over fisheries management in the Sargasso Sea. Instead, management falls to various Regional Fisheries Management Organizations (RFMOs). Each RFMO protects a different area or species; however, none of them encompass the entire ecosystem. Overlapping jurisdictions, and weak enforcement power have created a fragmented and ineffective system of regulation (Symes, 1997). In the Bermudian EEZ, fishery resources are underutilized, limiting the local economy and creating an unsustainable dependence on seafood imports.

Fishing in the Sargasso Sea
Pelagic, highly migratory fish species, such as albacore tuna, yellowfin tuna and Atlantic bluefin tuna, as well as the Spanish mackerel, are some of the most commercially fished species in the Sargasso Sea (Sumaila et al., 2013). Other fish such as swordfish, marlin and wahoo are also highly fished, both commercially and recreationally (Prince and Brown, 1991; Podestá et al., 1993). For all of these species except Spanish mackerel, the International Commission for the Conservation of Atlantic bluefin tuna (ICCAT) is, to some extent, the managing organization and determines maximum sustainable yields and catch limits.

Considerable amounts of commercial fishing takes place within the Sargasso Sea, particularly within the western portion. According to the Sargasso Sea Commission, the majority of the total landed values from Sargasso Sea fisheries are from fish taken from areas around the EEZs of Bermuda, the United States, and some Caribbean islands (Sumaila et al., 2013) (see Figure 16). Total landings fluctuate significantly from year to year, possibly because fishermen often use the Sargasso Sea as a “Plan B” when fish stocks in other parts of the world have temporarily become inaccessible (Laffoley et al. 2014). Although fisheries landing data suggests that Taiwan, Japan, and the USA are the nations fishing most heavily in the Sargasso Sea, it is unclear as to which nations are targeting which species (Laffoley et al., 2014). For instance, while some data imply that Japan is the lead nation in Atlantic bluefin tuna fisheries (Laffoley et al., 2014), other data demonstrate massive fluctuations in landings year to year (FAO, 2011).

Figure 16. depicts spatial distribution of catches in the Sargasso Sea during the year 2006. The red areas indicate landings of greater than 100 tons, while dark blue indicates a value of zero. Note that Bermuda’s EEZ is almost entirely dark blue. This figure was provided by the Sargasso Sea Alliance. (Sumaila et al. 2013)
Human Uses: Fisheries

Although it is unclear whether Japan has the largest ABT fishery, the Japanese population does consume over three quarters of the bluefin tuna sold on the market (McCurry, 2008). It is possible that Japan imports much of its bluefin tuna from other nations that fish within the Sargasso Sea.

Some species within the Sargasso Sea are highly overfished, including the Atlantic bluefin tuna (SCRS, 2014-2015), North Atlantic albacore tuna (Bard, 2003) and marlin (Peel, Nelson and Goodyear, 2003). Although ABT is managed as two stocks, Western and Eastern, each “population” is not biologically separate from the other. The Western managed stock is now considered “Depleted” by the IUCN and the Eastern stock is highly fragile (Collett et al., 2011a). Other species in the Sargasso Sea, such as yellowfin tuna and mahi mahi, are relatively stable fish stocks that are managed well in global fisheries (Collett et al., 2011b, Collett et al., 2011c). These species are fast-growing and reproduce quickly, which enables the stock to replenish, unlike the slow growing and maturing ABT (Collett et al., 2011b). Yellowfin tuna is currently a much more sustainable option and is a possible replacement for ABT if bluefin stocks continue to decline.

Fishing in Bermuda

Recreational fishing in Bermuda is a favored pastime among locals and a popular tourist attraction. A 2012 report published by the government of Bermuda, created using a 2011 government survey on shoreline recreational fishing, implies that though most recreational fishermen consume their catch, recreational fishing in Bermuda is largely an activity of leisure rather than a necessity for subsistence. Of the 86 people surveyed, 96% said that they sought out specific species, and “grey snappers were most frequently targeted, followed by whitewater snappers, bonita, yellowtail snappers, mackerel and hogfish” (Government of Bermuda, 2012). The report also estimated that the volume of recreational fishing is roughly equal to two-thirds that of Bermudian commercial fishing, indicating that recreational fishing has a relatively high impact on Bermuda’s marine ecosystems. It should be noted that this survey only included people who fish on the shoreline and did not account for charter boats or fishing tournaments (Government of Bermuda, 2012).

The species fished most heavily by commercial fisheries within Bermuda’s EEZ by tonnage are wahoo and yellowfin tuna (Sea Around Us). That being said, Bermuda’s commercial fisheries are not their primary source of seafood. Bermuda imports 75% of its seafood (Link, 1985) despite the fact that its waters are home to many economically significant fish species. There are multiple reasons contributing to this economic dependence on seafood imports. Though the island is just 21 square miles, it has a population of 65,000, and sees up to 10 times that much traffic every year due to tourism. As a result, the demand for all types of food, including seafood, is tremendously high. Locals estimate that if all shipping to Bermuda was halted, the island’s communities would last only two weeks before running out of food. Even though it is an island, very little commercial fishing takes place inside Bermuda’s Exclusive Economic Zone (EEZ). Bermudian fishermen rarely venture outside of their EEZ to fish, despite their proximity to major fishing grounds. Furthermore, the majority of the commercial fishing that takes place within the EEZ is within 50 nautical miles of the coastline.

The Bermudian government recognizes this discrepancy and has made attempts to solve it. In 2010, the government published A Strategy for the Sustainable Use of Bermuda’s Living Marine Resources (“Strategy”), which details various ways in which Bermuda could access the full potential of the marine resources to which its people are legally entitled. One idea proposed was the development of new shoreside facilities, where catches could be stored until there was a demand for them, which will allow for a more reliable supply of local fish. This is useful because the main fishery targets (wahoo and yellowfin) in Bermuda are migratory, which means that abundance and availability is not consistent year round. Shoreside facilities could also serve as data collection points to help determine abundance and seasonal availability of fish species.
Human Uses: Fisheries

(Government of Bermuda, 2010). At this point, all attempts at creating shoreside facilities have failed due to lack of funding and none have been successfully built.

Another idea proposed in the Strategy was the introduction of aquaculture facilities to meet existing markets such as dolphinfish, clams, and other fast-growing species. Additionally, the Strategy promotes the safe consumption of lionfish, an invasive species that is frequently caught as bycatch in lobster traps, but is prohibited for sale. (See further discussion of lionfish in the Conservation Stressors section.) Bear in mind that consumption of lionfish or other invasives may come with unexpected consequences: one study suggests that consuming invasive species is detrimental to ecosystem health because it can create a market and culture surrounding the species and might even encourage conservation of said species (Nuñez et al., 2012).

Fishing Equipment Used in the Sargasso Sea

There are a variety of fishing methods practiced in high seas areas which heavily influence marine ecosystems through overfishing, bycatch and destruction of habitats. Many types of fishing gear are not designed to selectively target specific species and are thus harmful to non-targeted species. The equipment most commonly used by commercial fishermen in the Sargasso Sea are longlines, purse seine nets, and gillnets, and are used to fish a large variety of species including tuna species, marlin, and wahoo.

Bycatch, or the incidental catch of non-target species or individuals, is an important consideration when discussing commercial fishing (Lewison et al., 2004). This term is very broad and can be broken down into sub sections: useable species, discard, or bycatch mortality. Usable species are fish that are unintentionally caught but are then used or sold. A fish is classified as discard when it is caught still alive, but is unwanted, either because it is the wrong species or is too small to be of use. If the unwanted organism is dead or mortally injured, it is classified as bycatch mortality (Davies et al., 2009). Bycatch mortality is the most common meaning of the broader term bycatch (Hall et al., 2000).

Longlining is a commonly used technique in commercial fishing, and has accounted for approximately two thirds of the landings from the Sargasso Sea over the last decade (Laffoley et al., 2011). A longline consists of a main horizontal line ranging from 200-1000 meters (600-3000 feet) long, with 4 to 20 branching lines hanging vertically in the water column. Each branching line consists of a wire leader and baited hook. In the Sargasso Sea, these techniques target a variety of tuna, billfish, and wahoo (NOAA, 2014d). There are two main types of longline; one that lies on the bottom of the ocean floor, and one that floats on the surface. The latter is used in the Sargasso Sea because the depth of the Sargasso Sea makes it impossible to leave lines on the seafloor (FDA, 2014). Longlines are typically hauled in by fishing vessels ranging between 30-70 meters (90-210 feet). These vessels have the capacity to store their catch and sustain their crews for months at a time, with some even able to stay at sea for two years (NOAA, 2014d). When used correctly, longlining can generate lower levels of bycatch when compared to other commercial fishing methods (Laffoley et al., 2011). However, it is still a concern. For longlines, bycatch may include but is not limited to non-targeted fish species, sea turtles, albatrosses, dolphins, and sharks. The type of bycatch depends on the size, type, and placement of the bait. The cause of death ranges from drowning to stress to predation. Additionally, whales have the potential to become entangled in the longline fishing gear. Unfortunately, the destruction that
longlines pose is not restricted to actively used gear. When the equipment becomes damaged or unwanted, fishermen often discard their equipment into the ocean, creating ghost fishing gear which causes additional bycatch mortality (Matsuoka, 2005).

Purse seine nets are another commercially used fishing gear that pose a stressor to the fish populations of the Sargasso Sea (NOAA, 2014e). Purse seines are large walls of netting deployed by two vessels working together that surround an entire area or school of fish. The nets float along the top line with a lead line threaded through rings along the bottom. Once a school of fish is located, the vessels encircle the school with the net, then once encircled, the fishermen tighten the bottom of the net, trapping the fish inside. The nets are then hauled in with the targeted fish, along with any other species in the area. This is most commonly used for schooling fish like tunas (NOAA, 2014d). Like longlines, it is very common to get bycatch using purse seines. Purse-seining is particularly damaging in the Sargasso Sea, as bycatch is greater around floating Sargassum rafts (Laffoley et al., 2011).

The last commonly used fishing gear in the Sargasso Sea is gillnets. Gillnets are large nets that are suspended vertically in the water column, with various mesh sizes designed to target specific fish (NOAA, 2014c). Fish swim into the suspended gillnets and get their gills or other body parts tangled in the net. Due to the variability in the sizes of the nets, they have the potential to catch a range of fish species, but in the Sargasso Sea they are most commonly used to catch tuna and billfish (NOAA, 2014c). Gillnets do not target specific species well and are known to catch a variety of different bycatch species ranging from dolphins to sharks to whales (NOAA, 2014c). Entanglement records from 1990 through 2007 maintained by the NMFS Northeast Regional Office recorded 46 confirmed right whale entanglements. Because whales often free themselves from gear following an entanglement event, scarring may be a better indicator of fisheries interaction than entanglement records. In an analysis of right whales, 338 of 447 whales examined during a period from 1980-2002 were scarred by fishing gear (Knowlton et al., 2003). Volgfoenau et al. (1995) also found that in the Gulf of Maine gillnets were the primary cause of entanglements and entanglement mortalities of humpbacks between 1975 and 1990. While these data are not from the Sargasso Sea, they clearly point to the unintended impact of gillnets on marine mammals.

Although not commonly used in the Sargasso Sea, bottom trawling is another fishing technique that herds and captures target species, like ground fish or crabs, by towing heavily weighted nets along the ocean floor. Metal “doors” that can weigh more than several hundred pounds are used to hold open the net, which can be as large as 40 feet tall and 200 feet wide (Morgan and Chuenpagdee, 2003). In some regions, additional weights and hard rubber wheels are added to the front of the net. When the weighted nets and trawl doors are dragged along the seafloor, everything in their path is disturbed or destroyed, including seagrasses, coral reefs or rock gardens where fish hide from predators (Stiles et al., 2010). These nets are often towed for several hours, over miles of ocean floor (NOAA, 2014a). This is particularly damaging at ecologically significant areas such as seamounts, which are unique and vulnerable habitats (see the Conservation Targets section for further discussion). Along with causing widespread habitat destruction, bottom trawling is responsible for up to half of all discarded fish and marine life worldwide (Kelleher, 2005). Valuable fish, turtles, seabirds, marine mammals and other animals are all captured and discarded by bottom trawls, and many do not survive (Morgan and Chuenpagdee, 2003). Fish that are unwanted and discarded by the bottom trawler are often juveniles of valuable species caught by other fishermen, which can lead to fish stock reduction (Stiles et al., 2010).

Bottom trawls can be operated at a very wide range of depths, from a couple of meters to 2000 meters (NOAA, 2014a). Since most of the Sargasso Sea is much deeper than this, bottom trawling is only possible around seamounts and the Bermuda shelf. Due to its environmental impacts, it is highly regulated. In 2008, the Northwest Atlantic Fisheries Organization (NAFO) established a moratorium on bottom
trawling in its area of jurisdiction, which includes the seamounts in the Sargasso Sea (NAFO, 2015).

The need for fishing as a food collection method will continue to be essential to the world’s growing population. However, fishing techniques need to be refined and regulated so that the oceans can be fished sustainably. In 1992, the UN implemented a ban on all drift nets larger than 2.5 km long in international waters (FAO, 2015). However, other than this ban, most fishing, excluding bottom trawling, is unregulated in international waters, with fishermen only needing a fishing license. The fishing techniques and gear used in the Sargasso Sea are just another factor affecting the fish stock in this region, and has the potential to be improved not just in the Sargasso Sea, but globally.

Current State of Fish Stocks

Some of the most commonly fished species in the Sargasso Sea, such as Atlantic bluefin tuna (ABT), albacore tuna, and marlin are at risk due to overfishing. The ABT is a wide-ranging species that inhabits the pelagic areas of the North Atlantic Ocean and the adjacent seas (Galuardi et al., 2010). Their migration routes cover large areas, but ABT are found in higher concentrations in different regions on the ocean depending on factors such as oceanic fronts, temperature and temporal factors (Fromentin and Powers, 2005). Migration patterns may also be influenced by environmental changes (Fromentin and Powers, 2005). ABT migrate across the North Atlantic Ocean and spawn in the Gulf of Mexico and the Mediterranean Sea (Fromentin and Powers, 2005). These complex and fairly unpredictable migration patterns make them a difficult species to monitor and track (Galuardi et al., 2010).

Currently ABT are managed as two separate stock populations, the western and eastern stocks. However, research has shown that while ABT may prefer one side of the North Atlantic to the other, the two stock species interbreed and are not biologically separate stocks (Galuardi et al., 2010). This could be a potential problem as ABT are an at risk stock population that has been overfished for decades. ABT eastern and western stocks overlap which could create incorrect assessment of population numbers and lead to management decisions based on incorrect data (Fromentin and Powers, 2005). For a fish stock under pressure, incorrectly determining the state of the stock due to incorrect assessments of the number of fish could be detrimental to the fish populations and cause a population collapse.

ABT are a declining fish stock, despite the existence of management measures, which include catch limits implemented by the International Commission for the Conservation of Atlantic Tuna (ICCAT) (Webster, 2011). ICCAT catch limits have been set too high for decades which has significantly contributed to the declining stocks. In recent years ICCAT has begun to implement sustainable catch limits for both the western and eastern stocks, decreasing the eastern ABT total allowable catch (TAC) from 34,516 tons in 2013 to 13,500 tons in 2014 (SCRS, 2014). ABT fisheries in the western North Atlantic are highly restricted, with very few vessels permitted to fish (SCRS, 2014-2015). However, unreported fishing of ABT is thought to occur every year, which accounts for tens of thousands of tons of ABT caught every year (SCRS, 2014). ICCAT has begun to take the declining ABT stocks seriously and has increased their oversight accordingly. They are taking into consideration unreported ABT catches and have begun to set the TAC lower than the scientifically recommended TAC in order to take into consideration the unreported catches (SCRS, 2014; Webster, 2011).

White marlin, blue marlin, and North Atlantic albacore also fall under ICCAT jurisdiction. All three of these fish species have been declining in population size due to overfishing (Bard, 2003; Peel et al., 2003). Increasing efficiency of fishing gear has led to the overexploitation of North Atlantic albacore (Bard, 2003). The largest and most consistent North Atlantic albacore fisheries are currently in the EU (SCRS, 2013). Although they are managed by ICCAT, North Atlantic albacore continue to be overfished (SCRS, 2013).

Both species of Atlantic marlin, white and blue, are regulated only as bycatch by ICCAT. However, marlin are overexploited through
Human Uses: Fisheries

recreational fisheries, which ICCAT does not regulate (Peel et al., 2003). Marlin are an interesting example of a fish stock that needs more regulation, but due to how it is being exploited, there are currently no high seas organizations that manage them. Marlin are at risk for population collapse and are currently under-regulated (Peel et al., 2003).

The fish stocks discussed above are slow growing and reproduce slowly (Collette et al., 2003b). Combined with increasingly efficient fishing technology, this creates unsustainable fisheries for these fish stocks. Other fish stocks however, such as yellowfin tuna and mahi mahi, are fast growing species that reproduce quickly and can replenish their stocks quickly. These two fish stocks in particular are sustainable and should be a focus for Sargasso Sea fisheries. Often the main problem with fisheries is that catch limits are set too high and do not take into account unreported catches. Both commercial and recreational fisheries need to be regulated in order to ensure the sustainability of fish stocks.

High Seas Fisheries Management

Fisheries management in areas beyond national jurisdiction needs to emerge through international cooperation, and thus relies primarily on Regional Fisheries Management Organizations (RFMOs) and UN Agreements. In the Sargasso Sea, weak cooperation has led to a fragmented and ineffective system.

In 1995, the U.N. Fish Stocks Agreement was established to create a mechanism through which to implement the ambiguous fisheries protection provisions of UN Convention for the Law of the Sea (UNCLOS). Through this agreement, nations are obligated to cooperate to ensure the effective conservation and management of straddling fish stocks and highly migratory fish stocks (FAO, 1995b) (see Governance section for more information). In the same year, more than 170 members of the Food and Agriculture Organization of the United Nations (FAO) adopted the Code of Conduct for Responsible Fisheries. Aimed at everyone involved in fisheries and aquaculture, the Code provides a set of global principles and standards of behavior to guide responsible fisheries practices. It is a voluntary document that is

![Image: Regional Fisheries Management Organizations in the Sargasso Sea]

Figure 17. depicts the Regional Fisheries Management Organizations (RFMOs) in the Sargasso Sea. Each protects a different area or species; however, none encompass the entire ecosystem, leaving the Sargasso Sea as a whole unprotected by fisheries governance (Source: SEA)
consistent with relevant rules of international marine law such as UNCLOS and provides a framework to “insure sustainable exploitation of aquatic living resources” (FAO, 1995a).

The requirement to manage and conserve marine living resources on the high seas, and across international boundaries, has led to the creation of many RFMOs. These international governing bodies are established by international agreements signed by member nations that share a commitment to managing and conserving fish stocks in a particular region. Some RFMOs focus on particular species, while others manage all fish stocks within a specific area.

There are four RFMOs with jurisdiction over the Sargasso Sea (see Figure 17): the International Commission for the Conservation of Atlantic Tunas (ICCAT), the North Atlantic Salmon Conservation Organization (NASCO), the Northwest Atlantic Fisheries Organization (NAFO), and the Western Central Atlantic Fisheries Commission (WECAFC). Each protects a different area or species; however, none of them encompass the entire ecosystem. Without a single comprehensive regulatory framework for the area, it remains largely unprotected.

Established in 1966, the International Commission for the Conservation of Atlantic Tunas (ICCAT) covers the entire Atlantic Ocean, but only applies to tuna and tuna-like species (ICCAT, 2007). This is a management body, and has the ability to implement binding regulations on member nations, but only after an objection period – any member that objects during this time is exempt from the regulation. The organization has been strongly criticized by scientists and environmental advocates for its repeated failure to conserve the sustainability of the tuna fishery by consistently supporting overfishing (Kolbert, 2010).

Like ICCAT, the North Atlantic Salmon Conservation Organization (NASCO) only protects one species within the Sargasso Sea. Established in 1983, it prohibits fishing of Atlantic salmon in the North Atlantic high seas, and protects only the northern edge of the Sargasso Sea. It recognizes the need for research and restoration of salmon stocks and acts as a forum for consultation and cooperation, along with proposing regulatory measures for fishing and making recommendations on scientific research (NASCO, 1983). Despite the strict regulations on fishing, salmon stocks are still declining. Reasons for this include threats during the freshwater phase of the life cycle, such as urbanization and the introduction of nonindigenous species, as well as decreased survival at sea due to climate change and illegal fishing (Hutchinson and Windsor, 2001). NASCO is responding to these declines by implementing the precautionary principle and considering an international code of conduct to minimize the impacts of aquaculture on wild stocks (Windsor and Hutchinson, 1990; Hutchinson and Windsor, 2001).

The Northwest Atlantic Fisheries Organization (NAFO) was established in 1979. Unlike ICCAT or NASCO, this organization is committed to the conservation of all fishery resources within the Convention area, which covers the northern edge of the Sargasso Sea. In 2007, NAFO began to implement an ecosystem approach to fisheries management through the introduction of new working groups, expanding beyond a focus on the sustainable use of northwest Atlantic commercial fishery resources by committing to protect the associated marine ecosystems from adverse fisheries effects (NAFO, 2007). NAFO can impose binding measures on its Contracting Parties; however, enforcement remains difficult (Symes, 1997). To address this, NAFO has implemented a Vessel Monitoring System (VMS), and submits vessels to frequent inspections (NAFO, 2007). All fishing vessels in the NAFO Regulatory Area are required to have satellite tracking devices that transmit position reports hourly, which are then forwarded automatically to Contracting Parties with an inspection presence in the area (Canada and the EU). Through the VMS, the inspectors can easily locate any fishing vessel.

Finally, the Western Central Atlantic Fisheries Commission (WECAFC) was established in 1973 and covers the southern Sargasso Sea, with a mission “to promote the effective conservation, management, and development of the living marine resources of the area” (FAO,
1973). Unlike the International Commission for the Conservation of Atlantic Tunas or the Northwest Atlantic Fisheries Organization, WECAFC is not a management body but an advisory body that can only suggest the enforcement of international guidelines. In this role, it advises members on conservation goals, raises funds, and oversees research (FAO, 1973). Although these services are valuable, the ability to implement binding regulations is sorely needed to ensure the protection of the area.

These four regional fisheries management organizations all have some role in the conservation of the Sargasso Sea, but they aren’t enough. Despite the multitude of them, none protect the entire area for non-tuna species. Cullis-Suzuki and Pauly (2010) reviewed 18 RFMOs based on their performance on paper and in practice. Results showed low performance of all RFMOs for both assessments. This is emphasized by another study that found that two-thirds of high seas fish stocks under RFMO management are either depleted or overexploited (Global Ocean Commission, 2013). The reasons for this poor success are many: for one, the high seas are vast and distant, making monitoring a unique challenge (SeaWeb, 2015). Furthermore, few RFMOs are management bodies capable of implementing binding regulations – in the Sargasso Sea, only ICCAT and NAFO have this power. Even for these, the regulations only bind member nations, leaving non-parties to do as they please with minimal repercussions, as fishing on the high seas in the waters managed by an RFMO is not a crime (Global Ocean Commission, 2013).

Elsewhere in the oceans, nations are collaborating to conserve large areas in the high seas. While these examples don’t focus entirely on fisheries, their general management strategies are useful in informing potential future fisheries management in the Sargasso Sea.

In the Southern Ocean, one such example exists: the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), a 1982 agreement to protect the high seas around Antarctica that focuses primarily on krill and its dependent predators. This was established in a unique legal setting, as the area was already partially protected under the Antarctic Treaty System, making it an imperfect comparison to the Sargasso Sea (Delfour-Samama and Leboeuf, 2014). However, CCAMLR is an excellent example of an ecosystem approach to fishery management, which does not concentrate solely on the species fished, but also seeks to avoid situations in which fisheries have a significant adverse effect on ‘dependent and related species’ (Kock et al., 2007).

To accomplish this, CCAMLR has an Ecosystem Monitoring Program that assesses the health of the ecosystem and helps develop models to provide precautionary limits for annual yields, a strategy that could be very useful in the Sargasso Sea. The 2010 study by Cullis-Suzuki and Pauly referenced above, that evaluated RFMO performance, found that CCAMLR ranked well both on paper (with the highest score among all RFMOs for Conservation and Management) and in practice.

The North-East Atlantic Ocean is another successful example of high seas fisheries management. The 1998 OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic is an agreement for regulating international cooperation on environmental protection in the North-East Atlantic. However, fishing falls outside OSPAR’s competence and is primarily regulated through the North-East Atlantic Fisheries Commission (NEAFC) (Sen, 1997). Although not a comprehensive body like CCAMLR, this example provides a model of an area governed by both a regional seas agreement (OSPAR) and a regional fisheries management organization (NEAFC), which collaborate to great success. The OSPAR Commission has developed a “Collective Agreement” for cooperation amongst relevant organizations, including NEAFC, which helps coordinate information exchange, allowing organizations to bring issues of mutual interest to each other’s attention. Although specifically designed for the institutional framework in the North-East Atlantic, this international non-binding agreement might provide a model for other areas where collaboration is essential to sustainable stewardship, including the Sargasso Sea (Freestone et al., 2014).
**Focus on ICCAT**

The International Commission for the Conservation of Atlantic Tuna (ICCAT) is the most well-established RFMO in the Sargasso Sea and has the highest ability to implement and enforce fishing regulations. ICCAT was established in 1969 with the purpose of carrying out the objectives defined in the International Convention for the Conservation of Atlantic Tuna. This treaty is signed by fifty nations, including the United States, Japan and Mexico, with the intention to conserve tuna and tuna-like species in the Atlantic Ocean for continued future use of fish stocks (ICCAT Basic Texts, 2007). ICCAT has the responsibility to research new sources of data and incorporate existing data into policy and regulation recommendations that are presented to the contracting parties of the treaty. Each contracting party has one vote in ICCAT policy decisions (ICCAT Basic Texts, 2007). ICCAT has a scientific research branch as well as several monitoring branches, but no enforcement branch (ICCAT, 2015). ICCAT has the ability to conduct scientific research and compile data, as well as the ability to monitor contracting party’s compliance with policy regulations (ICCAT, 2015). However, enforcement of ICCAT regulations is the responsibility of the contracting parties (ICCAT Basic Texts, 2007). ICCAT’s scientific research branch, the Standing Committee on Research and Statistics (SCRS), recommends that fish stocks under ICCAT jurisdiction be managed according to their maximum sustainable yield (ICCAT, 2015). The voting body of ICCAT then determines the catch limits for fish species based on the maximum sustainable yield presented by the SCRS. However, the voting body of ICCAT often sets catch limits for certain species well above the recommended maximum sustainable yield. This is putting species such as Atlantic bluefin tuna, North Atlantic albacore and two species of marlin, fish that support some of the most economically important fisheries, at risk for stock depletion (Bard, 2003; Peel et al., 2003; Fromentin and Powers, 2005). However, in recent years the organization has adopted a strict recovery plan for ABT (Pew Environment Group, 2012).

In the Sargasso Sea, there is no regional environmental treaty covering the area, nor is there a regional fisheries treaty applicable to the whole area for non-tuna species. The future management of the area can be modeled after these successful examples: CCAMLR can inform the discussion about broadening the mandate of Regional Fisheries Bodies to explicitly address conservation of marine biodiversity (Rochette et al., 2014), and OSPAR can provide a framework for collaboration between RFMOs and regional seas management bodies.

Today, fisheries governance in the high seas takes place through multiple sectoral agreements and institutions, reflecting a high degree of policy fragmentation. Coordination and cooperation between RFMOs and other governing bodies are key to successful conservation in areas beyond national jurisdiction, as demonstrated by both the North-East Atlantic and the Southern Oceans (Delfour-Samama and Leboeuf, 2014).

**Bermuda Fisheries Management**

Bermuda’s fisheries and other marine resources are managed by the Marine Resources Board, which is part of the Bermudian government. The department has multiple objectives, including but not limited to the protection and conservation of Bermuda’s marine resources and environment by enacting and enforcing legislation. The ultimate goal of the department is to “promote the sustainable use of the Island’s natural resources” (Government of Bermuda, 2015).

The Marine Resources Board exists under the Health, Seniors, and Environment Department. The Board is comprised of twelve members chosen by the Minister of the Health, Seniors, and Environment Department, a Director from the Environmental Protection Department, and a Director of Conservation Services. The legislation governing the Board includes but is not limited to three main documents, the first of which is the Fisheries Act of 1972. This acts as “parent legislation” and provides governance for issues concerning use of marine resources and the environments in which they are produced and extracted from. Under this act, the Minister is granted permission for the following: to declare protected areas within Bermuda’s EEZ and to restrict the usage certain gear types, the capture of certain species, and the selling, possession, or...
Human Uses: Fisheries

consumption of certain species (Government of Bermuda, 1972). The second governing document, Fisheries Regulations 2010, outlines regulations regarding Bermudian fisheries, including topics such as the issue of fishing licenses, general restrictions on taking fish, protected fish, and regulations regarding the sale of fish. The third governing document, Fisheries (Protected Areas) Order 2000, outlines 29 areas within Bermuda's EEZ that are protected and managed in any way by the Bermudian government. Most protected areas are located around shipwrecks, and no ecological reason or basis is given for each of the protected areas. Each document is referenced for guidance in the decision-making process by each of the Marine Resources Board members.

Conclusion

Several commercially- and recreationally-targeted fish stocks in the Sargasso Sea are declining due to fishing pressure. Marlin is one example of an undermanaged fish stock that is at high risk because of recreational fisheries, yet is managed only as bycatch. The Atlantic Bluefin Tuna benefits from extensive regulation under the International Commission for the Conservation of Atlantic Tunas, but remains at risk due to its high market value. Fishing gear adds further pressure to these fish stocks, as many techniques generate high volumes of bycatch. High seas fisheries management in the Sargasso Sea is fragmented and poorly enforced, lacking sufficient coordination between Regional Fisheries Management Organizations. In Bermuda, fishery resources are underutilized, leaving the island almost completely dependent on seafood imports. Supporting these Bermudian markets and adopting stricter regulations for at-risk species in the high seas are essential steps towards creating sustainable fisheries in the Sargasso Sea.
Shipping is vital to the global economy, but poses threats to marine conservation in the Sargasso Sea and elsewhere. With the North Atlantic being the most heavily trafficked ocean in the world, the Sargasso Sea could face high levels of environmental stress from shipping. To effectively manage the Sargasso Sea, decision-makers must know the overall quantity, location, and impact of vessel traffic. Much information is already available from systems such as the Automatic Identification System (AIS), the Voluntary Observing Ship program (VOS), and satellite-based sensors, and more data could be collected if additional funding was available. Commercial shipping is primarily concentrated in the Western Sargasso Sea and along a few routes crossing the Eastern Sargasso Sea from Northeast to the Southwest. Maritime traffic brings a wide array of environmental impacts, but the effects in the Sargasso Sea, specifically, remain under-researched. In addition to understanding traffic characteristics and impacts, it is important for decision-makers to be able to navigate the web of international governing bodies and agreements that regulate High Seas shipping. The most important are the International Maritime Organization (IMO) and one of its conventions, the International Convention for the Prevention of Pollution from Ships (MARPOL), which regulates ship-based pollution. The IMO and MARPOL provide avenues for managing shipping within areas of the Sargasso Sea through different levels of regulation and protection, such as by designating areas as either a MARPOL Special Area or a Particularly Sensitive Sea Area.
Maritime Traffic

I. Types of Maritime Traffic

Shipping is a large, international, and economically important industry, the worth of which exceeds the Gross Domestic Product (GDP) of many countries. Commercial shipping has made possible the globalization of the world economy and is sometimes referred to as the “global economic engine” (World Shipping Council n.d.). The North Atlantic has the highest levels of commercial shipping in the world (Roberts, 2011). It is also a hotspot for cruise ship and recreational boating activity due to its proximity to wealthy nations; the Sargasso Sea sees very high levels of vessel traffic. Currently, no publicly available data details all vessel movements, but the location and traffic density of some vessel types can be characterized with reasonable accuracy; data on commercial ships are easier to find than on fishing and military vessels.

A. Cargo Ships

The vast majority of shipping traffic, in terms of tonnage, is cargo transport or commercial shipping (World Shipping Council, n.d.). The most common type of cargo ship is the container ship. These vessels carry stacks of shipping containers filled with consumer goods. When plying their trade, these vessels move along predictable routes regularly between ports (Kaluza et al., 2010). Bulk dry carriers are ships that carry their cargo without containers. The cargo is most commonly bulk commodities such as grain or coal. The movements of these vessels are unpredictable, as they have more ports that their goods are received at than containers ships do, and bulk carriers will often change their course on short notice to cash in on current market trends (Kaluza et al., 2010). Tankers move in similar patterns to bulk dry carriers, except that they exclusively carry oil and oil-based products. As such, they move between a smaller number of ports, as there fewer ports with the facilities for receiving oil (Kaluza et al., 2010).

Shipping through the Sargasso Sea is crucial to the entire shipping industry and the global economy. At least 60% of the world’s shipping takes place in the Atlantic Ocean, and of that, 70% of it is in the northern Atlantic (Roberts, 2011). The shipping industry itself produces $183.3 billion in revenue annually, and if all activities tied to shipping, such as wharf jobs and maritime

<table>
<thead>
<tr>
<th>Ship Type</th>
<th>What it Carries</th>
<th>Where it Goes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Container</td>
<td>Consumer Goods (Shoes &amp; toys)</td>
<td>Repeting routes between most ports</td>
</tr>
<tr>
<td>Oil Tanker</td>
<td>Oil and oil based products</td>
<td>Irregular movements between few ports</td>
</tr>
<tr>
<td>Bulk Dry Carrier</td>
<td>Bulk dry items (grain &amp; coal)</td>
<td>Irregular movements between most ports</td>
</tr>
<tr>
<td>Cruise</td>
<td>Tourists</td>
<td>Regular repeating routes between tropical areas</td>
</tr>
</tbody>
</table>
Maritime Traffic

communities, are counted, the industry is worth $436.6 billion (IHS Global Insight, 2009). The reason that shipping throughout the Atlantic is so important to the industry is that the fastest way to get from Europe to the Pacific is through the Panama Canal; ships going between Europe and Asia or the U.S. West coast pass through the Sargasso Sea (Kaluza et al., 2010). Shipping is especially critical to Bermuda, a small island nation unable to produce most of the goods it needs; it relies upon shipping in the north Atlantic to provide most of its commodities. Cars, food, and other consumer products must be shipped in from elsewhere, thus necessitating the need for a strong shipping presence. In 2014, the United States alone exported goods worth $646.4 million to Bermuda (U.S. Census, 2014), the vast majority of which likely arrived by ship. Costly changes to shipping in the Sargasso Sea would result in the rise of prices for goods on Bermuda, thus all changes must be made as efficiently as possible (Dalton, 2004).

B. Cruise Ships

Another major type of vessel traversing the southern and western Sargasso Sea is the cruise ship. Transporting people rather than cargo, cruise ships constitute a major part of both the shipping industry and tourism industry. Cruise ships move in regularly repeating predictable routes, tending to stick to tropical areas (Roberts, 2011). Cruise ship traffic in this region is generally concentrated in the Eastern Caribbean and Florida, as well as on routes from the U.S. mainland to Bermuda (Roberts, 2011). Some trans-Atlantic cruise ship traffic exists, but the volume of cruise ship traffic is not nearly as large as the volume of commercial shipping traffic (Roberts, 2011).

The island of Bermuda is an important destination for cruise ships, and there are two major routes ending there, one from New York City and one from Boston. The Bermudan tourist industry accounts for 28% of the GDP, and 355,880 of the 584,489 tourists who visited Bermuda in 2014 came from cruise ships (van Beukering n.d., Bermuda Tourism Authority, 2014). Recent analysis shows that the popularity of Bermuda as a destination is in decline, so the prospect of limiting cruise ship movements within the Sargasso Sea might be difficult, given the pressure that the sector is already under (Mccarthy, 2014).

C. Recreation

Many private yachts travel through the Sargasso Sea for pleasure cruising or to cross from one port to another. The Caribbean is a popular sailing destination, and many yachts travel between there and U.S. east coast recreational ports, such as Annapolis, MD and Newport, RI. Yachts also cross the Sargasso Sea when making the transatlantic crossing. Bermuda is also a hot spot for yachting, hosting many sailing races and events, and the yachts traverse the Sargasso Sea in order to attend.

Many yacht races take place in Bermuda, including the famous biennial Newport - Bermuda race (Newport Bermuda Race, 2014). The race covers over 635 miles of ocean, and attracts about 150 boats every two years. This race is an established tradition in the Sargasso Sea, having had its first race in 1906. This race has a good record for vessel safety, with over 150 vessels of a wide range of classifications entering annually.

D. Military

The Sargasso Sea borders two of the strongest naval powers in the world: the United States and the United Kingdom (the latter through its overseas territory, Bermuda). Data on military activity are difficult to find, but the British Royal Navy, U.S. Navy and U.S. Coast Guard almost certainly have a strong presence in the area. Bermuda, being an overseas territory of the United Kingdom, does not have its own navy, and therefore relies on the British Royal Navy for all its naval needs, although there is no British Royal Navy establishment on the island. Bermuda is
also protected by the Her Majesty’s Coastguard, which acts in conjunction with Her Majesty’s Customs. Together, the two services control all shipping and transportation which moves through Bermuda’s waters, ensuring all trade is legal.

The U.S. also has a strong military presence in the Sargasso Sea, as part of the wider Atlantic. The U.S. Coast Guard also operates in the Sargasso Sea, with 29 cutters in the Atlantic that perform operations such as search and rescue and drug trafficking prevention. These ships mainly operate within the U.S. EEZ, but may move farther afield as deemed necessary by their mission (U.S. Coast Guard, n.d.). The major Atlantic naval station for the U.S. is in Norfolk, VA, and is only 297 miles away from the edge of the Sargasso Sea and 730 miles to Bermuda. There are 75 ships alone at this station, with more at other stations along the East Coast (U.S. Military, n.d.). It is difficult to gain information on naval ships’ operations and whereabouts, as U.S. Navy ships are exempt from publicly-available ship tracking programs.

II. Technology to Track Ships

To accurately assess human uses and their potential environmental impacts, marine spatial planners need to know where maritime traffic takes place in order to design an effective management plan. Several tools exist that allow for the tracking of maritime vessels, including the Automatic Identification System (AIS), the Long Range Identification and Tracking (LRIT) program, and the Voluntary Observing Ship (VOS) program. The data from these programs can ultimately be transformed into mapped vessel tracks with associated metadata for the vessels. Advanced analysis and data mining can calculate traffic density, tonnage distribution, and flag countries for the vessels that participate in these programs (Halpern et al., 2008). In addition, satellite-borne sensors may be used to track ships (Greidanus, 2008).

A. AIS and LRIT

The AIS is a compulsory program for all vessels above 300 tons, excluding military and fishing vessels, and is also used by smaller vessels on a voluntary basis (Pallotta et al., 2013). It is mandated by the International Convention for the Safety of Life at Sea (SOLAS), the primary international treaty regarding required safety equipment on ships (International Maritime Organization, 1974, International Maritime Organization, 2015). The primary purpose of the AIS is collision avoidance and monitoring of ships for international security reasons, but the data from it can be used also to map vessel traffic. The AIS has limited range as it is based on ground stations and ship-to-ship transmissions. However, with more satellite-based receivers being established, and third-party providers aggregating global AIS data, the scope and ease of access of AIS data is continually increasing (Marine Traffic, n.d.). AIS involves near-real time collection of the location of vessels, and with enough resources these data can be purchased and aggregated (Pallotta et al., 2013). Once aggregated, these data can show areas of traffic density (Figure 18). While this process may be resource intensive, continual monitoring for enforcement of any shipping regulations does not have to be; algorithms have been developed to automatically identify ships engaged in “low-likelihood behaviors” indicative of prohibited behaviors (Pallotta et al., 2013). It should also be trivial to set up alerts for vessels entering prohibited areas. This will significantly decrease the monitoring burden for any agency seeking to enforce future regulations in the Sargasso Sea.

The LRIT, a global position reporting system mandated by SOLAS and implemented through the IMO (International Maritime Organization, n.d.), went into force in 2009, and is similar to AIS but with a greater range. It is compulsory for many vessel types above 300 tons on international voyages (Roberts, 2011), and requires position reports four times daily. AIS and LRIT provide comprehensive information on
Maritime Traffic

large vessel traffic for anyone with the resources to access and mine the data.

B. VOS

The VOS is a voluntary program run by NOAA through which ships report basic ground weather observations such as wind direction and speed, sea state, and temperature; location information is merely a component byproduct of these observations (NOAA, 2009). VOS data are biased in unknown ways due to the fact that not all vessels are part of the program (Halpern et al., 2008). The number of participating vessels has dropped to around 4,000 from 7,700 in the 1980s (NOAA, 2009). The ease of data access makes the VOS an attractive option for research in spite of its shortcomings.

C. Available Spatial Information

Approximated shipping routes can be easily mapped by connecting major ports with straight lines as geographically appropriate, and the volume of traffic on those routes can be estimated using export data. More accurate representations of traffic location and density require the use of data from the tracking programs mentioned above, including the VOS (Figure 19). While data from AIS and similar systems requires substantial computing power to process, and the existing products are expensive, maps showing calculated traffic densities have been published in peer-reviewed journals and elsewhere (Kaluza et al., 2010). Such maps show a concentration of shipping traffic on specific routes – the shortest route between ports. This particular feature in
Figure 18 should be interpreted with caution, however: this figure was constructed by drawing the shortest line between points, assuming that this is the route ships will take to minimize fuel consumption (Halpern et al., 2008). Plots of vessel densities like the one in Figure 18 have also been made for specific vessel types, showing that container ships are the most common in the Sargasso Sea (Roberts, 2011). While much remains unknown about the location and density of maritime traffic in the Sargasso Sea, some conclusions can be drawn from the studies that have been published: vessel traffic is primarily concentrated in the Western Sargasso Sea, close to the U.S. East Coast and the Caribbean, and along a few major shipping routes transiting through the Eastern Sargasso Sea (Figure 20).

III. Governance Related to Maritime Traffic

Globally, shipping presents several well-known challenges to conservation. While the precise impact of commercial shipping on the Sargasso Sea ecosystem is unknown, in other parts of the world shipping is responsible for the introduction of invasive species, airborne emissions, marine pollution, spills, and collisions (e.g., Halpern et al., 2008; Endressen et al., 2003; Roberts, 2011). It is important to understand that global shipping, in the Sargasso Sea and other high seas areas, is governed primarily by
integrate into effect, each signatory nation must complete five steps (the details of which will vary depending on that nation’s government) (IMO, 2002). Those five steps are signature, ratification, acceptance, approval, and accession. Once the member nation’s government ratifies the convention, the convention can come into effect.

The IMO also has six main bodies that deal with the adoption of the conventions and four main councils including the Marine Environmental Protection Committee, which creates regulations involved in pollution caused by ships. Other organizations can also be associated with the IMO but cannot become a member. Non-governmental organizations (NGO) have the ability to “be granted a consultative status by the council with the approval of the Assembly” (IMO, 2015c). In order to become a consulting member, an NGO must have the ability to provide substantial contribution to the IMO’s work. Some relevant NGOs that work with the IMO include the World Wide Fund for Nature (WWF), the International Union of Marine Insurance (IUMI), and The Institute of Marine Engineering, Science and Technology (IMarEST). Intergovernmental organizations (IGOs) can also form agreements with the IMO. These IGOs must have common interests with the IMO and must participate in maximum coordination with the IMO. Some IGOs working with the IMO include the International Whaling Commission (IWC), the Regional Organization for the Protection of the Marine Environment (ROPME), and the International Oil Pollution Compensation Fund, 1971 (1971 FUND). There are a total of 140 NGOs and IGOs associated with the IMO.

IV. Additional Mechanisms Under the IMO

A. The IMO’s Marine Environment Protection Committee

The Marine Environment Protection Committee (MEPC) of the IMO is in charge of addressing marine environmental impacts caused by shipping. The MEPC contains many other...
sub-committees such as the Sub-Committee on Pollution Prevention and Response. The MEPC was originally formed to address oil pollution in 1973, but has since expanded, incorporating many other pollutants. The MEPC meets at least annually to discuss pollutants caused by ships in which the member nations can suggest revisions to MARPOL. Each meeting ends with a final report that is then sent to the IMO council to be approved and ratified (Maritime New Zealand, 2015). The latest session of the MEPC, the 68th session, was in May of 2015. This session addressed such issues as the International Convention for the Control and Management of Ships’ Ballast Water and Sediments, black carbon emissions, and the availability and quality of marine fuels. Another significant session of the MEPC was Session 65, which addressed technical cooperation. The technical cooperation measure addressed new technology for ships that would provide them with more energy efficient technology to reduce carbon emissions (Maritime New Zealand, 2015).

B. IMO Special Areas

The IMO manages global shipping practices through specific regulations under treaties like MARPOL, and also through the designation of specific areas of concern. One designation is the MARPOL Special Area. Special Areas use the annexes under MARPOL to create more stringent pollution regulations. An area can become a Special Area for reasons relating to oceanographic or ecological disturbances caused by shipping traffic. Some current MARPOL Special Areas include the Mediterranean Sea, the Red Sea, and the Baltic Sea. These areas each have more stringent regulations relating to the MARPOL annexes. For example, the Baltic Sea Special Area has further regulation on sulfur oxide emissions released by ships beyond the standard air pollution requirements established under MARPOL Annex VI (IMO, 2015a). Furthermore an area can only be designated a Special Area if there are sufficient reception facilities in that area for the harmful substances carried by the ships (NOAA, 2015).

Annexes that have been used in the designation of Special Areas include, Annex I: Oil, Annex II: Noxious liquid substances, Annex III: Harmful substances in packaged form, Annex IV: Sewage, Annex V: Garbage, and Annex VI: Air pollution. Annex I and Annex V have been used in Special Area designation the most, with a total of twelve different areas total. A proposal to designate a Special Area can be submitted to the Marine Environmental Protection Committee (MEPC). The proposal must contain a draft amendment to MARPOL and background information to the area in question. The committee may then approve or disapprove the designation of a new Special Area (IMO, 2002). It is important to note that most of these areas are located within states’ EEZs and not in the High Seas (IMO, 2015a). The lack of Special Areas in the High Seas may be due to the difficulty regulating the High Seas areas.

C. Particularly Sensitive Sea Areas (PSSA)

Another type of area that can be designated under the IMO, for the purposes of managing the environmental impacts of shipping traffic, is a Particularly Sensitive Sea Area (PSSA). PSSAs are not established under MARPOL, but instead through a separate IMO resolution. PSSAs are established in areas where shipping poses a stress to the ecological environment, socio-economics, or scientific attributes of the area. A PSSA application can be submitted to the IMO by any member state. The application must include proposed protective measures such as the use of navigational aids or traffic separation schemes. Some examples of current PSSAs include the Great Barrier Reef in Australia and the Galapagos Archipelago. Although similar, Particularly Sensitive Sea Areas and MARPOL Special Areas are not mutually exclusive. PSSAs can be within MARPOL Special Areas and vice versa (IMO, 2015b). The most notable regulations PSSAs can implement are rerouting shipping lanes, designating areas to be avoided, and
enacting more stringent pollution regulations (Altman, n.d.).

While there are several mechanisms for implementing shipping regulations, there are no specific mechanisms that address, apply to, or are located within the Sargasso Sea. There are no existing Special Areas, or PSSAs in the Sargasso Sea, an area which is vulnerable to pollution from shipping.

V. Shipping Stressors and Relating Governance

To understand the extent of the stressors posed by shipping in the Sargasso Sea and elsewhere, comprehensive spatial analyses of vessel types and movements are required. The stressors associated with shipping practices are mostly related to operational practices. Infrequently, they are the result of accidents. This section analyzes some of the major stressors and highlights the need for improved management to mitigate these stressors. Marine ecosystems are complex and dynamic systems making their management highly demanding. Prioritizing the stressors is a challenging issue but of high importance; decision-makers should take into account not only biological and ecological features, but also the degree of feasibility and what tools exist to address them.

A. Atmospheric pollution

Description

Chemical substances produced by shipping vessels can spread either into the atmosphere or into the water. Atmospheric emissions are emissions related to ships’ engines and generators burning fossil fuels. These releases include the release of high quantities of oxides such as sulfur oxides (SOx) and nitrogen oxides (NOx), as well as a variety of hydrocarbons, and greenhouse gases like carbon monoxide and carbon dioxide (CO₂) (Herz, 2002). The amount discharged into the air depends on the vessel’s size and speed as well as the type of fuel that it is using. Studies focusing on the global impacts of gas emissions related to shipping activities have showed that commercial ship emissions contribute approximately 16% of sulfur and 14% of nitrogen overall emissions to the atmosphere (Corbett et al., 1999).

Governance

<table>
<thead>
<tr>
<th>MARPOL Annexes</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annex I: Prevention of Pollution by Oil</td>
<td>Regulations pertaining to the amount of oil and oil discharge</td>
</tr>
<tr>
<td>Annex II: Control of Pollution by Noxious Liquid Substances</td>
<td>Regulations pertaining to carrying capacity of noxious liquid substances in bulk</td>
</tr>
<tr>
<td>Annex III: Prevention of Pollution by Harmful Substances in Packaged form</td>
<td>Regulates standards on packing, marking, labeling, documentation, stowage, and quantity limits of harmful substances</td>
</tr>
<tr>
<td>Annex IV: Prevention of Pollution by Sewage from Ships</td>
<td>Regulates pollution of the ocean from ships’ sewage</td>
</tr>
<tr>
<td>Annex V: Prevention of Pollution by Garbage from Ships</td>
<td>Regulates location, amount, and type of garbage disposal</td>
</tr>
<tr>
<td>Annex VI: Prevention of Air Pollution from Ships</td>
<td>Regulates sulfur oxide and nitrogen oxide</td>
</tr>
</tbody>
</table>
MARPOL Annex VI, Prevention of Air Pollution from Ships, addresses atmospheric pollution caused by vessels. Annex VI sets limits on NOx and SOx emissions from ship exhaust. The IMO also adopted new prevention measures in 2011 that were put into action in 2013. This new prevention measure aims to significantly reduce CO₂ emissions through mandatory technical and operational energy efficiency measures. Additionally, the IMO has begun to discuss the reduction of greenhouse gas emissions by vessels (IMO, 2015a). Although there are regulations on air pollution from ships, the IMO has only discussed greenhouse gases and has not formed any regulations.

B. Chemical and Oil Pollution

Description

Cargo ships, as opposed to other types of large vessels, are mainly responsible for the release of high concentrations of chemical substances into the water column. These materials include hazardous and noxious substances that persist for a long period once released into the water, and that are either toxic or reactive compounds; examples include detergents, pesticides and heavy metals (Herz, 2002).

These substances are mostly released following normal operations, but they can also be released as a result of accidental leaks. Chemical spills encompass a wide range of harmful or less harmful substances that a vessel can release to the surrounding environment as a result of collisions or technical failures. Chemical spills are rare events and the degree of dispersal and the subsequent ecological damage depends on the type and quantity of substance released, the sensitivity of the area impacted, and the oceanographic conditions. Spills directly or indirectly can negatively impact marine species and habitats. While spilling toxic substances in or near coastal areas directly threatens human health by skin contact and through ingestion, releases in the open ocean have indirect effects, primarily through interfering with other human uses like fishing (GESAMP, 2009). Even though accidental spills are less common than releases due to operational practices, policy makers should increase and enforce regulations aimed at avoiding accidental spills by mandating regular control of the ship’s equipment and operations.

Another example of chemical pollution of great concern is oil input to the ocean. Oil is most frequently discharged not through large-scale spills or deliberate dumping, but through leaks from the engine and the cargo tanks of large vessels. If highly concentrated, these substances can become harmful to marine organisms (Wiese, 2002). Governance MARPOL Annex I, Regulations for the Prevention of Pollution by Oil, specifically addresses oil pollution. The only regulation that MARPOL Annex I requires is a double hull for oil tankers; it includes no regulation addressing oil discharge or leaking. However, there are two conventions under the IMO that address other oil pollution concerns: the Oil Pollution Casualties Convention of 1969 and the International Convention on Oil Pollution Preparedness, Response and Co-

Figure 21: A pictorial representation of Annex V under MARPOL describing where one is allowed to dispose of garbage. (United States Coast Guard Auxiliary, n.d.)
operation of 1990. The Oil Pollution Casualties Convention of 1969 focuses on nations taking charge of oil spills that pose a threat to their coastlines, not open ocean areas as in the case of the Sargasso Sea. The International Convention on Oil Pollution Preparedness, Response and Co-operation better addresses oil pollution and requires all vessels to have an emergency oil preparedness plan (IMO, 2015). There are also other MARPOL Annexes that address chemical contamination, specifically Annex II, Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk, and Annex III, Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form. Both Annex II and III only regulate the prevention of chemical pollution (IMO, 2015a). There are multiple conventions and regulations on oil pollution prevention and response but there are none that addresses other harmful chemical spills; this is a gap in the IMO framework.

C. Sewage

Description

Sewage waste is produced mainly by vessels with large crew and passenger complements, like cruise ships, and is a potential vector of pathogens to the marine environment (Roberts, 2011). A study published by Raaymakers (2003) has shown that sewage dumped in the open ocean does not pose health problems to humans; however, the impact in the ocean as compared to coastal waters is understudied. Sewage treatment on board ships is typically less efficient than sewage treatment on land. As a result, the liquid substances discharged in the ocean are more concentrated (Herz, 2002), warranting further investigation to better understand the environmental impacts.

Governance

MARPOL Annex IV specifically addresses sewage disposal: “treated sewage can be discharged 3 nautical miles from land and untreated sewage can be discharged at a moderate rate 12 nautical miles from land” (IMO, 2015a). Annex IV also states that untreated sewage may not be discharged anywhere in the ocean. Nations are required to have in their ports proper sewage reception facilities that do not delay shipping processes, such as unloading cargo and traveling to the next port (IMO, 2015a). However, providing ships with adequate port reception facilities may provide problems for some nations. Bermuda, for example, is a small nation that may not have the resources to allocate large port reception facilities that are able to manage the vast amount of cruise ships that enter Bermudian ports.

D. Solid Waste

Description

Solid waste from ships includes garbage released into the marine environment. Despite the fact that little is known about its abundance in the open ocean, marine debris is known to accumulate in oceanic gyres like the Sargasso Sea (Laffoley et al., 2011). Plastic debris, for example, represents a major stressor to marine ecosystems because plastics can be ingested by marine organisms, causing their death. Plastic debris can possibly transport harmful organisms and pollutants, like persistent organic pollutants and polybutylene terephthalate, across the ocean (Andrady, 2011 & Rochman et al., 2013). (For further discussion on plastics as a stressor to the Sargasso Sea, please see the Conservation Stressors section.) Solid debris can also potentially damage vessels’ propellers. Even though port facilities in both U.S. and Caribbean harbors exist, a large number of vessels illegally discharge their waste when transiting the Sargasso Sea (Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP), 2009).

Governance

MARPOL Annex V addresses garbage disposal or dumping. The latest amendment to this annex was put into action in January 2013.
This annex prohibits the discharge of plastics, packing materials, paper products, glass, and metal in any location of the ocean. Untreated food wastes may only be discharged into the ocean beyond the 12-nautical mile territorial sea boundary. A pictorial representation of garbage disposal regulations can be seen in Figure 21. Another convention further regulating garbage dumping is the Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter. This treaty applies more strict regulations to signatories as to what can be dumped into the ocean (IMO, 2015a). These protections are insufficient due to the large amount of plastics still accumulating in the oceans (Law et al., 2010), and more regulation and enforcement of garbage disposal is needed.

E. Invasive species through ballast water

**Description**

Ships use ballast water to maintain their stability throughout changes in type and volume of cargo. Invasive species can be transported in ballast tanks and then released into the environment once the ballast waters are discharged. According to Roberts (2011), bulk carrier and liquid tankers are the major transporters of ballast water, being responsible for transporting invasive species across the world. In states such as California, vessels have to empty their ballast waters out of state waters; however, their impact on open ocean ecosystems is unknown. The best available options for treating ballast water include heat treatment (GESAMP, 2009) and ballast water exchange (IMO, 2005). Other examples of limiting the risk of non-native species propagation include treatment systems and ballast discharge standards on vessels (Lloyd’s Register EMEA, 2014). For further discussion of the stressors associated with invasive species, see the Conservation Stressors section.

**Governance**

Currently there is no annex under MARPOL that addresses ballast water disposal, but the International Convention for the Control and Management of Ships’ Ballast Water and Sediments (BWC) addresses ballast water concerns. Under this convention, ships bound for international waters are required to manage their ballast water to a specific standard. The convention also requires these vessels to keep a ballast water discharge log. Furthermore, the convention suggests that vessels dispose of ballast water mid-ocean, and that they eventually install ballast water management systems onboard (IMO, 2015b). However, the BWC has not yet entered into force due to a lack of signatories. Since the BWC has a lack of signatories, there is no protection currently in place against ballast water pollution. For further discussion of the BWC, see the Conservation Stressors section.

F. Acoustic pollution

**Description**

Noise generated by ships’ engines and propellers is a relatively newly-identified stressor; studies have shown that it has negative impacts on marine mammals, particularly on cetaceans. Undersea noise interferes with various vital functions; it can physically damage marine mammals or interfere with vital communication signals and induces changes in their behavior (National Research Council of the U.S. National Academies 2000, 2003). While some research has been done, the way sound spreads in the water column can vary significantly based on factors associated with the properties of the environment, and so further studies are needed (Hatch et al., 2008).

**Governance**

Even though there are no international regulations addressing or regulating noise pollution caused by vessels, there is widespread support for creation of these regulations: support from organizations like the International Fund for Animal Welfare (IFAW, 2015), the Oceanic Preservation Society (OPS, 2015), North American
Ocean Noise Coalition (Ocean Noise Coalition, n.d.), and the Convention on the Conservation of Migratory Species of Wild Animals (CMS, 2015). Many NGOs are working towards the creation of regulation on vessel noise; some NGOs include the North American Ocean Noise Coalition and the European Coalition for Silent Oceans (Ocean Noise Coalition, n.d.).

G. Ship strikes

Description

Ship collisions have been reported to occur with marine mammals such as large whales, small cetaceans, and other marine vertebrates (Panigada et al., 2012). Among the 11 species of whales that have been recorded as subjects of ship strikes (Jensen & Silber, 2003), the North Atlantic right whale *Eubalaena glacialis* has drawn special attention since it is a highly vulnerable species listed as endangered on the IUCN Red List (2015). The Sargasso Sea is one of the species’ major habitats, and busy shipping lanes cross this area. Because large vessels transit the Sargasso Sea at high speed, the most significant stressor to this species is ship strikes (Knowlton & Kraus, 2001; Kraus & Rolland, 2007). The North Atlantic right whale is a top predator, a large animal at the top of the food chain that keeps population numbers of other species lower on the food chain in check. Removing a top predator from an ecosystem could have unpredictable and irreversible consequences, making protection of this whale species a priority. Additionally, protecting endangered species is urgent, because no one knows how close they are to extinction. For further discussion of right whales, see the Conservation Targets section.

Governance

Major existing frameworks concerning ship strikes and whales are focused on coastal and EEZ waters. The IMO has implemented specific actions for U.S., Canadian and Mediterranean waters (Silber et al., 2012). In U.S. waters, for example, the National Oceanic and Atmospheric Administration (NOAA) and the U.S. Coast Guard implemented the Mandatory Ship Reporting System in 1999 under the IMO. According to NOAA guidelines, vessels within the U.S. EEZ greater than 330 gross tons that transit right whale designated habitats should report sightings to a U.S. station. Through this system, within areas where traffic is high, mariners are given general protection guidance to avoid ship strikes and contribute to mapping right whale populations and migratory corridors within these areas.

Another example of whale protection is the designation of Seasonal Management Areas within the U.S. EEZ by NOAA. In these areas, vessels 65 feet (19.8 m) or longer are restricted to speeds of 10 knots or less in whale calving and nursery areas, as well as migratory routes of North Atlantic right whales (Mandatory Ship Speed Restriction Plan). In the high seas, whale occurrence and distribution patterns are somewhat poorly documented, therefore it is challenging to implement similar regulations. Despite limited technological capabilities and data about the amount and nature of vessel traffic as well as the exact location of right whale habitats in the Sargasso Sea, future research should be focused on particular areas where such regulations could be implemented.

There is a wide array of environmental concerns related to shipping in the Sargasso Sea, but the real impact of shipping on the environment in this area is poorly understood; much more is known about the environmental impacts of shipping practices in coastal areas than in open ocean environments. To effectively address these stressors, given limited resources and knowledge, the stressors need to be prioritized based on their degree of severity and feasibility. The section below shows why the existing legal scheme is currently insufficient to address the stressors and demonstrates the need to focus on better enforcement measures rather than the creation of more regulations that could potentially be equally ineffective.
VI. Governance Gaps: Implementation and Enforcement of the IMO’s Regulations by Member States

While the IMO can facilitate communication between nations and facilitate the adoption of international treaties and agreements, it cannot implement or enforce these agreements. The implementation and enforcement of treaties is up to the member nations’ governments. Many nations have various ways of accepting and implementing international governance frameworks; some nations have extensive and continuous implementation processes (David, Raustiala, & Skolnikoff, 1998). Many factors influence whether a nation’s implementation is effective; these include power, the nature of the commitment, and the commitment’s scope, clarity, and application. An example of improper clarity, application, and scope of a commitment is the international regime for oil pollution (David, Raustiala, & Skolnikoff, 1998). This regime tried to target tanker captains who often travel across the high seas, which possibly made regulations difficult to enforce. Tanker captains failed to comply with the regulations because of the lack of enforcement and influence. These challenges illustrate how implementation and enforcement relies on IMO member states.

VII. Conclusion

Maritime traffic in the Sargasso Sea is an important factor to consider before implementing any management areas. The shipping industry has made possible the globalization of the world economy and produces hundreds of billions of dollars in revenue each year, but brings a wide array of environmental impacts, including air emissions, chemical pollution, and sewage discharge. The specific impacts vary between the many types of vessels that transit the Sargasso Sea. The details of maritime traffic location and density remain unknown. Because an understanding of traffic patterns is required for the effective design of management areas, more resources need to be allocated to research. The intensity of maritime traffic in the Sargasso Sea has the potential to negatively impact the sensitive ecosystem, and raises concerns about the effectiveness of existing regulations. The main governing body is the United Nations agency the International Maritime Organization (IMO) and its convention, the International Convention for the Prevention of Pollution from Ships (MARPOL), dealing with marine pollution. Although MARPOL regulates pollution, it does not cover all types of pollution. Many other types of environmental impacts, like acoustic noise pollution, are not regulated by any international conventions. Additionally, the process for enacting conventions is long, their implementation is inconsistent, and the enforcement of adopted conventions is often lacking. In order for a comprehensive management plan to be developed for the Sargasso Sea, all aspects of maritime traffic must be considered. An effective management plan will achieve environmental protection by taking into consideration all human uses and all the stakeholders involved.
Recommendations
Background

Through a consensus-based process, the proposal team (Sea Education Association class C-259) has developed a marine management plan for the Sargasso Sea by selecting several areas in which to focus management efforts. These areas were selected based on criteria outlined in the introductory section, which include the presence of seamounts and Sargassum, the density of human uses (specifically fisheries and maritime traffic), the economic value of the area, the ecological sensitivity of the area, and the feasibility of managing the area given the limitations of managing activities in Areas Beyond National Jurisdiction. Based on these criteria, the proposal team identified several management areas: the New England and Corner Rise seamount clusters, the western portion of the Sargasso Sea, and four research locations spaced throughout the Sargasso Sea. Management measures, tools, and strategies for each of these areas were determined based on the density and types of activities in the area. The proposal also includes overarching recommendations for the Sargasso Sea from the following working groups: governance, conservation targets, conservation stressors, fisheries, and maritime traffic. Finally, the proposal outlines existing and new governance mechanisms that could be utilized to implement and enforce the proposed management measures.

Figure 22. Map showing all resources and uses of the Sargasso Sea (Source: SEA).
Recommendations: Identification of Specific Marine Management Areas and Recommended Management Measures

Figure 23. Map depicting the areas of the Sargasso Sea marine management plan (Source: SEA).

Recommendations

I. MANAGEMENT AREAS

A. New England and Corner Rise Seamount Areas: Seamounts, part or all of which are within 2000 meters of the surface, located in the New England Seamounts and Corner Rise Seamounts clusters shall be designated as management areas. A 2-nautical mile radius buffer shall be established around each individual seamount, and one polygon drawn around each cluster to establish management area boundaries (Figure 22 and Figure 23).

B. Western Management Area (WMA): This area has a high concentration of human activity, presence of Sargassum in the spring, and is a migratory pathway for North Atlantic Right Whales. This designated management area shall be defined as the area between the United States and Caribbean Exclusive Economic Zones (EEZs) to the west, and 065° W Longitude line, excluding Bermuda’s EEZ, to the east.

C. Four research stations as follows:
   1. New England Seamounts (location to be determined)
   2. Corner Rise Seamounts (location to be determined)
   3. Southeastern corner of the Sargasso Sea at approximately 30°N, 47°W
   4. Western corner of the Sargasso Sea, inside the Western Management Area, at approximately 30°N, 74°W
D. Recommendation for future management area: The westernmost region of the Sargasso Sea is a potential area to focus management efforts in the future due to the concentration of human uses.

II. MANAGEMENT TOOLS AND ACTIONS FOR DESIGNATED MANAGEMENT AREAS

A. Entire Sargasso Sea Area (including Seamounts)
   1. Mining
      The proposal team recommends that seabed mining be prohibited in the entire Sargasso Sea area. In the future, the International Seabed Authority (ISA) should conduct impact assessments to determine whether mining would have significant adverse impacts on ecosystems on the seafloor, inclusive of seamounts. If mining activities are found to have significant adverse impacts, the International Seabed Authority should ensure that mining on seamounts and the seabed continues to be prohibited.

   2. Research
      The proposal team recommends that four areas of the Sargasso Sea be identified as priorities for scientific research. These areas include the New England Seamounts, the Corner Rise Seamounts, an eastern research station at 30°N, 74°W, and a western research station at 30°N, 47°W. Scientific monitoring stations shall be established within each area to begin building a time series dataset. This time series should collect data on human use of the area (including, but not limited to, impacts related to maritime traffic, fishing, and other activities), and oceanographic data (including, but not limited to, currents and water quality: pH, temp, chl(a), and nutrient levels).

B. New England and Corner Rise Seamount Areas
   1. General
      a. The proposal team recommends full protection of seamounts, part or all of which are located within 2000 meters of the surface. These are located within the New England Seamount Area and the Corner Rise Seamount Area (see Figure 23).
      b. The proposal team recommends that the two seamount areas, as defined by the encompassing polygons, be designated as Particularly Sensitive Sea Areas (PSSAs) under the International Maritime Organization (IMO). PSSAs, as defined by the IMO, are areas that warrant special protection through action by the IMO because of their significance for recognized ecological, socio-economic, or scientific reasons and which may be vulnerable to damage by international maritime activities. The proposal team recommends the seamounts for this classification due to their ecological significance and vulnerability. When an area is approved as a PSSA, specific measures can be used to control the maritime activities in that area, such as ship routing measures, strict application of MARPOL discharge and equipment requirements for ships such as oil tankers, and implementation of Vessel Traffic Services (VTS).
Recommendations: Identification of Specific Marine Management Areas and Recommended Management Measures

2. Fishing
   a. The proposal team recommends that bottom trawl fishing should be prohibited inside the polygons encompassing the New England Seamounts Area and the Corner Rise Seamounts Area. There is currently a bottom trawling prohibition in place by the North Atlantic Fisheries Organization (NAFO), which is set to expire in 2015. The team recommends that NAFO extend this moratorium into the future.
   b. The proposal team recommends that fishing for tuna and tuna-like species, using gill nets, longlines and purse seine nets, should be prohibited inside the New England Seamounts Area and the Corner Rise Seamounts Area on a seasonal basis (April – May of each year). This seasonal closure should be implemented through the International Commission for the Conservation of Atlantic Tuna (ICCAT), which manages tuna and tuna-like species in the Sargasso Sea.
   c. There are several sets of seamounts within the Bermudian EEZ. The proposal team recommends that the Sargasso Sea Commission work with the Bermuda government and Bermudian stakeholders to reduce or eliminate the impacts of destructive fishing in these areas, particularly bottom trawling. The team recommends prohibiting trawling around seamounts within Bermuda’s EEZ.

C. Western Management Area (WMA)
   1. General
      a. The proposal team recommends that the western management area (WMA) be designated as a Special Area under MARPOL annexes I, II, IV and V (Table 1). Special Area designation shall be pursued through the IMO. Special Area classification allows for stricter regulations regarding the types of wastes that can be put into the ocean. As the WMA is the area with the highest human activity, we recommend that this be the area classified as a Special Area for further management.
      b. Within the WMA, the westernmost region is of particular management concern given its proximity to land and the high concentration of human uses that occur there. The proposal team recommends that the WMA consider this corner for potential future designation as a Particularly Sensitive Sea Area, but acknowledges that further research must first be done to serve as a foundation for this designation.

Table 1. The annexes of MARPOL (IMO, 2015).

<table>
<thead>
<tr>
<th>Annex</th>
<th>Regulations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annex I</td>
<td>Regulations for the Prevention of Pollution by Oil (entered into force 2 October 1983)</td>
</tr>
<tr>
<td>Annex II</td>
<td>Regulations for the Control of Pollution by Noxious Liquid Substances in Bulk (entered into force 2 October 1983)</td>
</tr>
<tr>
<td>Annex III</td>
<td>Prevention of Pollution by Harmful Substances Carried by Sea in Packaged Form (entered into force 1 July 1992)</td>
</tr>
</tbody>
</table>
2. Pollution
   a. The proposal team recommends that a series of limitations be established on ship discharge and dumping activity for vessels over 100 Gross Tons (GT) and/or with crew of 15 or more. All provisions shall be implemented through the IMO.
      i. The proposal team recommends that all regulations within the MARPOL Annex V (Table 1) protocol be applied to vessels over 100 GT and/or with crew of 15 or more to provide a more comprehensive management strategy.
      ii. The proposal team recommends that no discharge of untreated ballast or grey/black water, and no dumping of inorganic materials, be permitted within the WMA. These targets are covered under MARPOL Annexes I through VI (Table 1).
      iii. The proposal team recommends that the IMO conduct increased monitoring of activity and enforcement of regulations with states party to MARPOL 73/78 and the London Convention.
      iv. The proposal team recommends that the stringent Ballast Water requirements of the Ballast Water Convention, which has not yet entered into force because of the lack of signatories, be applied within the WMA.

3. Sargassum Harvesting
   a. The proposal team recommends that a moratorium on Sargassum harvesting be established until sufficient impact assessments can be conducted to determine whether Sargassum harvesting would have significant adverse impacts on these ecosystems. If Sargassum harvesting is found to have significant adverse impacts, then Sargassum harvesting shall continue to be prohibited.
   b. The proposal team recommends that this moratorium be established through the United Nations Agreement on Straddling and Highly Migratory Fish Stocks, which requires that nations determine the importance of habitats for straddling and highly migratory fish stocks, and implemented and enforced through the authority of ICCAT.

4. Research
   a. Refer to section II.A.2. “Entire Sargasso Sea Area” above for WMA research recommendations.
5. Reporting

a. Voluntary Reporting System for N. Atlantic Right Whales in the Western Area

i. The proposal team recommends that a reporting system be implemented and enforced by the IMO with the cooperation of other intergovernmental bodies like the International Whaling Commission (IWC) and the North Atlantic Marine Mammal Commission (NAMMCO).

ii. The proposal team recommends that the Mandatory Ship Reporting System by the National Oceanic and Atmospheric Administration (NOAA) and Coast Guard be used as a case study example.

iii. The proposal team recommends that the report system should be voluntary, and if more data suggest high abundance or critical habitats of right whales, then reporting should be mandatory.

iv. The proposal team recommends that vessels be automatically alerted when entering an area where they may encounter right whales and be informed of the harmful effects of undersea noise, ship strikes to these animals, and damage to the vessel, using the Inmarsat C communication system.

b. Voluntary Reporting System for Sargassum aggregations

i. The proposal team recommends that this be implemented and enforced by the IMO.

ii. The proposal team recommends that the Mandatory Ship Reporting System by the NOAA and Coast Guard be used as a case study.

iii. The proposal team recommends that this should be voluntary, and if more data suggest high abundance, then reporting should be mandatory.

iv. The proposal team recommends that vessels be automatically alerted when entering an area where they may encounter Sargassum aggregations and be informed of the ecological importance of Sargassum using the Inmarsat C communication system.

III. Recommendations by Focus

A. Governance

1. In order to address current gaps in the governance and management of the Sargasso Sea, the proposal team recommends both short and long term goals for increased governance, protection, and management of the Sargasso Sea (Figure 24).

2. In the short term, the proposal team recommends that the signatories of the Hamilton Declaration be convened in order to work towards increased collaboration with regards to the protection and management of the Sargasso Sea.
3. The proposal team recommends that the Hamilton Declaration be made into a legally-binding agreement, giving the Commission more authority to implement and enforce a management plan for the five countries that have already shown a strong interest in the Sargasso Sea.

4. The proposal team recommends that the Sargasso Sea Commission begin to work towards the inclusion of more nations in the protection and management of the Sargasso Sea.

5. The proposal team recommends that, once a management plan has been established and implementation begins, the Commission approach the United Nations in order to work towards the creation of a new international governance body, a Regional Ocean Management Organization (ROMO).

6. This ROMO would be responsible for facilitating coordination among existing international organizations and overviewing all activities in the Sargasso Sea. This organization would eventually include all countries with an interest in the area. This organization could mandate environmental impact assessments for activities in the Sargasso Sea, provide economic incentives for participation in the management plan, and would be responsible for the enforcement of the management plan.

7. The proposal team recommends involving relevant international and local organizations with a vested interest in Sargasso Sea resources in management of the Sargasso Sea, and the implementation of this management plan. Organizations include but are not limited to the Sargasso Sea Commission (SSC), the current and future signatories to the Hamilton Declaration, the Food and Agriculture Organization of the United Nations (FAO), the International Seabed Authority, the International Maritime Organization (IMO), the International Commissions for the Conservation of Atlantic Tunas (ICCAT) and other Regional Fisheries Management Organizations, the International Union for Conservation of Nature (IUCN), the World Wildlife Fund (WWF), Woods Hole Oceanographic Institution (WHOI), the Bermuda Institution of Ocean Sciences (BIOS), and the Sea Education Association (SEA).

8. Collaborating partners (listed above) should work to promote and support public outreach and education regarding the ecological and economic values of the Sargasso Sea, the stressors that jeopardize these values, and the choices and actions that consumers can make to mitigate the stressors.

9. The proposal team stresses the creation of an overarching and broadly applicable framework for determining stakeholders and their relative importance not only in the area of focus, the Sargasso Sea, but for all Areas Beyond National Jurisdiction (Figure 25).
Recommendations: Identification of Specific Marine Management Areas and Recommended Management Measures

Figure 24. The steps for establishing increased governance in the Sargasso Sea under a central governance body that can implement a management plan for the Sargasso Sea.

Figure 25. A schematic for classifying stakeholders by taking into consideration key characteristics of common stakeholder groups. Original graph made with information from Pomeroy and Douvere, 2008.

B. Conservation Targets

1. The proposal team recommends that the U.S. and other Hamilton Declaration signatories support research on:
   a. The impacts of human uses at the Western and Eastern Research Stations, as designated by the Management Proposal map.
   b. Long-term oceanographic monitoring of water quality at the Western and Eastern Research Stations, which could include parameters that are related to climate change such as ocean temperature, ocean pH, and dissolved oxygen concentration.
Recommendations: Identification of Specific Marine Management Areas and Recommended Management Measures

c. The impacts of deep-sea mining on seamount ecosystems and the impacts of Sargassum harvesting on Sargassum ecosystems before extraction of deep sea minerals and Sargassum begins in the Sargasso Sea.
d. Sargassum mat tracking systems using satellite data.
e. Invasive species in the Sargasso Sea.

2. The proposal research recommends that a Sargasso Sea Partnership for endangered or threatened migratory species be established under the United Nations Environmental Programme (UNEP).
   a. Use the Sister Sanctuary Partnership (Stellwagen Sanctuary and the Bermudian government) as a starting point for humpback whales.
   b. It should include a wider range of vulnerable or threatened marine species found in the Sargasso Sea listed by the International Union for Conservation of Nature (IUCN) red list such as marine mammals (right whales, humpback whales) sharks (whale sharks, tiger sharks) and rays (manta and spotted eagle rays).
   c. This partnership should at first include all contracting parties of the Hamilton Declaration and then encourage more countries to join to build an international constituency on marine mammals in the Sargasso Sea. For example, engage contracting parties of the Convention on the Conservation of Migratory Species of Wild Animals (CMS) under UNEP.
   d. The short term goal is to stimulate intergovernmental cooperation, facilitate data sharing about habitat and migration routes of these species, and gather information for the designation of potential critical nursery habitats, feeding habitats, marine mammal protected areas, or other protected areas for these endangered or threatened migratory species within the Sargasso Sea.

C. Conservation Stressors

1. The proposal team acknowledges that climate change is an overarching, systems-level stressor on biodiversity in the Sargasso Sea and exacerbates other stressors such as commercial fishing. Rather than directly attempting to manage the sources of climate change, the proposal team recommends that other stressors, such as fishing, shipping, and pollution, be mitigated in order to reduce the synergistic impact of climate change.

2. The proposal team recommends exploring potential international collaboration for land-based management strategies to minimize other sources of plastic input to the Sargasso Sea.

3. The proposal team recommends that Bermuda implement a plastic recycling and reduction program to minimize Bermuda’s plastic input in the Sargasso Sea.
Recommendations: Identification of Specific Marine Management Areas and Recommended Management Measures

4. The proposed Sargasso Sea ROMO shall prohibit seabed mining until an environmental impact assessment is performed by the ISA. This shall apply to all nations including those not party to the ISA.

5. The proposal team recommends that improved standards for environmental impact assessments be developed and implemented by the International Seabed Authority, and that these assessments be conducted prior to any exploration for mining.

6. The proposal team recommends that the international community push for signing and ratification of the Ballast Water Convention, which, if entered into force, would institute these stringent requirements worldwide.

D. Fisheries

1. The proposal team encourages the use of fishing techniques that are more targeted to specific species, and further recommends research into new fishing gear that minimizes bycatch. These recommendations will be implemented through ICCAT and other interested organizations using buyback programs of old gear to incentivize the use of new sustainable technology.

2. The proposal team recommends that the SSC work with the government of Bermuda’s Marine Resources Board to encourage sustainable growth of Bermudian fisheries and aquaculture. Additionally the proposal team recommends involving Bermudian fisheries stakeholders in the process.

3. The team encourages the growth of aquaculture industries, specifically the production and harvest of fast-growing species, including but not limited to sea cucumbers and bivalves.

4. The team also recommends increasing the capture and consumption of locally available species such as Yellowfin tuna and Wahoo, which are generally caught further offshore. This will involve the creation of shoreside facilities which will aid offshore fishermen in the storage of excess catch, and additionally serve as a data collection point for research.

5. Last, the team recommends capture and consumption of the invasive Lionfish, accompanied by public education about the species to ensure that it is prepared safely and properly.

6. The proposal team recommends a satellite-based monitoring system of illegal fishing activity be implemented through INTERPOL Fisheries Crime Working Group and the IMO.

E. Maritime Traffic

1. The Maritime Traffic workgroup recommends the following:
   a. The Sargasso Sea Commission should:
Recommendations: Identification of Specific Marine Management Areas and Recommended Management Measures

i. Work with the IMO towards consolidating shipping into lanes along already established routes, focusing primarily on the Western Sargasso Sea, citing benefits to safety at sea to encourage insurance companies to enforce adherence to lanes.

b. The signatories of the Hamilton Declaration should:

i. Work within and with the IMO to increase international environmental standards, make environmental regulations more stringent, and have more on-the-ground inspections occur.

ii. Work along interested ENGOs (Environmental Non-Governmental Organizations) to publicly promote shipping companies that improve their environmental performance, through advertisements and awards like the Green Award.

iii. Encourage the IMO to establish and enforce maximum-noise-level standards for ships.

iv. Encourage the IMO to further educate mariners on the toxicity of products traditionally used on board (e.g. chemical detergents, toxic paints, etc.) and to establish training programs for the reduction of pollution for mariners.

v. Encourage the World Bank to give “green” loans towards improving ship performance in areas of noise reduction, wastewater treatment, and pollution reduction.

vi. Support increased research of the impact of acoustic pollution on the environment, with particular focus on marine mammals.

vii. Support increased research on maritime traffic location and density, to inform management of shipping in the area.
Works Cited


conservation planning: A better recipe for managing the high seas for biodiversity conservation and sustainable use. *Conservation Letters, 7*(1), 41-54.


Department of Environmental Protection. (2010). Fisheries Regulations. St. George’s, Bermuda.


ecosystems to anthropogenic threats. Conservation Biology, 21(5), 1301-1315.


International Maritime Organization. (2015). Non-Governmental international Organizations which have been granted consultative status with IMO. http://www.imo.org/About/Membership/Pages/NGOsInConsultativeStatus.aspx.


International Maritime Organization. (2015). Status of multilateral conventions and instruments in respect of which the international maritime organization or its secretary-general performs depository or other functions.


say-235-experts-on-the-EU-proposal-on-invasive-alien-species.


Kleypas, J. and Yates, K. (2009). Coral reefs and ocean acidification. Oceanography,


measures A. Abdullah and O. Lindend, IUCN, Switzerland, p. 10.


an integrated cross-sectoral regime for high seas governance for the 21st century.


Roe, S.J. (ed). (2011). Submission of scientific information to describe ecologically or biologically significant areas. The Sargasso Sea Alliance.


Standing Committee on Research and Statistics (SCRS). (2013). Atlantic Bluefin Tuna Stock Assessment. ICCAT.


www.un.org/depts/los/convention_agreements/texts/fish_stocks_agreement/
CONF164_37.htm.


United States Coast Guard. (n.d.). U.S. Coast Guard. Retrieved from
https://www.uscg.mil.

United States Military. (n.d.). Naval Station Norfolk. Retrieved from


their influence on the seamount ecosystem. Oceanic Seamounts: An Integrated Study. No. EVK3-CT-2002-00073-OASIS.


Images Used:

Any photos not cited here are from Solvin Zankl

Introduction
   In Text Map: Library of Congress

Governance and Stakeholder Context
   Cover: Solvin Zankl (top and bottom) and J. Adams (middle)

Biodiversity and Conservation Targets and Priorities
   Cover: Solvin Zankl (top image) and Brian Skerry (bottom)

Stressors on Biodiversity and Natural Resources
   Cover: Daily Genius (top) and Ray Berklemans

Fisheries
   Cover: Ugo Montaldo (top), Diving Dominican Republic (website) (bottom)

Maritime Traffic
   Cover: AISlive.org (top) and Zatasvki.com (bottom)

Recommendations
   Cover: Solvin Zankl (top and bottom right) and Joseph Townsend (bottom left)