Implementing Ecosystem-based Management (EBM) for the Protection of Endangered Cetacean Species: A Case Study of Humpback Whales (*Megaptera novaeangliae*) in the Northwest Atlantic Ocean

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A thesis submitted
in partial fulfillment of the requirements
for the degree of
Bachelor of Science
(Program in the Environment)
April 2008

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Abstract

Recent shifts in the paradigm surrounding the management of natural resources from single species Maximum Sustainable Yield (MSY) quota systems to the holistic Ecosystem-based Management (EBM) has been received with a flurry of theoretical reviews and the incorporation of EBM into many management plans. Despite the discussion surrounding the necessary components of EBM, and the widespread expert endorsement, implementing EBM in the marine environment has not yet been completed successfully. This thesis investigates the extent to which EBM is currently being implemented for the protection of humpback whales (*Megaptera novaeangliae*) in the Northwest Atlantic Ocean. Four principles consistently cited as central to implementing EBM are identified. These principles are applied to a case study of humpback whales in the Northwest Atlantic Ocean. Findings indicate that although there is much enthusiasm concerning EBM and elements of its principles have begun to be implemented. However, there is still much room to expand upon its implementation, especially concerning Marine Protected Area (MPA) coverage and managerial cooperation. Although a complete re-organization of the review management institutions would make the most dramatic positive difference in implementing marine EBM, the thesis concludes that this would neither currently be politically feasible nor timely. An extension of the current MPA system to meet EBM goals would quickly allow for EBM implementation to rapidly advance in the Northwest Atlantic Ocean.

Acknowledgements

The author would like to thank her advisor, Dr. Dean Bavington for his endless commitment, enthusiasm, and assistance in the creation of this thesis. From two hour discussions to helping map an outline on his office floor, his help was truly invaluable. The author would also like to thank her reader, Dr. Jim Diana for his time and effort spent editing this thesis. Finally, the author would like to thank her family and friends for their patience and encouragement throughout the writing process.

"And so it is with whales. There may come a time when, in some remote, moonlit ocean glade, deserted of humanity, the last call of a humpback whale will start, and spread out, and then vanish, until those who heard it last will only wonder if they heard it all."

-Roger Payne, Among Whales

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Chapter One
Investigating the Implementation of Ecosystem-based Management (EBM) in the Marine Environment

Introduction

There has been a recent shift in the theory of how to effectively manage marine resources. Generally, the emphasis has shifted from maintaining the profitable industrial exploitation of singles species marine populations to considering the whole system within which marine species are embedded. Ecosystem-based management (EBM) is a relatively new approach; considerations for using EBM for land-based resources only began to appear in the early 1990s. The published work EBM has dramatically expanded in recent years and most recently has been applied to the marine environment. Just three years ago, in 2005, a consensus was formed between 217 academic scientists and policy experts with relevant experience on the definition of EBM in the marine context (McLoed 2005).

This committee also identified EBM as "the approach that holds the most promise for delivering desired results" (McLoed 2005). This quote highlights how work surrounding EBM has changed from theory and policy development to questions concerning practical implementation on land and in the sea. Though many international and national marine management structures have praised EBM in theory and have incorporated EBM into legislation and policy, there are few existing examples of successful implementation of an EBM

plan (Ruckelshaus et al. 2008, Muhweezi et al. 2007). Furthermore, ideas on implementing marine EBM have primarily focused on commercially important fish species (Hixon 2007). Extending EBM beyond fish to include the management of other marine animals is currently high on the agenda of many national and international organizations and agencies (EarthOcean 2008).

Management efforts surrounding humpback whales in the Northwest Atlantic provide a unique opportunity to look at how EBM is currently being implemented. Whaling in these waters was previously managed using MSY catch-quotas but, since a commercial whaling moratorium in 1982, management has shifted away from extractive goals and toward the protection of ecosystem integrity and the mitigation of negative human impacts. To track this shift in marine management and identify specifically how EBM is being implemented with respect to humpback whales, this thesis poses and answers three questions:

1. What are the core principles and consensus scientific opinions that have emerged with respect to implementing EBM in the marine environment?
2. How is marine EBM being implemented regarding humpback whales (*Megaptera novaeangliae*) in the Northwest Atlantic?

3. How can marine management agencies in the Northwest Atlantic more effectively implement EBM with respect to the humpback whale?

Why Study Humpback Whales in the Northwest Atlantic?

"We have a female humpback whale at three o'clock, oh, and a breach in the distance at five o'clock!" a voice blares from a tour boat's microphone. Looking out into the direction where she is pointing, I see bubble-nets, flukes, fins, and blows of all types peppering the surface of the Massachusetts coast. A nursing mother accompanied by her calf surfaces in the wake of the tour boat I am on, as naturalists teach those aboard about the physiological function of baleen. The tour boat, carefully complying with the many regulations mandated by the marine sanctuary where the whales have congregated, is accompanied by a research vessel whose team is attempting to attach tags onto the humpback whales to collect data on their feeding behavior. Dozens of pleasure boats sit on the water for hours waiting for a glimpse of a tail, even if only for a brief moment.

This flurry of activity and curiosity are a daily occurrence on the Stellwagen Bank National Marine Sanctuary, just east of Boston, where I was working as an intern for the advocacy organization *Ocean Alliance* in the summer of 2006. Many of the people that frequent the area knew the whales by name identifying them through the slightest

glance of their fluke or sometimes even by their personality exhibited at the surface of the water. People who have dedicated their lives to study these humpback whales have told me that an entire whale's story can be revealed by its surface displays.

Despite the commotion from June through September, when October comes the sanctuary will be desolate of visitors other then a few lingering blows from a handful of dawdling whales. It struck me that in spite of the attention and care the whales receive while they are physically in the vicinity of the sanctuary, this fascination and concern fades during the months of the year when the whales migrate south to warmer waters in the winter where mating and calving occur.

Five months after ending my internship with *Ocean* Alliance, on a humid January morning in the Turks and Caicos Islands, I was sitting on a bench that overlooked the Atlantic Ocean in all directions. Rather than enjoying a whale tour, I was pouring over fish species names for an exam I had for my study abroad program. The view of the Caribbean-blue ocean was calm and peaceful, occasionally disrupted by small fishing boats traveling into the shallows to dive for the day's catch. I looked away from my taxonomy text out toward the horizon for a relaxing study break and there, not too far off in the water, was a lone humpback whale slowly gliding with the current. I watched the whale pass uninterrupted, unrecognized, and untouched, until it finally took a deep dive and was lost from sight.

This contrast of activity that surrounds the whales at the frontiers of their range is augmented, in my mind, by their disappearance from our consciousnesses when they are not physically in front of us. The fading of human attention between the two spatial areas and times of the year struck me as indicative of the history of human relationships with whales and the current state of marine management. The phrase "save the whales" has become a cliché while whale populations continue to decline and the numbers of whales on endangered species lists continue to grow. Whales not only disappear from Stellwagen when they migrate south, but they also disappear from human concern and care.

This pulse in concern and care for whales and other marine life could be different. What if there was more connectivity and cooperation between the areas where whales travel? I knew that a substantial amount of effort was being put into research, legislation, policy, and other management activities at the extremes of the whales' range. What if more energy was put into not only the extremes, but also the middle of the range, creating a more holistic approach to care and concern? As I began to form these questions, I found that there were many others asking the same thing. However, one aspect that remained unanswered by all of us was how individual care and concern could be practically implemented collectively through management agencies, institutions, and organizations. How exactly

could a marine holistic approach to whale care and concern be implemented? This question motivated me to undertake an honor thesis on this topic. What follows is the beginning of an answer to this pressing concern.

Situational Factors Conducive to Using Humpback Whales to Focus on Implementing Marine EBM

In addition to my personal observations, there are four situational factors that make humpback whales a relevant focus for exploring the implementation of marine EBM. Humpback whales serve as an "umbrella species", there are already many management efforts currently aimed at whale populations, the intra-jurisdictional nature of the whales' migration patterns, and that there is very little work that has been conducted on the implementation of EBM for marine species other than commercially harvested fish populations.

Because the area whales inhabit contains many other marine organisms, humpback whales serve as an "umbrella species" for conservation efforts (Hoyt 2005). Since the biological range of the Northwest Atlantic population extends over diverse ocean zones from coral reefs to arctic seas, it inherently encompasses all the flora, fauna, and biomes that occupy this area (EarthOcean 2008). By effectively protecting the area where humpbacks live, the organisms and ecosystems with which they coexist will also need to be protected, possibly extending the beneficial impact of management interventions.

The effectiveness of focusing on a flagship species in this manner is highly debated with scientific studies both criticizing and commending this approach (Dietz et al. 1994, Angelman & Fagan 2000, Lindenmayer et al. 2002).

Second, since the moratorium on whaling was imposed in 1982, Northwest Atlantic whale populations have been the target of many protection attempts including the formation of management units and interest groups. This includes the formation of an international protected area network, data collection from government agencies including NOAA, and several NGOs such as Ocean Alliance who work to conduct research and educational programs on whales and the ocean environment. These initiatives offer a unique opportunity to analyze the effectiveness of management activities already in progress and look at the latest developments in the monitoring and protection of endangered species. Humpback whales are one of the most studied whale species in the world and therefore, a large amount of consistent data has been collected on the species for a long period of time. This is especially true in the Northwest Atlantic Ocean where at least 500 whales have been individually identified by color patterns on their flukes over the past 12 years (NOAA 1993).

Third, because of the size of their range, humpback whales in the Northwest Atlantic cross through many international, national, and regional jurisdictional boundaries (Figure 1). Even considering the

Large Marine Ecosystem (LME) scheme (Sherman & Alexander 1986) that has been used for the management of migratory fish species (Sherman 1991, 1999), humpback whales will still cross at least four boundaries (Figure 2). The highly migratory nature of humpback whales allows for a unique opportunity to analyze both the tangled hierarchies and collaborative management activities that have recently become a topic of intense debate in marine management (Bavington & Kay 2007). Migratory species like the humpback whale pose intense inter-organizational management challenges, which are only beginning to be recognized and addressed (Hyrenbach et al. 2000, Decker & Chase 1997).

Finally, as previously mentioned, the EBM approach is a relatively novel management concept, especially in marine settings. Moreover, the implementation of marine EBM up to this point has mainly focused on fisheries (Bavington & Kay 2007, Hixon 2007) with marginal attention to non-fish species. The implementation of EBM for marine mammals, specifically humpback whales, is a subject only just beginning to be addressed (Hooker & Gerber 2004). An analysis of the humpback whale population in the Northwest Atlantic allows for a thorough application of EBM principles and the identification of barriers and bridges for implementation.

Historical Context from which Ecosystem-based Management has emerged

The following is the progression of events in the Northwest Atlantic consisting of subsistence hunting, a flourishing extractive industry, the beginning of population declines, and finally the initial attempt at implementing a managerial approach, which illuminates both the evolution of the relationship between this large-scale biological system and the human world that overlaps it as well as the framework that preceded the emergence of EBM in the ocean realm.

Although the exact date when whaling began is unknown, humans have been hunting whales for thousands of years (Dolin 2007). The earliest whaling was subsistence hunting and did not evolve into an industrial enterprise until the 1800s. Whales were appealing to hunt because of their large size, which early in the history of whaling would provide food for many people, later blubber to produce large amounts of oil, and whale bone for a variety of industrial and artisan uses (Carpenter & Carpenter 1988, Ackman 1989, Mahaffey 1954). Whale oil was exceptionally critical to fuel many appliances such as most lamps before petroleum was discovered. Additionally, being migratory, many species moved together in predictable patterns, making them consistently easy to find (WDCS 2006). Originally, whaling consisted of collecting washed up carcasses taking advantage of the natural death rate of the whales as well as their propensity to become beached due to sickness or disorientation (Dolin 2007). However, it wasn't long before whalers

actively began hunting whales traveling around the world to find their target resources in expanding numbers. In North America, there are accounts of both John Smith and the men of the *Mayflower* traveling around modern-day Provincetown Harbor and Cape Cod in Massachusetts attempting to catch what have been interpreted as fin, humpback, and right whales (Bradford et al. 1849). However, as their journals illustrated, their attempts were usually fruitless without modern instruments and techniques, "When the whale saw her time, she gave a snuff and away" (Bradford et al. 1849, pg. 142).

As technology improved and the market for whale products including whalebone (from baleen whales) and oil (spermaceti from sperm whales) dramatically increased, the whaling industry took off, especially in North America. The golden age of North American whaling came in the first half of the nineteenth century. At that time, the United States had the largest whaling fleet in history consisting of 735 of the world's 900 whaling ships (Clapham & Link 2006). Although many whaling operations moved abroad into foreign oceans, a substantial presence could be felt in the North Atlantic waters where right, humpback, and sperm whales were the main targets (Clapham & Link 2006). Whalers patrolled the animals' entire ranges from the tropics to the high latitudes. At its height, this massive industry provided for the livelihood of 70 thousand people and brought in around $70 million in income (Dolin 2007). In 1853, which is

considered to be the industry's most profitable year, 8,000 whales were taken to produce 103,000 barrels of sperm oil, 260,000 barrels of other whale oil, and 5.7 million pounds of baleen (Dolin 2007).

Europeans, Canadians and several Caribbean nations also fully took advantage of the seasonal migrations of whale populations by participating in whaling activities in the Atlantic. Whales migrating from their breeding grounds in Caribbean waters to the rich feeding areas in the Gulf of Maine and the east coast of Canada at one time had to pass through seven distinct whaling zones – defined as a nation where whales were being taken for an industry. This exposure to hunting occurred twice per year when they migrated back and forth through the whale hunting areas that were adjacent to coastal human settlements (see Table 1).

The late 19th and early 20th century brought both a change in the products whalers were after and a shift to whaling mainly on the west coast of North America. While the introduction of petroleum gradually eliminated the need for whale oil, baleen products made a comeback in American culture during this time (Dolin 2007). One could find many fashionable products made from whales including whips, canes, penholders, shoehorns, brushes, and mattresses (Starbuck 1878). However, it just wasn't a shift in the market that sent whalers west. The truth was that the Atlantic had been "fished out", and the move was imperative to keep a profitable industry afloat

(Ashley 1926). By 1900, there was not a single area in the North Atlantic that had not been subject to whaling efforts at some point in time (Clapham & Link 2006). The future was looking dim for the east coast whaler at this point, and for some it was certain that the pinnacle of whaling had passed and it was time to find other profitable industrial ventures. "Only one thing may be prophesied with certainty, which is that at no remote date these two whales [sperm and bowhead] will again become commercially important" (Ashley 1926, pg. 126). The whales had become commercially extinct.

However, the late 19th century was simultaneously a time of rapid scientific and industrial change that expanded the ability to locate and harvest a variety of whale species. It was at this point in time that a machine was invented that would fundamentally change the future of the whaling industry. In the 1860s, Norwegian whalers introduced the whale cannon. This rocket-like gun featured an explosive tip that could detonate on contact making it possible for whalers to kill or at least maim whales with a single blow (Dolin 2007). It is difficult to overestimate the significance of this shift in the technology of taking whales. The whale cannon, combined with an increase in global demand for whale products, began the era of industrial whaling. Industrial whaling saw the rise of whaling super powers such as Russia and Japan, and after Pacific whale populations

were rapidly made commercially extinct, a movement into previously un-touched Antarctic waters.

By the 1940s, the number of whales was becoming so low that, for the first time in history, an international body was formed in an attempt to manage whales as valuable natural resources and global commodities. On December 2, 1946, representatives of 42 nations signed the International Convention for the Regulation of Whaling (IWC 1946). Included in this regulation was the creation of a new international institution - the International Whaling Commission (IWC) - whose original purpose was to "provide for the proper conservation of whale stocks and thus make possible the *orderly development* of the whaling industry" (Bromley 2006). The formation of the IWC represented a general trend in marine management agencies to combine conflicting goals. They were to balance both the conservation of natural resources and arrange for their orderly and profitable exploitation (Kurlansky 1997).

There were several fundamental flaws that can be seen in the combination of roles the formation of the IWC represents. The attempt to apply a single species Maximum Sustainable Yield (MSY) approach, known as "The New Management Plan" from fisheries science to the whaling industry, combined with an insistence on a marketplace mentality toward whale populations, ultimately led to widespread disapproval of and discontent with the IWC.

The quota system can be seen in the strategy called the "New Management Procedure" (NMP), which was created in 1974. Whaling nations agreed that they would not take more whales each year than could be naturally replaced through population growth, fitting with the single species MSY model (Figure 3). According to the accepted level dictated by the MSY model, catches of exploited populations must be halted if population numbers fall below 54% of their theoretical carrying capacity (where carrying capacity (K) equals the estimated pre-exploitation level of a given stock) (Palumbi & Roman 2006). This number represents the point at which the maximum numbers of whales could be caught without depleting the stock.

The single species MSY system first emerged from fisheries science and very little was changed from the original format when applied to the whaling industry (Holm 1996). A committee of four scientific experts from primarily western nations and UN agencies set quotas for each whale population (Dr. D.G. Chapman, of the United States, Mr. K.R. Allen, then of New Zealand, Mr. S.J. Holt, from the United Nations Food and Agriculture Organization in Rome, and Dr. J. Gulland, of the United Kingdom). Their management actions and advice deployed the latest mathematical models and techniques borrowed from fishery assessment (Gambell 1993).

The use of MSY requires reliable and certain population estimates on which the quotas can be based (Holm 1996). Uncertainty

surrounding extraction quotas can lead to the ultimate decline of that population if too many individuals are taken (Schrank & Pontocorvo 2007). Regarding the whaling industry, it became difficult for nations with conflicting interests to agree on whale harvest numbers and adhere to them. Although much uncertainty exists in marine fisheries, this is perhaps even more pervasive when considering whale populations merely because of their expansive range and temporal variation, making it extremely difficult to estimate population size. The IWC's whale population estimates varied so widely that many countries - namely the United States and the United Kingdom – began to argue that they were too unreliable to allow for any safe and sustainable industrial whale harvests (Butterworth 1992).

Beyond theoretical problems with the MSY strategy, the fundamental concept of the IWC as a management unit was criticized for biased science and corrupt politics from its inception. The use of the MSY model was seen to reflect a marketplace mentality, consistent with a goal of achieving maximum production without exhausting the resource for future utilization, or in this case, an industry (Watanabe 1980). The quotas set by the IWC were generally seen as too high and failing to mitigate the depletion of whale stocks (Watanabe 1980). Observers pointed out that in the first two decades of the IWC, more whales were killed than at any other time in human history - close to 40,000 whales in the 29 years from 1933 to 1962 (Day 1987). There

was also an increase in harvest of what was known as 'commercially extinct' species to eight out of the ten species that the IWC had targeted to protect, ultimately leading to the species becoming commercially extinct (Day 1987).

By the 1970's, it was generally evident that the IWC's attempt to regulate whaling and increase whale numbers was not working. In 1965, close to twenty years after the IWC was formed, three of the central whale species taken for commercial purposes (blue, fin, and humpback whales) were added to the IUCN Red List of Threatened species for the first time (IUCN 2007). Despite several different management and policy strategies being employed by the IWC and national governments, many whale species were slipping into extinction. Shortly thereafter, in 1982, the IWC called for a moratorium – a temporary pause of commercial whaling - because of the global concern about the falling numbers of these profitable species.

The 1982 whaling moratorium forced managers to expand upon their management approaches, beyond that used to control hunting quotas. Despite the fact that there are currently (as of 2008) five active commercial whaling operations in the North Atlantic - Norwegian commercial whaling, Japanese "scientific whaling", and three other indigenous subsistence hunts with very low numbers of individual animals taken per year including those in the Caribbean and

in Alaska (Clapham & Link 2006, EPA 2000), it has become essential to develop new managerial strategies for ocean life. It is from this need that marine EBM has emerged and has begun to be implemented in the Northwest Atlantic.

Ecological Context Relevant to Marine EBM in the Northwest Atlantic

Northwest Atlantic humpback whales live in a diverse ecosystem that extends from coral reef systems in the Caribbean, across mid-Atlantic waters supporting many migrating fish species, to the diverse Gulf of Maine region (Figure 4). Highly migratory, humpback whales annually migrate from Caribbean waters, mostly off the coast of the Dominican Republic, where they breed and give birth, to the Gulf of Maine where they feed and nurse their young.

This area contains over fifteen species of marine mammals including four species of large whales that have been listed on the IUCN Red List of Endangered Species (NOAA 1993). The IUCN Red List, the authoritative list of endangered species worldwide, includes the North Atlantic right whale (endangered), the humpback whale (vulnerable), the minke whale (near threatened), and the fin whale (endangered) (IUCN 2007). The endangered status of these populations, which is determined in compliance with the Global Marine Species Assessment (GMSA) pioneered by IUCN's Biodiversity Assessment Unit, unfortunately represents the general

trend among whales. The IUCN Red List states that more than one third of all great whale species are 'endangered' and out of 84 species of whales and dolphins, half are listed as 'data deficient', meaning that scientists do not know enough about the species to even speculate if there are vulnerable of becoming extinct (Hoyt 2005). The humpback population is currently believed to be growing at a modest rate of 4% per year (Clapham 2003). Both the rate of population growth and abundance of humpback whales are in marked contrast to other whale populations in the Northwest Atlantic that also experienced heavy hunted during whaling, such as the North Atlantic right whale. The population of North Atlantic right whales is extremely endangered numbering from 300-350 individuals and is showing an annual rate of decline (IWC 2007).

Large parts of the humpback whale's range in the Northwest Atlantic are located adjacent to extremely high levels of human activity and heavily populated coastal cities. The eastern seaboard of the U.S. features eleven major cities[1] with 38,470,759 people living in these metropolitan areas in 2000 (Table 2). To this number, one must also add the 994,791 people living on the eastern coast of Canada and approximately 91,875 people who live in the Samana region of the Dominican Republic, where the highest concentration of whales breed (Statistics Canada 2006, ONE 2002).

[1] Portalnd, ME, Portsmouth, NH, Boston, MA, Providence, RI, New York City, NY, Baltimore, MD, Washinton, D.C., Virginia Beach, VA, Charleston, SC, and Savannah, GA

There are also several high traffic seaports along the coast, which represent the extraordinary amount of industrial activity that occurs in this area. In the New Jersey and New York seaport alone, over 31 million tons of shipments moved through the port authority in 2006 (Port Authority of New York and New Jersey 2007). There are also major seaports in the Washington, DC area, Charleston, and Boston that create direct and indirect impacts on whale habitat and direct impact on the whales themselves. In addition to seaport traffic other influences on the ocean environment need to be considered such as the amount of sewage and pollution being dissipated into the surrounding coastal waters and the commercial fishing industry.

As previously mentioned, there is typically a large amount of uncertainty surrounding estimations of population size in cetaceans. This is no different in the Northwest Atlantic where estimates of humpback whale population sizes are strongly debated and range from 5,505 to 11, 570 individuals (NOAA 1993, Stevick et al. 2003). However, this is in contrast to the amount of information known about individual whales in the population. Over 5,000 whales have been individually named in these waters, which makes it possible for researchers to follow the whales' intimate life history details (WhaleNet 2008). This knowledge is illustrated in the case of a whale named "Salt", who researchers have been following since she was first spotted as a juvenile in 1976 (WhaleVideo 2008). Since that time, her

ten calves and five grand-calves have also been tracked throughout their lives building a very intricate family history that is annually updated (WhaleVideo 2008).

Outline of the Elements Central to Implementing EBM for Humpback Whales in the Northwest Atlantic

Although there have been numerous, often conflicting definitions and theories of the important elements comprising EBM (Slocombe 1990, 1993; Grumbine 1994; Kaplan 2007; De la Mare 2005; Reeves 2004; Guénette, S. and J. Adler 2007; Frid et al. 2006) and a consensus has only just been reached for the marine environment (McLoed 2005), several common elements are consistently presented in the literature. Four of these elements have been synthesized below to clarify the components critical to the implementation of marine EBM for humpback whales in the Northwest Atlantic. The synthesis was achieved through a comparative review of the authors mentioned above (Table 3). A contextual example is given for each principle to demonstrate exactly how it is possible to be implemented in the natural environment.

1. Humans are an integral part of ecosystems and EBM must consider existing and potential impacts of interactions between target ecosystems and industrial and socio-economic activities.

EBM adopts a comprehensive holistic view of cetaceans under management. Comprehensiveness and holism require recognizing that humans and their many activities are integral parts of ecosystems.

Holism often presents organizational and knowledge challenges for management agencies since the protection of single biological components (i.e. populations) have usually been the catalyst for the original organization of management schemes. EBM emphasizes that it is not just environmental stresses that marine resources face but also includes stresses associated with economic institutions, markets, and industrial activities as well (Kaplan 2007). EBM philosophy emphasizes a "human ecological" or a "sociobiophysical" systems view that prioritizes understanding local and regional economies, cultures, societies, and their points of interaction with the natural environment (Slocombe 1990, Boyden 1992).

An example of where humans have been integrated into marine management is in the Northwestern Hawaiin Islands (NWHI) Marine National Monument Park regarding the coral reef management project (Toonen et al. 2007). Multiple human impacts on the coral were examined including marine debris, ship groundings, and ship waste and ranked according to the vulnerability of the coral to each of these threats (Figure 5). Recognizing which human impacts pose the largest threat in the ecosystem could help to direct threat mitigation projects in the future. In the case of the NWHI Marine National Monument Park, mapping the distribution of known anthropologic threats will help to set management priorities (Toonen et al. 2007).

2. Ecosystems cut across traditional management sectors and therefore management units should be designated bioregionally.

Conventionally, management sectors may be broken down into local, state, and national levels. This strategy may seem logical in the world's oceans especially since the extension of national coastal state ownership to include the 200 mile territorial sea called the Exclusive Economic Zone (EEZ), which was negotiated under the UN Law of the Sea Convention in 1982 (UN 1982). The UN Law of the Sea conventions focused on extending the national jurisdiction over marine resources that are concentrated along the world's continental shelves. However, these political management units do not correspond to the life history traits and ranges of many marine species that cross numerous national territorial sea boundaries and even enter into un-owned and largely unregulated international waters beyond the narrow 200 mile zone.

EBM presents an alternative framework to using traditional marine management units by focusing on adapting the management structures to biophysical and ecological elements such as watersheds, coral reef systems, or the total area covered by a migratory species. EBM units have been implemented at various levels in terrestrial (Slocombe 1993) and fresh water (MacKensie 1993) ecosystems but there is currently just a few existing ocean area currently adhering to this principle for the management of cetaceans (EarthOcean 2008).

Located in the Mediterranean Sea, the Palagos Sanctuary for Marine Mammals, formally known as the Liguarian Sea Cetacean Sanctuary, is an example of bioregional management currently in action. Situated between France, Corsica, and Italy, the sanctuary protects 84,000 km^2 of cetacean habitat (Figure 6). Although legislative goals of international collaboration have been met, many problems remain for implementing of bioregional management in the sanctuary (Johnson 2008). Enforcement of policies is a pervasive problem in the sanctuary, giving the area the nickname the "shipping sanctuary" because of the dramatic increase of shipping traffic, pollution levels, and deadly by-catch rates caused by fishing activity taking place within sanctuary boundaries (Johnson 2008).

3. EBM should be developed using existing management structures when possible and management cooperation

Building upon the idea of cross-jurisdictional management (Slocombe 1993, Grumbine 1994), development of a coordinated management structure is a central principle to EBM. This could either be in the form of a simplified and united single management agency or in the cooperation of all levels of management from local to federal and international levels (Slocombe 1993, Grumbine 1994). The ultimate goal of the re-organization of management institutions in this context is the formation of an "institution ecosystem" (Imperial 1999) to compliment the natural one.

Benefits and drawbacks associated with each approach have been cited in the literature: a simplified management scheme allows for a cooperative organization that is institutionally integrated and will include all aspects of management including monitoring, enforcement, and policy making in one cohesive and action-oriented unit (Grumbine 1994). Collaboration between management levels may involve a change in power relationships between the levels of government, and reorganization to limit conflicting legal mandates and management goals (Grumbine 1994).

Obstacles to managerial cooperation that have been outlined in the literature are the conflict-producing nature of having overlapping jurisdictions, competing agencies, varied goals, and multiple management and assessment processes (Slocombe 1993). This tends to occur as management units have been found to accumulate around environmental problems over time (Elmore 1985). EBM attempts to alleviate this tendency by creating inter-organizational structures for activities such as creating policies, comparing ideas, and coordinating enforcement efforts.

An example of the implementation of this inter-organizational concept is the formation of the Joint Ocean Commission Initiative in 2005. The commission was conceived to organize informed experts and policy makers across the U.S. to guide and encourage action by the U.S. government toward meaningful improvements in ocean policy

(Joint Ocean Commission Initiative 2006). This institution supports the concept of the use of existing management structures and managerial cooperation by working within the current ocean management framework and assembling a committee of authority on a wide range of ocean issues including fisheries, homeland security, transportation, and public policy (Join Ocean Commission Initiative 2008).

4. Use of an ecologically linked network of protected areas

A Marine Protected Area (MPA) can be defined as areas designated for special protection to enhance the management of marine resources (NRC 2000) A MPA network has been cited as a critical tool used in the successful implementation of marine EBM frameworks because of the highly connected nature of the sea (Kelleher 1992). While the use of MPAs has been growing in popularity for other marine species such as fish (Polunin 2002), MPAs have only very recently become more widely used in the protection of whales. The use of MPAs is quickly gaining popularity for whales and in 2002 there were 50 marine areas worldwide that specifically featured cetacean habitat, and more than 500 MPAs currently being proposed that include cetacean habitat protection as a management goal (Hoyt 2005).

Elements of MPAs that are relevant to implementing marine EBM include protecting species across the whole range and life cycle

and, for economically important species, preventing human extractive activities from entering sensitive areas (IUCN 1994). If the full range of a humpback whale population were to be completely covered by a MPA network, it would need to include areas where behaviors are performed that are critical to their survival, feeding, breeding, and all behaviors associated with healthy reproduction, namely hunting for food, socializing, nursing, and resting (Hoyt 2005). These areas are typically located at the extremes of the whales' range. In addition to the extremes, MPAs could also be applied to migration corridors that are used consistently by a whale population (Hoyt 2005). In addition to the extremes of an animal's range, migration corridors have been cited as critical to effectively using MPAs (Hyrenbach et al. 2000). Implementing full coverage of the sensitive areas at the extremes of the range as well as partial to full coverage of the migration corridor could enable managers to gain the more holistic perspective that is central to an EBM strategy (Hyrenbach et al. 2000).

MPAs also offer a helpful tool for the implementation of marine EBM because it is possible to allow for multiple activities to exist within them and for protection and monitoring extending to adjacent zones, including terrestrial ones, emphasizing controlling the human element central to EBM. Multiple use areas are generally accomplished using a zoning plan where varying degrees of human interaction are permitted (Dobbs 2007). One of the most prevalent

models used for MPA zoning is the Great Barrier Reef Marine Park (Figure 7). Zones in this network are color coded for human use and range from "preservation" and "Marine National Park" areas that include heavy regulation and monitoring to "general use" areas that require a permit for human entrance. The Great Barrier Reef Marine Park serves as the primary global example of how human activity and conservation can occur in the same general area using marine EBM (Dobbs 2007).

The relevant objectives used on the Great Barrier Reef are to separate conflicting human activities, to protect the natural and/or cultural qualities of the MPA while allowing a spectrum of reasonable human uses, to reserve suitable areas for particular human uses, while minimizing the effects of these uses on the MPA, and to preserve some areas of the MPA in their natural state undisturbed by humans except for the purposes of scientific research and education (Kelleher & Kenchington 1992).

Chapter Two
Methods for Investigating the Implementation of Marine EBM for Humpback Whales in the Northwest Atlantic

Methods: Choosing Three Principles for an In-Depth Analysis of their Implementation for humpback whales in the Northwest Atlantic

In this thesis, the four elements of EBM that were will be explored more in depth, specifically looking at their current implementation for humpback whales in the Northwest Atlantic and/or how the elements could be implemented in the future. Again, the four components of EBM that most directly apply to implementation for humpback whales in the Northwest Atlantic are:

1. Humans are an integral part of ecosystems
2. EBM should be developed using existing management structures when possible
3. Bioregional management
4. Use of an ecologically-linked network of protected areas

The first principle, humans are an integral part of ecosystems, applies directly to implementation of marine EBM in the Northwest Atlantic because it embodies the recent shift in the paradigm of managers concerned with whale populations. The movement away from the IWC's MSY strategy after the 1982 whaling moratorium toward a non-consumptive, holistic approach illustrates how the human relationship with the ecosystem has changed. Humans can now be seen as part of the ecosystem, not merely extractors from it. It is now necessary to examine if this paradigm is transcending theory and is currently being practiced in the Northwest Atlantic.

The second and third EBM principle, that EBM should be developed using existing management structures when possible and the use of bioregional management can be synthesized into a broader category, the reform in how managers think about management institutions. In this thesis I the synthesized element will be referred to as "Bioregional and Managerial Cooperation". These elements are directly applicable to humpback whales in the Northwest Atlantic because of the previously mentioned highly migratory nature of humpback whales and the fact that they cross through so many ecological regions and formal jurisdictions.

The last principle, the use of an ecologically-linked network of protected areas, is directly applicable to humpback whales in the Northwest Atlantic because of the recently announced collaboration between Stellwagen Bank National Marine Sanctuary (US) and el Sanctuaria de Mamiferos Marinos de la Republica Dominicana (Dominican Republic). This collaboration, announced in 2007, was formed in an attempt to build linkage between the sensitive breeding grounds and feeding areas of the humpback whale (NOAA 2007). Since the formation of a linked network has already begun, it seems logical to discern how this network could be expanded upon in the future to meet the goals of implementing marine EBM.

Methods: Humans are integrated in the environment

To explore how this principle is currently being implemented for humpback whales in the Northwest Atlantic, the collection of data on human-related whale mortality and mitigation efforts for these human activities were documented. Specifically, mortality caused by boat strikes and entanglement in fishing gear was focused on because they are human activities in the ecosystem beyond the extraction of whales that can directly cause the death of humpback whales.

In total, five organizations were selected to ascertain whether management institutions were collecting data concerning humpback whale mortality. Four government institutions were contacted because it was assumed marine management institutions would have access to mortality data. The institutions were: Environment Canada, Fisheries and Oceans Canada, Parks Canada, and NOAA. For the Caribbean region, the Eastern Caribbean Cetacean Network (ECCN) was contacted because this organization has several offices around the Caribbean giving a potentially larger area for data collection and because members of the network are affiliated with other governmental institutions.

Proactive management activity was also noted, specifically disentanglement teams. Stranding response teams were not included in this survey because it is these teams that are usually responding to a call for a humpback whale that is already deceased. The agencies contacted were the ECCN and the Provincetown Center for Coastal

Studies (PCCS). Description of activities, official management plans, and other documents were reviewed for this section of the data collection.

To address one of the causes of these mortalities, large container ships, the U.S. Department of Transportation was also contacted to attempt to secure a comprehensive map of shipping lanes on the Northwest Atlantic coast. This in conjunction with the other data was collected to gain a holistic picture of where human activities leading to whale mortality were occurring and how management institutions were dealing with it.

Methods: Bioregional Management and Managerial Cooperation

To establish how EBM could be implemented within the existing management framework, it is first necessary to outline what the existing management framework actually is. For this thesis, organizations were chosen that had direct input into legislation, enforcement, or scientific research on the humpback whales of the Northwest Atlantic.

To collect this data, the environmental programs of six national governments were surveyed: Canada, USA, the Bahamas, Turks and Caicos Islands (TCI), and the Dominican Republic. These are countries whose EEZ's humpback whales are thought to pass through during their annual migration. Three international organizations were

also investigated: the IWC, United Nations Educational, Scientific and Cultural Organization (UNESCO), and the United Nations Environmental Programme (UNEP) as humpback whales will occasionally cross into international waters and because whale populations have been under international management in the past (i.e. the IWC's New Management Plan). Two governmental programs were reviewed: NOAA's Marine Mammal Health and Stranding Response Program and the National Marine Sanctuary Network.

These institutions were reviewed and assessed according to five criteria:

1. Description of the organization (national, international, NGO, etc.)
2. Boundaries of their jurisdictional area or area in which they are active (depending on if the institution was a governmental department or an NGO or independent program)
3. Was EBM implementation a listed goal?
4. Were there goals, mandates, or programs related to marine EBM?
5. What were the goals, mandates, or programs related to implementing marine EBM for humpback whales in the Northwest Atlantic?

These criteria were selected to help build a complete and clear picture of how management institutions are currently related to each other and how they are interacting regarding humpback whales in the Northwest Atlantic.

Method: Use of an ecologically-linked network of protected areas

To create a picture of the current network of protected areas or MPAs created for humpback whales in the Northwest Atlantic, six governmental departments responsible for the creation of parks and protected areas were contacted in six nations: NOAA (US), Parks Canada (Canada), Departmento de Recursos Naturales y Ambientales (Puerto Rico), Department of Environmental and Coastal Resources (DECR) (TCI), Bahamas National Trust (Bahamas), Departmento de Medio Ambiente y Recursos Naturales - Subsecretaría de Recursos Costeros y Marinos (Dominican Republic). Announcements or descriptions of MPAs specifically mentioning humpback whales as a target species were noted.

Chapter Three
Implementing EBM for Humpback Whales in the Northwest Atlantic

Findings: Human are integrated with the environment

Out of the organizations contacted in the Northwest Atlantic area, the United States was the only nation that could produce relevant humpback whale mortality data, consisting of reports to NOAA from the National Marine Mammal Stranding Network. These data consist of sixteen stations along the east coast of the United States and is in compliance with the mandates of the Marine Mammal Protection Act (US Senate and House of Representatives 1972) (Table 4).

Data were collected separately from the NOAA's Southeast and Northeast regional fisheries offices. The Southeast office is responsible for reports from North Carolina, South Carolina, Georgia and Florida, while the Northeast office collects data from Virginia, Delaware, New Jersey, New York, Massachusetts, and Maine. Although there were humpbacks recorded in the database before 1989, consistent data entry was only found from 1989 to 2006. During this 17-year period, 33 humpbacks were recovered with fatal injuries caused by boat strikes or entanglements in fish gear/debris (Northeast Region Stranding Network and NOAA Fisheries 2007).

Of these mortalities, 78% (26 of 33) were identified as caused by boat strikes, 6% (2 of 33) because of entanglement in lines, and 9% (3 of 33) attributed to both (Figure 8). The incidences varied through

the ecosystem, with most occurring in the Chesapeake Bay area (Figure 9). In general, more mortality incidences occur in the Northeast region, seemingly because of the differences in residency time of the humpbacks (Malone 2007). Humpbacks are thought to spend a greater majority of their time feeding in Northeastern waters as opposed to migrating through Southeastern waters, putting them at risk of mortality for a longer period of time in the northern part of their range (Malone 2007).

Requests for a comprehensive map of shipping lanes on the Atlantic coast were inconclusive and no such map could be found. Requests were redirected toward specific Traffic Speration Schemes (TSSs), such as the Boston TSS that was previously mentioned. However, this contradicts the original idea to create a larger picture of the entire ecosystem. However, in a recent study of human impacts on the marine environment just published in February of 2008, a comprehensive map of global shipping lanes and their usage is clearly depicted (Halpern et al. 2008) (Figure 10).

Mitigation efforts that were found included recent shift of the Boston shipping lanes, and the PCCS disentanglement team. There are an estimated 1,000 industrial, commercial, and private ships that travel through the Boston port area each year (Sub-committee on Safety of Navigation 2006). In 1973, a TSS was established to facilitate the movement of these ships into their desired port. Previously, the TSS

was determined to overlap with critical feeding area for the large baleen whales and in particular, the Right whale. In 2006, NOAA and the United State Geological Survey (USGS) implemented a proposal that shifted the TSS twelve degrees to the north, which moved ship traffic into a section with considerably less density of feeding whales (Figure 11).

A second mitigation effort includes the disentanglement team from the Provincetown Center for Coastal Studies (PCCS), located in Provincetown, MA. PCCS is responsible for the disentanglement of marine mammals around Cape Cod and Stellwagen Bank when the whales are feeding during the summer months. Since its inception in 1984, the disentanglement team has freed more than 70 large whales including humpback whales, right whales, and fin whales (PCCS 2008). The common sources of entanglement have been found to be floating gillnets and lobster pots (Figure 12).

Even if the team successfully disentangles the animal, or the lines naturally break off, serious injuries such as deep gashes and mutilation to the dorsal fin usually result (Figure 13). These scars can be used to document how frequently members of the population become entangled. Estimates indicate that between 48-65% of humpback whales that were sampled in the Gulf of Maine exhibited scarring that was likely to have resulted from an entanglement, and that 10-25% of the population may become entangled each year (Jooke

& Mattila 2001). It was also found that 71% of whale entanglements go unreported in this region, revealing that entanglements could be a much more pervasive and threatening problem than previously thought (Jooke & Mattila 2001).

Findings: Bioregional Management and Managerial Cooperation

Through the review of management institutions, it was found that 25% explicitly stated a commitment to EBM in their goals and mandates (Table 5). Despite this low statistic, all of the reviewed organizations and programs had at least one goal, policy, or program related to the principles of EBM (Table 5). The most common elements that were found to be implemented were "humans are integrated with ecosystems" and "bioregional management", each of which was found to be present in 75% of the institutions reviewed (Figure 13).

Regarding humpback whale in the Northwest Atlantic, 50% of the institutions currently have directly applicable programs, legislation, or initiatives (Table 6). There was a wide range of activities found, including human impact mitigation, population structure projects, and protected areas.

Finally, there was a discrepancy found in the endangered status of the humpback whale. While almost all of the nations and organization reviewed considered the humpback whale endangered

and in need of management actions, Canadian institutions, in accordance with the Species at Risk Act, do not. Therefore, there are no Canadian programs directly targeting humpback whale protection in the Northwest Atlantic.

Findings: Use of an ecologically-linked network of protected areas

The collected data indicate that that a little over half (55%) of the relevant institutions reviewed had programs or plans aligned with the principle of "an ecologically-linked network of protected areas". "Relevant" in this case was defined as institutions that had the legislative and managerial power to create and enforce protected areas.

Only two out of the six governmental departments reviewed had a network of ecologically-linked protected areas specifically designated for humpback whales in the Northwest Atlantic (Figure 14). The U.S. has one area, Stellwagen Bank National Marine Sanctuary. The Domican Republic also has one, Stellwagen Bank's sister sanctuary, El Santuario de Mamiferos Marinos de la Republica Dominicana, which is connected to the Stellwagen Bank protected area by the previously mentioned management agreement for continued cooperation.

Chapter 4
Suggestions for Future Directions of Research and Management

Conclusions: Humans are integrated with ecosystems

The attempt to collect data from major management institutions across the humpback whales' range seems to indicate that the majority of the humpback whales' range remains unmeasured for mortality or that this data is not currently easily accessible.

Since NOAA was the sole institution that was able to produce relevant data, the entire Caribbean and Canadian regions remain void of data, leaving a substantial portion of the humpback whales' range undocumented for mortality caused by boat strikes or entanglements. Within the NOAA data, the information provided was from two NOAA facilities and therefore had to be integrated. It is unclear whether separation of the data would make it more difficult for NOAA managers to see a holistic view of the scope of these impacts if they are only looking at half of the collected data.

Aside from possible spatial issues present in the data, the quality of the data could also serve as an obstacle to its effective use. Keeping in mind that the given data had not yet been validated by NOAA fisheries (finalized for blanks, typos, and accuracy), the data lacked a continuous format. The main discrepancy was that before the data could be presented on a map, as in Figure 9, the latitude and longitude measurement formats first had to be individually adjusted.

This issue could point to a possible lack of use of the database and could allude to the possibility of more inconsistencies existing in the format of the data.

The examination of what mitigations currently exist to measure and/or cope with the impacts of human activity revealed that the only programs that currently exist focus on shifting the shipping lanes in Boston and the PCCS disentanglement team in Provincetown, MA. The movement of the Boston shipping lanes focuses on mitigating the chances of boat strikes, which is consistent with NOAA data indicating boat strikes as the most common human-caused form of mortality. This is also consistent with current literature that notes boat strikes are the most common human-related mortality factor for large whales such as the humpback (Laist et al. 2001). The focus of programs on mitigating boat strikes seems to be a relatively recent occurrence, which is consistent with the fact that in general, the number of ship strikes dramatically increased in the 1950's with the increase in the number of fast-moving and large container ships in Atlantic waters (Laist et al. 2001). The previously mentioned program in the NWHI Marine National Monument Park also first recognized which human activity was having the most negative impact in the park regarding coral health and then began to plan management actions around mitigating these impacts.

Although the PCCS disentanglement program focuses on the human activity that was found in this study to cause far less mortality than boat strikes, a project assessing the causes of scars on humpback whales in Stellwagen National Marine Sanctuary indicates that entanglement may be more pervasive than the mortality data indicates. This study, conducted by Jooke & Mattila in 2001, focused on the interaction between humpback whales and two types of fishing gear: gill nets and lobster pots (as seen in Figure 11). Results of the study found that between 48-56% of the humpback whales that were sampled bore scarring that was likely to have resulted from an entanglement and that each season, 10-25% of humpbacks become entangled. These findings seem to point toward the importance of an active disentanglement team because although many whales may become entangled each season, a large portion of them can survive if assisted.

Despite these mitigation efforts, they are fairly localized around the Stellwagen Bank National Marine Sanctuary area. After comparing the locations of mitigation efforts and the mapped NOAA data, it seems that there is a discrepancy between where the highest frequency of whale mortality was found and the areas where mitigation efforts are being focused. Although the highest frequency of boat strikes and entanglements was found off the shore of Delaware

and the greater Washington D.C. area (see Figure 9), no mitigation efforts were found to exist there.

Conclusions: Bioregional management and managerial cooperation

The table created for this thesis outlining relevant management institutions may be the first of its kind to compare institutions that participate in protecting the humpback whale the Northwest Atlantic. This comparison revealed that all reviewed institutions have already begun implementing EBM in some manner, indicating a high level of interest in EBM as a managerial approach. Many of the organizations cite common mandates or goals for the protection of humpback whale populations yet only two of them (NOAA and the government of the Dominican Republic) are working toward cooperation with each other. Because of this, it is clear that there is a need for either a synthesis of management structures or perhaps enhanced collaboration between them.

Regarding the discrepancy in the endangered status of the humpback whale, a consensus would need to be reached for effective bioregional management of this population. For true bioregional management, spanning the population's entire range, all nations with jurisdictions within this area would need to be committed to join in management efforts.

Conclusions: Use of an ecologically-linked network of protected areas

After outlining existing current protected areas, it is clear that only a small portion of the humpback whales' range – the breeding area and a portion of their feeding area are covered. This leaves the entirety of their migration paths and the extreme borders of their feeding and breeding areas, where a large portion of their time throughout the year is spent, completely unprotected. The small number of protected areas found in the Northwest Atlantic for humpback whales is not consistent with global trends, which indicate that internationally, the number of MPAs that protect cetacean habitat is growing and now globally consists of hundreds of protected areas (Hoyt 2005.

The use of protected areas has recently received approval from large international organizations including the World Summit on Sustainable Development (UN 2002) and the World Parks Congress (IUCN 2004). These endorsements call for governments to protect 20-30% of all marine habitats under their jurisdiction by 2012. In the past, MPAs have been identified as especially useful for the protection of vulnerable species, including the humpback whale (Bourdouresque et al. 2005). Connectivity between protected areas has also been cited as essential for an effective network, especially for migratory species (Roberts 1997).

Suggestions for Future Directions for Research and Management

Managerial Reform

The findings of this thesis, specifically the chart comparing management units involved in humpback whale in the Northwest Atlantic, indicate that there is a need for enhanced managerial collaboration. One strategy to increase management collaboration could be a re-organization of managerial structures or the development of an inter-institutional commission whose main goal would be to manage humpback whales in the Northwest Atlantic by implementing the elements outlined as central to the marine EBM approach in this thesis. A cross-jurisdictional international organization would be able to coordinate management efforts across the entire range of the humpback whale and ensure that all stakeholders were participating in management.

This hypothetical commission could resemble the previously mentioned Joint Ocean Commission Initiative, which brought experts from across the U.S. together in a forum to discuss how to better implement solutions to pervasive marine issues. The only problem that remains with this commission is that it only considers experts in the U.S. The ideal commission concerning humpback whales in the Northwest Atlantic would include experts as well as stakeholders from not just the U.S. but all countries whose jurisdictions overlap the range of the humpback whale population. A commission of this kind would

potentially allow for large-scale collaborations in human impact mitigation projects, data collection, and population studies.

This type of commission has been attempted in the past on a global scale (i.e. the IWC) and a commission focused on implementing EBM for humpback whales would have many things to learn from the IWC's experience. Enforcement, for example, would be an area where the new commission would need to make improvements as this was consistently an area where the IWC received criticism (Watanabe 1980).

The creation of a cross-jurisdictional international management organization may seem to be a clear suggestion for improving EBM implementation, but this may not be the most feasible option. This strategy requires severe re-organization and would need a lot of funding, planning, coordination, and time to be successful. Considering the endangered status of the humpback whale, and many other whale species in the Northwest Atlantic Ocean, implementing EBM calls for a more realistic and timely strategy.

The Need for Increased MPA Coverage/Connectivity

A more feasible alternative to major managerial reform is the expansion of the existing MPA system. This thesis cited a dearth in both total area covered by MPAs that were established for the protection of cetaceans, as well as a lack of connectivity between

established MPAs across the range of the humpback whale. MPA expansion serves as a feasible goal that would bring managers closer to implementing marine EBM. A connected network of protected areas has already been initiated, and greater area coverage by MPAs will help to mitigate other management issues such as the impacts of human activity. Linking and expanding MPAs offers a chance for immediate change in the management system, and it will allow for nations to maintain their current level of individual control while also permitting international coordination in the physical and theoretical design of MPA networks.

The 2007 announcement that the Stellwagen Bank National Marine Sanctuary and the Santuaria de Mamiferos Marinos de la Republica Dominicana will collaborate in future management planning was both a sign that there is enthusiasm for this type of international relationship among managers and an indication that this type of modification to the current system is an emerging possibility. Additions to MPA networks would bring management efforts closer to realizing bioregional management by creating a network of protected areas that span the full range of the humpback whale in the Northwest Atlantic. Building off the existing coordination between protected areas would also necessitate continued communication between nations and international bodies and thus, may increase the attention

paid to humpback whales by creating acceptance and accountability of each nation to the greater MPA network goals.

Creating more MPAs would also give managers more physical space in which mitigation efforts could be concentrated. The currently disjointed relationship between the distribution of human-related humpback whale mortality and the locations of mitigation initiatives could be improved through the creation of additional networked MPAs. Establishing protected areas in the places where the most mortality occurs would create spaces where legislation could be formed to decrease the rate of mortality caused by human activities, such as boat collisions and entanglement mortality mentioned in this thesis.

Drafting a plan for a larger MPA network also has the advantage of being more expedient than forming a commission. A cross-jurisdictional management organization would take an extensive amount of forums, votes, drafts, and international negotiation. Alternatively, an MPA network would be able to reach its goal faster by working within current institutional structures.

Finally, the expansion of an MPA network would give each nation some responsibility for the protected area within their jurisdiction, but would also generate a forum for a collaborative design of the MPA network and coordination in the regulations across each MPA. Keeping the nations within the whales' biological range in charge of

protected areas that fall within their jurisdiction would make regulation and enforcement more manageable. Maintaining an international forum where each nation could actively discuss the enforcement and decision-making process would keep nations accountable for the functioning of their protected areas and uphold common initiatives and goals. For an MPA network such as this to be successful in the Northwest Atlantic Ocean, the nations bordering the range of the humpback whale need to come to an agreement about the endangered status of this species and what needs to happen to ensure its survival. If a connected MPA network was accomplished, humpback whale management would be one step closer to successful implementation of EBM theory.

However, the expansion of the MPA network must not occur in isolation. The realization of other marine EBM principles must follow to achieve the goal of full implementation. An ecologically connected MPA network could be a critical first step that would make it unavoidable for management institutions to communicate with each other and hopefully one day participate in even more collaboration toward implementing marine EBM.

Final Conclusions

I was initially moved by the discrepancy between the flurry of activity and the loss of interest surrounding humpback whales in

Stellwagen Bank National Marine Sanctuary based upon their physical presence or absence from the area as well as the comparison between the whales' interactions with humans in New England waters and the lack of human presence in the waters of the Turks and Caicos Islands.

This launched me onto a path to explore the extent to which EBM could be implemented, or was already being implemented, for humpback whales in the Northwest Atlantic Ocean and what steps could be taken to best implement the principles of marine EBM. From my research, I can conclude that this ecosystem is much more complex than management agencies have so far recognized. There is a tangled network of interactions and relationships that create the opportunity for confusion and inconsistency. However, I am optimistic that the principles that I have laid out for implementing marine EBM for humpback whales in the Northwest Atlantic could one day be integrated in to the many plans and initiatives. Many plans and initiatives have already been initiated and if they can be built upon, I feel that it is possible to expand not only the MPA network but to take the fervor over EBM and use it toward even more major advancements in marine management, bringing humpback whale management closer to reaching the goal of successful implementing marine EBM.

Appendix A: Figures

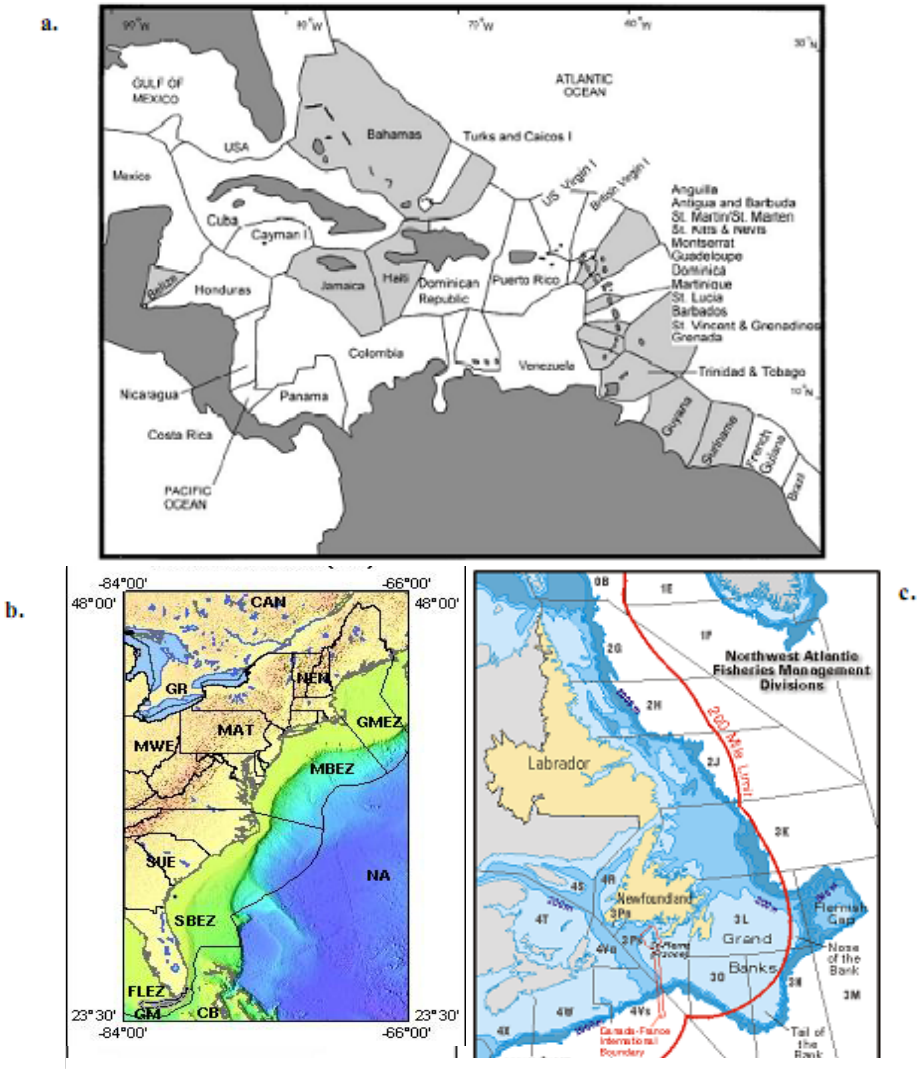


Figure 1. a) Map of the Exclusive Economic Zone (EEZ) of the Caribbean (Houghton 2004) b) Map of the EEZ of the United States in the Atlantic Ocean (USGS 2008) c) Map of the EEZ of Canada (DFO 2006)

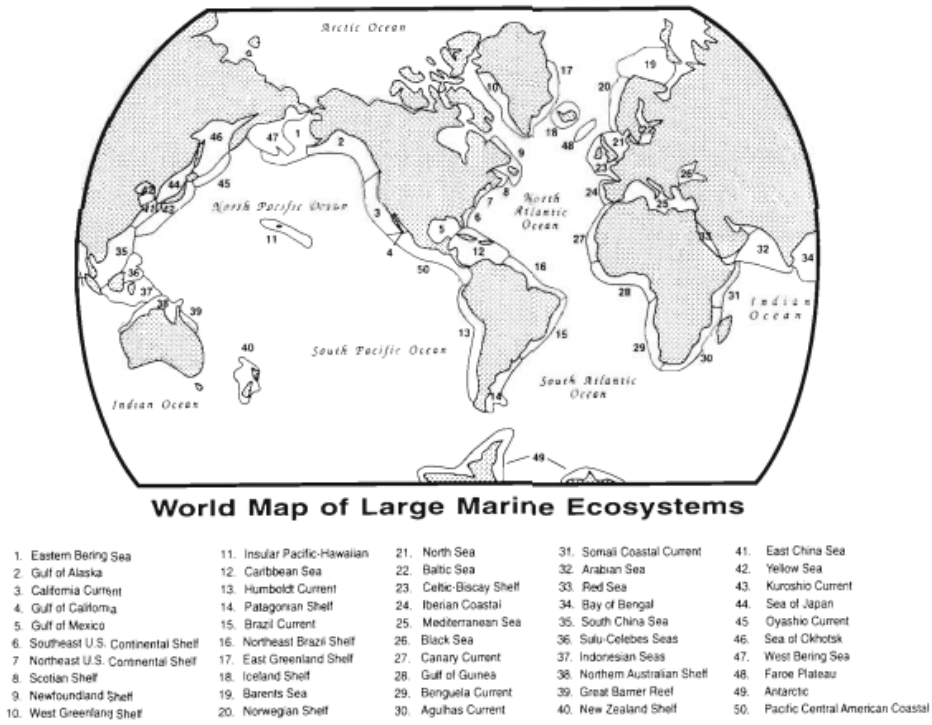


Figure 2. Map of Large Marine Ecosystems. (From Sherman etl al. 1986)

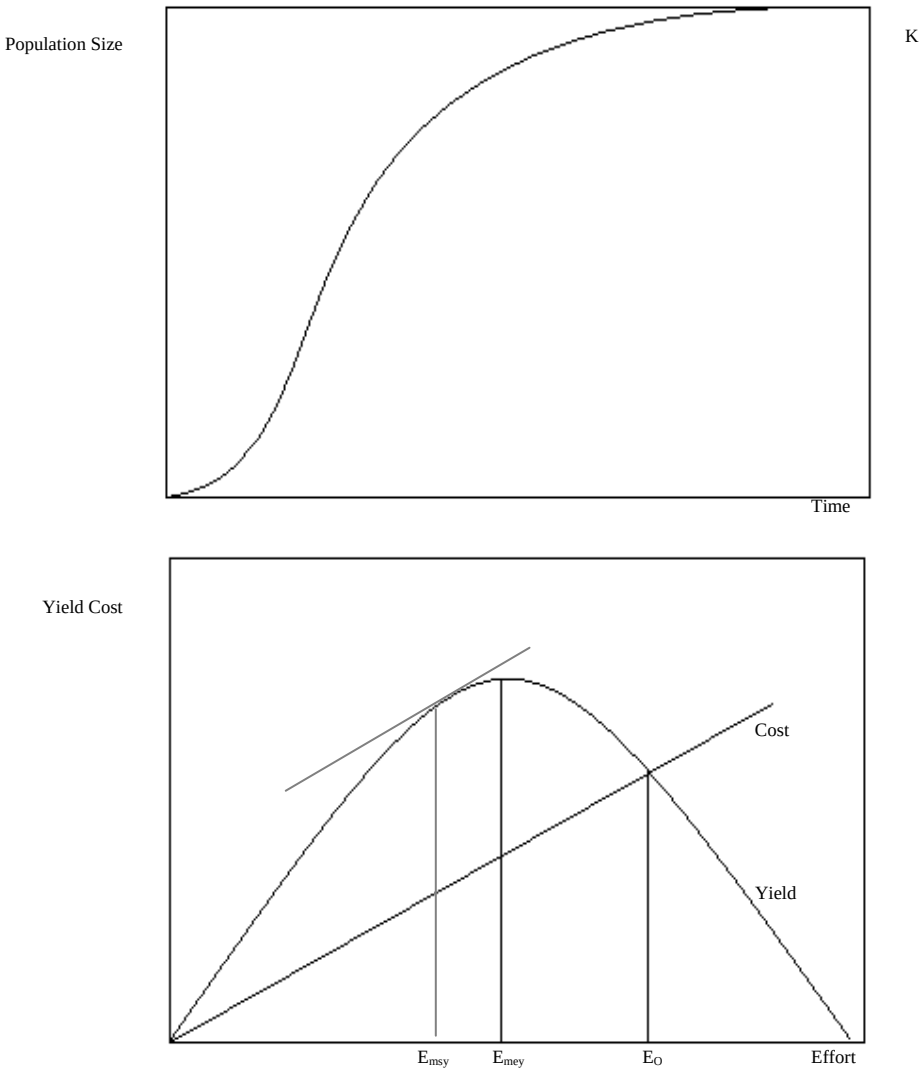


Figure 3. a) Gordon-Shafer model b) Logistic Growth model

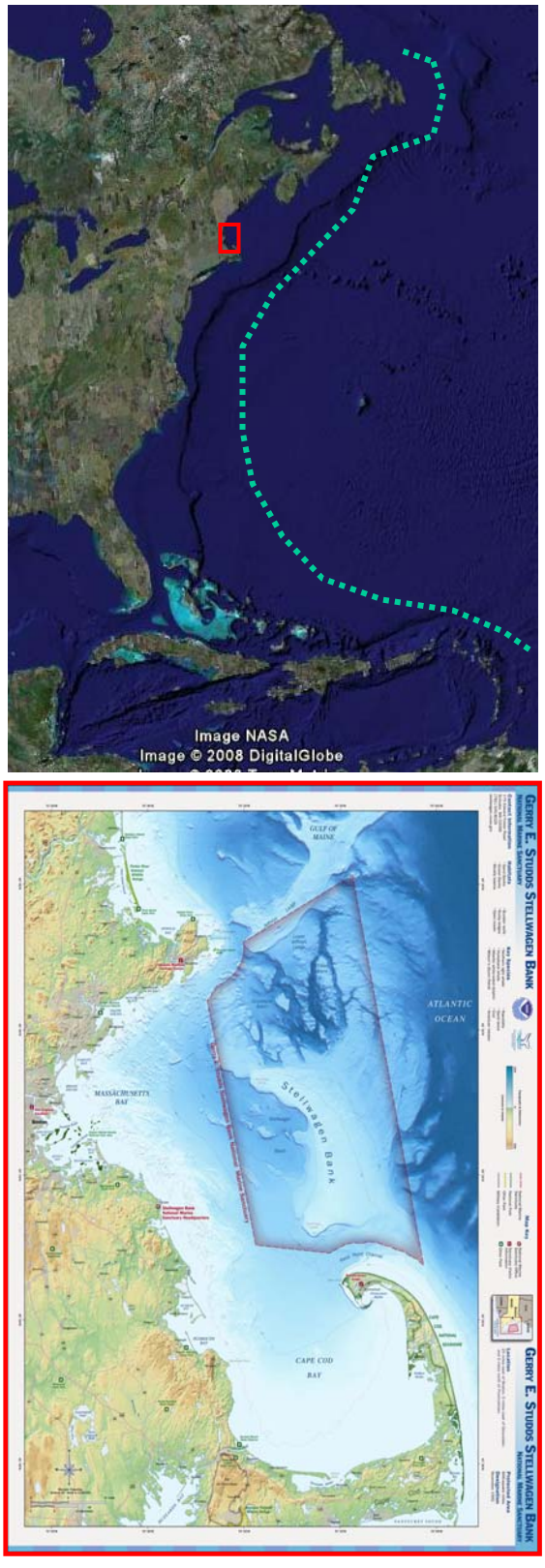


Figure 4. a) Map of the estimated range of humpback whales in the Northern West Atlantic ocean (GoogleEarth) b) A closer look at Stellwagen Bank, where a concentrated number of individuals feeding during summer months (NOAA 2008)

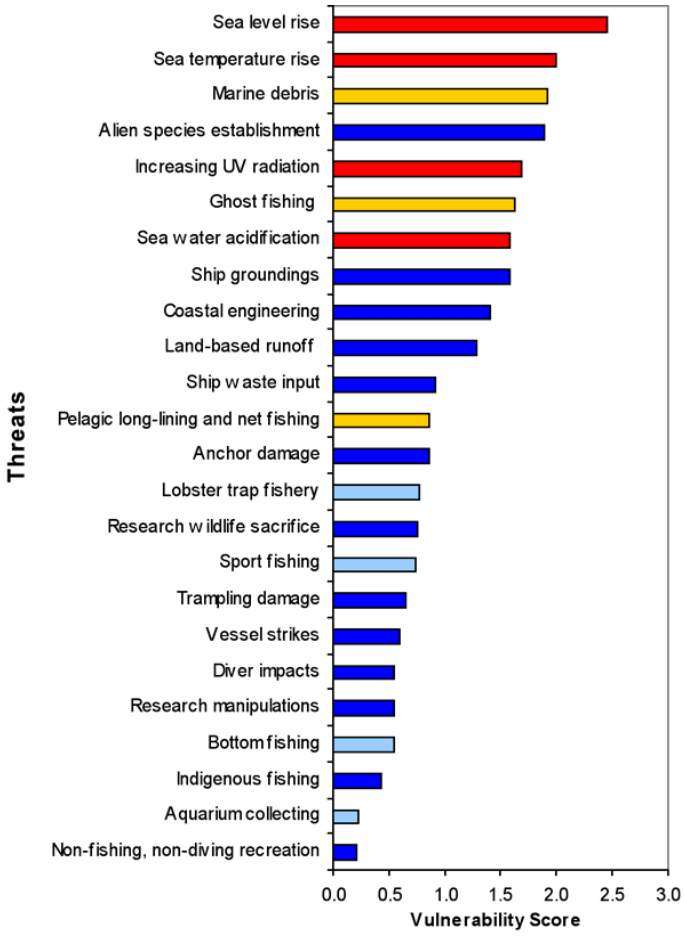


Figure 5. An assessment of human impacts on a coral system in the NWHI National Monument Park (From Toonen et al. 2007)

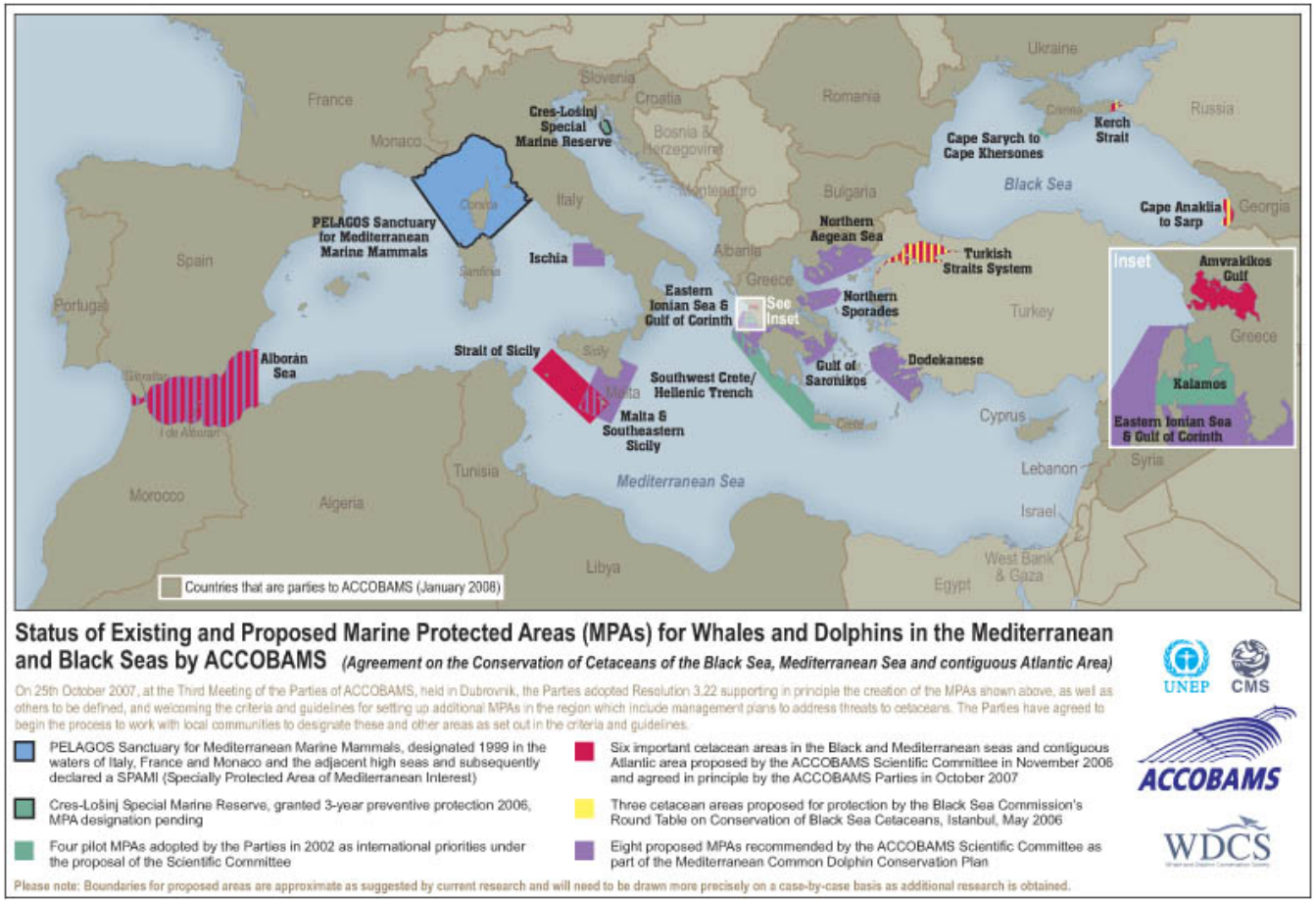


Figure 6. Current and proposed MPAs in the Pelagos Sanctuary for Marine Mammals (EarthOcean 2008)

Zone	Zone Colour	Previous Zoning Plans			
		FNS & Gumoo	Cairns	Central	Mac/Cap
General Use	Light blue	Permit	Permit	Permit	Permit
Habitat Protection	Dark blue	Permit	Permit	Permit	Permit
Conservation Park	Yellow	Permit	Permit	Permit	Permit
Buffer	Light green	Permit	Permit	*	*
Scientific Research	Orange	*	*	Not allowed	Not allowed
Marine National Park	Dark green	Permit	Permit	Not allowed	Not allowed
Preservation	Pink	Not allowed	Not allowed	Not allowed	Not allowed
Commonwealth Island	-	Permit	*	*	*

* = Not applicable in that specific Zoning Plan

Figure 7. Zoning plan for the Great Barrier Reef Marine Park *(From Dobbs 2007)*

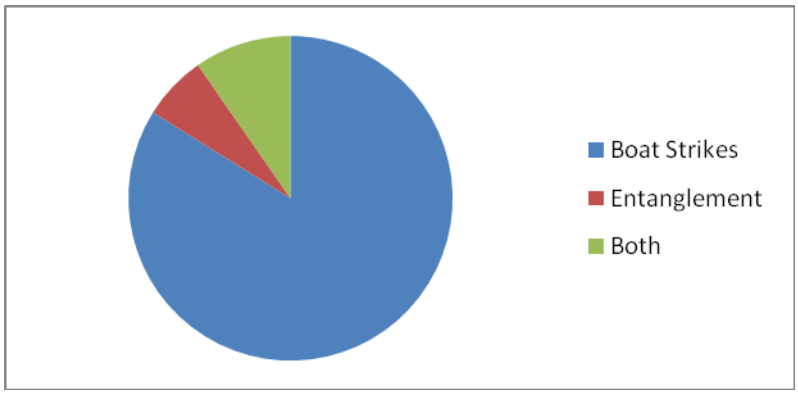


Figure 8. Pie chart of the causes of mortality of humpback whales in the Northwest Atlantic between 1989-2006 (mortality data from Northeast Region Stranding Network and NOAA Fisheries 2007).

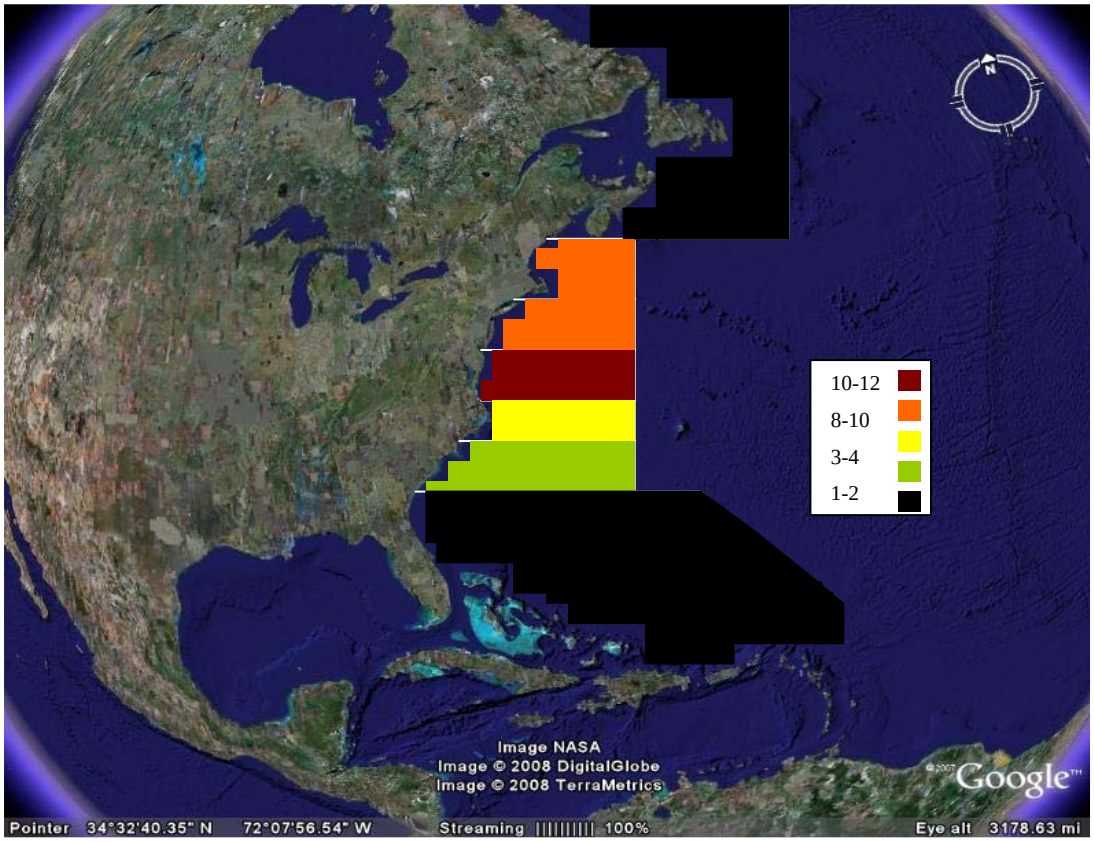


Figure 9. Zoning map of frequency of mortality reports caused by human interaction in humpback whales 1989-2006 (Map created using GoogleEarth 2008, GPS data from Northeast Region Stranding Network and NOAA Fisheries 2007)

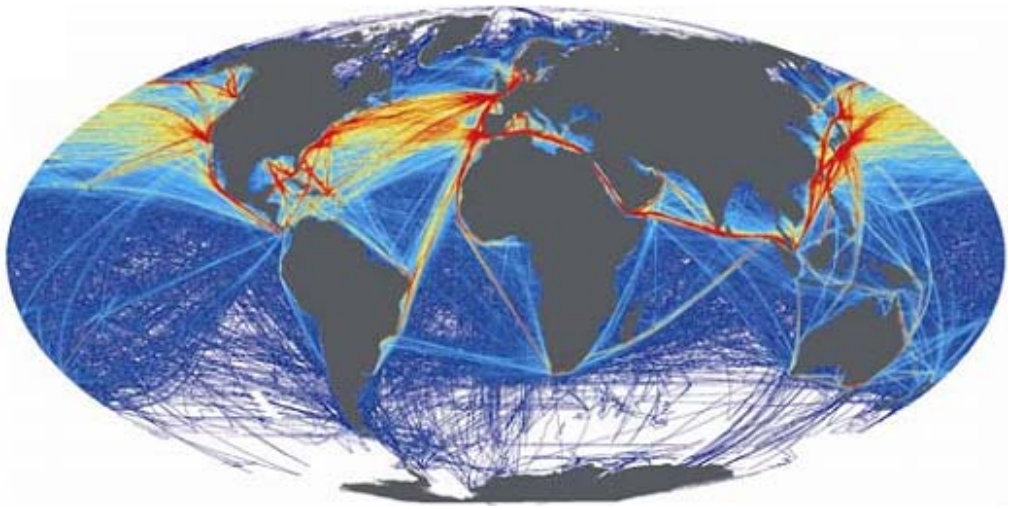


Figure 10. Comprehensive map of global shipping lanes and their usage (From Halpern et al. 2008)

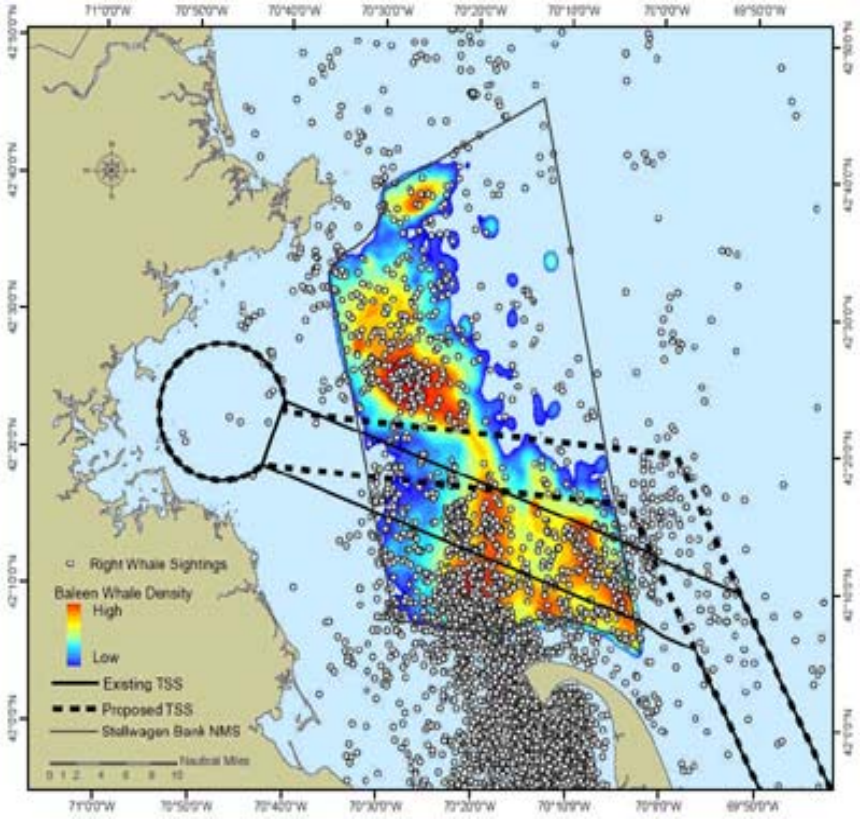
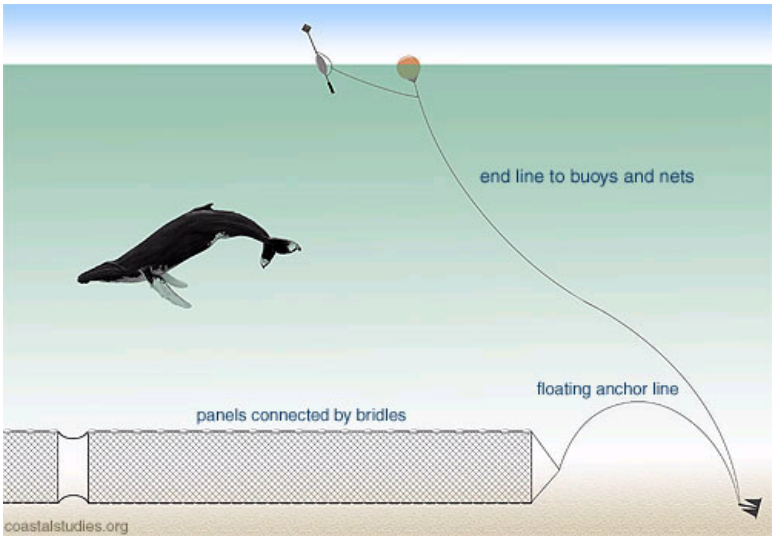


Figure 11. Map showing existing and altered TSS. This ship lane change moved thousands of ships out of area with high whale densities. (Van Parijs 2006)

a)



b)

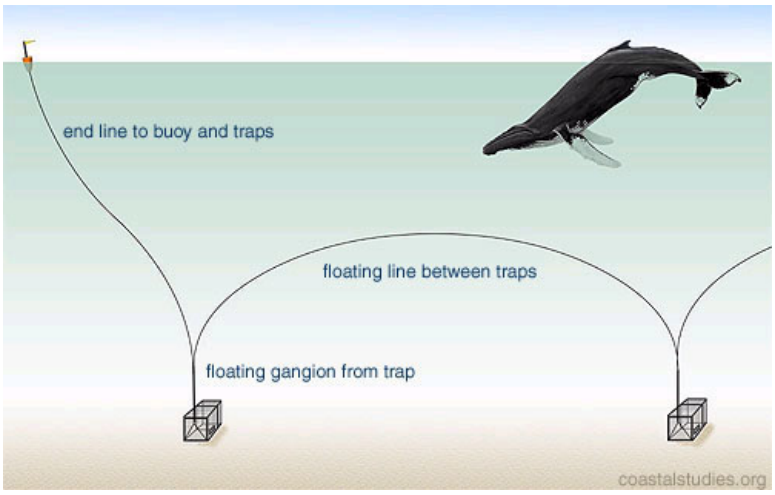


Figure 12. Diagram of a) typical gillnet and b) typical lobster pot that humpback whales become entangled in (PCCS 2008)

Figure 12. Photographs of whales on Stellwagen Bank during the summer of 2006 injured from boat collisions and entanglement in fishing line (Beaver 2006)

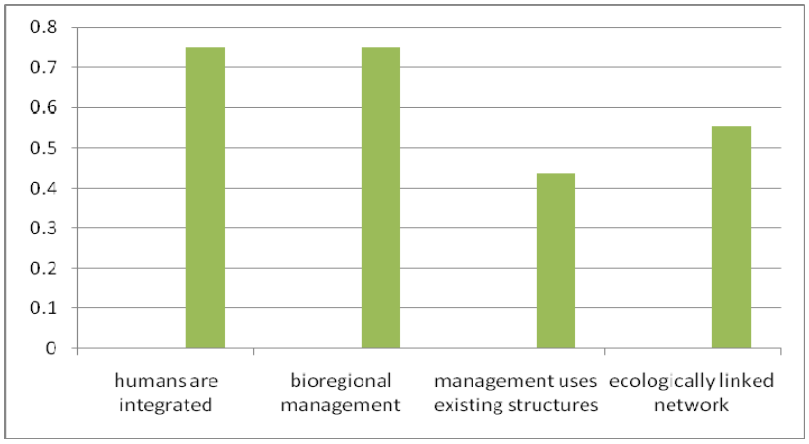


Figure 13. Frequency of the implementation of 4 marine EBM principles in managmenet institutions for humpback whales in the Northwest Atlantic

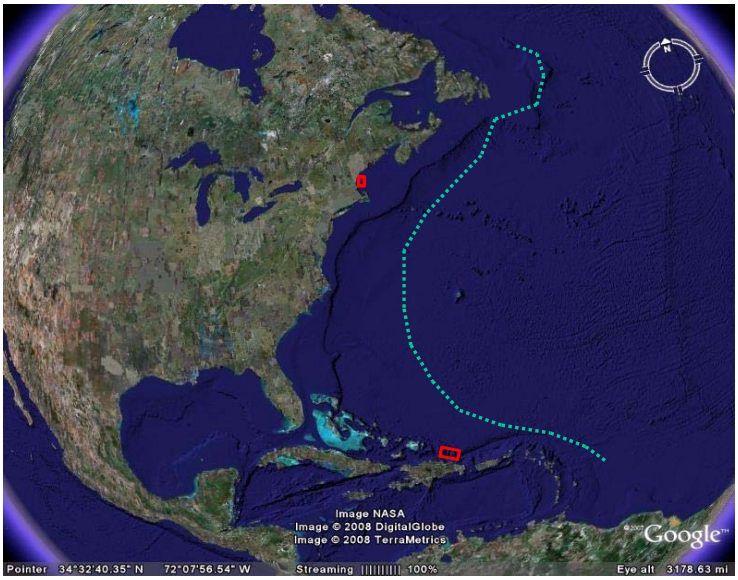


Figure 14. The existing marine protected areas for humpback whales in the Northwest Atlantic

Appendix B: Tables

Table 1. *Summary of whaling operations along the migratory path of whales on the East Coast of North America. Species names are abbreviated as follows: Bl-blue, Fi- fin, Hb- humpback, Se- sei, Gr- gray, R-right, Sp-sperm. (Adapted from Reeves and Smith 2006).*

Geographical area	Years of operation	Species targeted
Canada - Labrador	1650-1924	Bi, Fi, Sp, Hb, Se
Canada - Newfoundland	1775-1850	Hb, R
U.S. - East Coast	1898-1971	Hb, Gr, R
Burmuda	1607-1941	Sp, Hb
Barbados	1868-1913	Hb
Trinidad	1826-1865	Hb
West Indies	1876-ongoing	Sp, Hb

Table 2. Population of major metropolitan areas along the east coast of the United States in 2000 (U.S. Census Bureau 2000)

	Boston--Worcester--Lawrence, MA	Charleston—NC, Charleston, SC	New York City, Northern NJ, Long Island, NY--	Norfolk, VA, Virginia Beach, Newport News, NC	Portland, ME	Providence--Fall River Warwick, RI	Savannah, GA	Washington, DC, Baltimore, MD
Total	5,819,100	549,033	21,199,865	1,569,541	243,537	1,188,613	293,000	7,608,070

Table 3. Compilation of main principles of Ecosystem-Based Management presented in recent literature (Slocombe 1990, 1993; Grumbine 1994; Kaplan 2007; De la Mare 2005; Reeves 2004; Guénette, S. and J. Adler 2007; Frid et al. 2006)

	4 Principles applicable to the Implementation of marine EBM			
Authors	**Use of an Ecologically-linked network of Protected Areas**	**Bioregional management**	**Humans are integrated in the environment**	**Use of existing management structures**
Slocombe	Protected Areas	Bioregionalism	Stakeholder involvement	Cooperative Management
Grumbine		Ecological Boundaries, Ecological Integrity, Hierarchical Context	Humans embedded in nature, Local involvement, values	Interagency Cooperation
Kaplan			Understanding of industrial and socio-economic activities	Improve communication among management programs
De la Mare		Need for hierarchical control		
Reeves	Use of MPA networks, Ocean Zoning			
Guénette & Adler			Managing each activity in isolation not sufficient	
Frid et al.	Need for ecologically linked network of protected areas	Ecosystems, by nature, cut across traditional management sectors	Human activities compatible with ecosystem functioning	

Table 4. Marine Mammal Stranding Centers that are part of the National Marine Mammal Stranding Network (adapted from NOAA 2008)

State	**Name of Organization**
Florida	Marine Animal Rescue Society
Georgia	Coastal Resources Division of the Georgia Department of Natural Resources
South Carolina	South Carolina Marine Mammal Stranding Network
North Carolina	Marine Mammal Stranding Program
Virginia	Virginia Marine Science Program
Maryland	National Aquarium in Baltimore
Delaware	The Marine Education, Research & Rehabilitation Institute, Inc.
New Jersey	Marine Mammal Stranding Center
New York	The Riverhead Foundation for Marine Research and Preservation
Connecticut	Mystic Aquarium and Institute for Exploration
Rhode Island	
Massachusetts	Protected Resources Division - NMFS Northeast Region Protected Species Branch - NMFS Northeast Fisheries Science Center National Park Service - Cape Cod National Seashore New England Aquarium The National Marine Life Center, Inc. The Whale Center of New England

Table 6. Compilation of management systems involved in the management of humpback whales in the Northwest Atlantic Ocean regarding any initiatives align with the metrics of EBM or humpback whale conservation (sources used: NOAA Fisheries 2008, NOAA & U.S. Department of Commerce 2005, Environment Canada 2003, DECR 2007, Environment Canada 2008, Gulf of Maine Council on the Environment 2007, Fisheries and Oceans Canada 2005, The Canadian Gazette 2002, Parks Canada 2007, Department of Justice Canada 2002, ECCN 2007, Subsecretaría de Recursos Costeros y Marinos 2007, NMS 2008, IWC 2007, DRNA 2006, Lloyd 2006, UNEP 2006, Iachetti 2006, The Bahamas National Trust 2008, Norse 2005, Coast Information Team 2004, PCCS 2008c, WHOI 2008).

				Goals, mandates, programs related to EBM			
Organization Name	**Description**	**Jurisdictional Area**	**Goal of EBM implementation?**	**1. Humans integrated in the environment**	**2. Bioregional Management**	**3. Management Cooperation**	**4. Use of Protected Areas**
NOAA Fisheries - Office of Protected Resources (U.S.)	Federal agency under the U.S. Dept. of Commerce responsible for "the stewardship of American marine resources" and the enforcement of the Endangered Species Act and the Marine Mammal Protection Act	United States' EEZ (200 mi offshore), has been broken up into regional ecosystems	yes	Mission: considers multiple external influences, and strives to balance diverse social objectives.	Mission: specified geographically	Mission: management that is adaptive	n/a
Environment Canada	National dept., mandate -" to preserve and enhance the quality of the natural environment; conserve Canadas renewable resources, conserve and protect Canadas water resoures"; enforce rules relating to boundary waters; and coordinate environmental policies and programs for the federal government	Canada's EEZ (200 mi offshore)	no		Spirit Bear Rainforest project in British Colombia		Spirit Bear Rainforest project in British Colombia
Fisheries and Oceans Canada	A federal government department responsible for developing policies and programs in support of Canada's economic ecological, and scientific interests in oceans and inland waters	Nearly 12 million hectares of terrestrial area	yes	Adherence to the Oceans Act: promotes relations with stakeholders based on principles of ecosystem-based management	Adherence to the Accord for the Protection of Species at Risk: species do not recognize jurisdictional boundaries	Adherence to the Oceans Act: focus on building and nurturing working relationships across 20 federal organizations;	n/a

				Goals, mandates, programs related to EBM			
Organization Name	**Description**	**Jurisdictional Area**	**Goal of EBM implementation?**	**1. Humans integrated in the environment**	**2. Bioregional Management**	**3. Management Cooperation**	**4. Use of Protected Areas**
Parks Canada	Responsible for National Parks, National Historic Sites, and the National Marine Conservation Areas Program	Currently have two operating sites: Fathom Five National Marine Park in Ontario and Saguenay-St. Lawrence Marine Park in Quebec	yes	Adherence to the Canada National Marine Conservation Areas Act (2002): inclusion of cultural sites and areas of economic importance; combination of conservation practices with human activities VS preservation of the ecosystem in a state unaltered by humans	Adherence to the Canada National Marine Conservation Areas Act (2002): regional divisions based on physical and biological characteristics		Adherence to the Canada National Marine Conservation Areas Act (2002): including zoning of marine protected areas
Eastern Caribbean Cetacean Network (Caribbean)	A regional, volunteer network that records sightings and strandings of marine mammals in the Eastern Caribbean; participants include indivudals from NOAA, Woods Hole Oceanagraphic Institute, the caribbean whale-watching industry and other independent researchers; offcial affiliations are with the United Nations Environmental Programme and the Smithsonian Institute	Eastern Caribbean, currently are represented in: Antigua and Barbuda, Barbados, Dominica, Grenada, Guadaloupe, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, and Trinadad and Tobago	no	Emphasis on community involvement and increasing local knowledge	regional approach to scientific monitoring		n/a

				Goals, mandates, programs related to EBM			
Organization Name	**Description**	**Jurisdictional Area**	**Goal of EBM implementation?**	**1. Humans integrated in the environment**	**2. Bioregional Management**	**3. Management Cooperation**	**4. Use of Protected Areas**
Departmento de Medio Ambiente y Recursos Naturales - Subsecretaría de Recursos Costeros y Marinos (Dom. Repub.)	Regulating the management, conservation, and sustainable use of marine and coastal and inland resources	The EEZ of the Dominican Republic and inland waters	no	Incorporates four fundamental elements of sustainability - poverty, population, technology, and quality of life with the goal of conservation	Joining with NOAA's Stellwagen Bank National Marine Sanctuary to create biological connectvity in the protected area network for humpback whales		
NOAA's National Marine Sanctuary Network (U.S.)	14 marine protected areas, managed by the Office of National Marine Sanctuaries, part of NOAA	Over 150,000 mi2 of coastline including the Great Lakes and American Samoa	yes	Promotes conservation and compatible commercial and recreational activities; focus on raising public awareness and education	Stellwagen Bank NMS connectivity with Silver Bank Sanctuary	Cooperation between the public and federal, state, and local officials; point out the issue of overlapping regulations and authorities	"No other federal agency is directly mandated to comprehensively conserve and manage special areas of the marine environment"

				Goals, mandates, programs related to EBM			
Organization Name	**Description**	**Jurisdictional Area**	**Goal of EBM implementation?**	**1. Humans integrated in the environment**	**2. Bioregional Management**	**3. Management Cooperation**	**4. Use of Protected Areas**
UNEP (United Nations Environmental Program)	Part of the United Nations; mission: "To provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations."	Global	no		"Ecosystem-based Management: Markers for Assessing Progress" as part of this program, emphasizes using EBM to link land and marine issues.		
IUCN - Global Marine Programme	IUCN: world's first global environmental organization, mission: "to influence, encourage, and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitiable and ecologically sustainable"	Global	no	Within goals of "Coastal Information Team" in BC, Canada	Cited in the goals of: "Legal framework for areas beyond national jurisdiction"; "Large Marine Ecosystem (LME) governance"; "Marine spatial planning"		

				Goals, mandates, programs related to EBM			
Organization Name	**Description**	**Jurisdictional Area**	**Goal of EBM implementation?**	**1. Humans integrated in the environment**	**2. Bioregional Management**	**3. Management Cooperation**	**4. Use of Protected Areas**
Department of Environment and Coastal Resources (T.C.I.)	The government agency of the Turks and Caicos Islands charged with the conservation, protection, and management of natural resources	The EEZ of the Turks and Caicos Islands	no	Planning, public awareness, policy and legislation development, enforcement; combines the promotion of biodiversity and economic prosperity			utlizes a zoned network of marine protected areas ranging from national parks that aim to protect ecosystem integrity
The International Whaling Commission (IWC)	An international agency whose purpose is to provide for the proper conservation of whale stocks and thus make possible the orderly development of the whaling industry	Global, membership to the IWC is open to any country	no	Increased research that considers whales as an integral part of their environment (Southern Ocean Whale and Ecosystem Research Programme); Resolution 1979:2+5 - in 2003, drafted resolutions for ecosystem approaches	Creation of the Indian Ocean and Southern Ocean Sanctuaries	Has BLANK members from all over the world	Creation of the Indian Ocean and Southern Ocean Sanctuaries
Departamento de Recursos Naturales y Ambientales (Puerto Rico)	The national agency of Puerto Rico whose mandate is to protect, conserve and administer the natural and environmental resources of the country	Terrestrial and marine areas of Puerto Rico	no	Stated vision of the transformation of the environmental culture of Puerto Ricans towards one of conservation		Vision: participation of all the sectors of society to improve their quality of life	

				Goals, mandates, programs related to EBM			
Organization Name	**Description**	**Jurisdictional Area**	**Goal of EBM implementation?**	**1. Humans integrated in the environment**	**2. Bioregional Management**	**3. Management Cooperation**	**4. Use of Protected Areas**
Woods Hole Oceanographic Institute (WHOI)	The Woods Hole Oceanographic Institution is dedicated to research and education to advance understanding of the ocean and its interaction with the Earth system, and to communicating this understanding for the benefit of society.	Programs globally, focus in the Northwest Atlantic	no	Produced research central to the movement of the Boston shipping lanes		Collborates with other governmental and non-governmental institutions for specific projects	n/a
Provincetown Center for Coastal Studies (PCCS)	Non-governmental scientific organization with an emphasis on marine mammals in the Gulf of Maine	Gulf of Maine	yes	Coastal Solutions Initiative, examines issues and conflicts affecting the coastal and marine environment and seeks creative solutions based on the principles of conservation biology, sustainability, and ecosystem based management, whale disentanglement program	YONAH project - an international collaboration to study North Atlantic humpback whales across most of their known range	Collaborations with other governmental institutions and scientific organizations; Coastal Solutions Initiative, conducts public forums involving scientists, lawmakers, governmental and non-governmental agencies, and resource users	n/a

				Goals, mandates, programs related to EBM			
Organization Name	**Description**	**Jurisdictional Area**	**Goal of EBM implementation?**	**1. Humans integrated in the environment**	**2. Bioregional Managment**	**3. Managerial Cooperation**	**4. Use of Protected Areas**
Bahamas National Trust	A non-governmental, self-funded, non-profit organization, mandated with the development and management of the National Park System of The Bahamas.	Terrestrial and marine areas of the Bahamas	no	Mentioned in specific projects: the Bahamas Biocomplexity Project - an interdisciplinary approach to EBM that is mainly being implemented to aid in coral reef conservation			
Marine Mammal Health and Stranding Response Program (U.S.)	Part of NOAA's National Marine Fisheries Service, designated to coordinate stranding networks, responses/investigations of mortality events, biomonitoring, tissue/serum banking, analytical quality assurance	On the east coast, stranding centers occur in every state from Florida to Maine and include the Virgin Islands and Puerto Rico	no		A regional approach to scientific monitoring, the collaboration of several states/countries to create a more complete picture of marine mammal mortality in the U.S.		n/a

Table 6. Review of management institutions with goals, mandates and programs related to implementing EBM for humpback whales in the Northwest Atlantic (Sources used: NOAA Fisheries 2008, Fisheries and Oceans Canada 2005, DECR 2007, Environment Canada 2008, Parks Canada 2007, ECCN 2007, Subsecretaría de Recursos Costeros y Marinos 2007, IWC 2007, DRNA 2006, UNEP 2006).

Organization Name	Goals, mandates, programs related to Implementing EBM for Humpback Whales in the Northwest Atlantic
NOAA Fisheries - Office of Protected Resources (U.S.)	1. To stop the decline of protected species populations to reduce the risk of extinction. 2. Stablize populations, make them functional members of marine and coastal ecosystems
Environment Canada	The North Atlantic population has been deemed "not at risk" as of May 2003 because: "Neither the population, nor its breeding populations, has regrown to at least a substantial proportion of its pre-whaling size and is not at risk from current activity levels or levels that may reasonably be forseen in the next few years". Have created recovery plans for North Atlantic right whales and fin whales.
Fisheries and Oceans Canada	Several whale species appear on the Species At Risk including the Fin Whale, North Atlantic Right Whale. Humpback whale does not appear but entanglements in fishing gear, oil spills, and over exploitation of capelin stocks are cited as threats to the humpback whale population.
Parks Canada	See above, no protected area specifically including humpback whales as a target species
Eastern Caribbean Cetacean Network (Caribbean)	Collect data on strandings and sightings of humpback whales; this includes assessing residency of individual whales and monitoring their occurrence and distribution
Marine Mammal Health and Stranding Response Program (U.S.)	Data collected on all large whales found in this ecosystem, can diversify the number of known causes of mortality for the population
Departmento de Medio Ambiente y Recursos Naturales - Subsecretaría de Recursos Costeros y Marinos (Dom. Repub.)	The creation of "El Santuario de Mamiferos Marinos de la Republica Dominicana" ("The Marine Mammal Sanctuary of the Dominican Republic")
NOAA's National Marine Sanctuary Network (U.S.)	Stellwagen Bank NMS and connectivity to sister sanctuary in the Dominican Republic, Hawaiian Islands Humpback Whales NMS on the Pacific Coast
Department of Environment and Coastal Resources (T.C.I.)	The development of policy guidelines for the protection of humpback whales and other cetaeans: includes rules of conduct for whale watching, prohibits marine construction during migrating seasons, cruise ship and large tanker navigation around whale areas
The International Whaling Commission (IWC)	No protected areas cover the Northwest Atlantic Area, no whales have been hunted in the area since the moratorium since 1985
Departamento de Recursos Naturales y Ambientales (Puerto Rico)	none
Bahamas National Trust	none
UNEP (United Nations Environmental Program)	SPAW (Specially Protected Areas and Wildlife) Protocol , participating in the sister-sanctuary relationship between Stellwagen and the Dominican Republic sanctuaries.
IUCN - Global Marine Programme	Have a Cetacean Specialist Group (CSG) that focuses only on cetaceans. However, mainly focus on species that receive little attention; humpbacks are not included in this category.
Provincetown Center for Coastal Studies (PCCS)	Humpback whale disentanglement team, YONAH project
Woods Hole Oceanographic Institute (WHOI)	Mainly focused on the North Atlantic Right whale

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