A Policy Analysis of Open Ocean Aquaculture in the Hawaiian Islands Humpback Whale National Marine Sanctuary

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A POLICY ANALYSIS OF OPEN OCEAN AQUACULTURE IN THE HAWAIIAN ISLANDS HUMPBACK WHALE NATIONAL MARINE SANCTUARY

By

Collin Crecco

A THESIS

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the requirements for the degree of
Master of Science

A POLICY ANALYSIS OF OPEN OCEAN AQUACULTURE IN THE HAWAIIAN
ISLANDS HUMPBACK WHALE NATIONAL MARINE SANCTUARY

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An exponentially growing world population has put human innovation and ingenuity to the test. Over the past few decades, our ability to develop technology for the purpose of adjusting to an increasing demand for natural resources has shown our capacity for growth and adaptation. However, how much growth can be sustained to solve problems related to food security? Aquaculture has become a viable option to combat food scarcity issues. Aquaculture that takes place offshore is a relatively new field of study that warrants further investigation. As research continues to evaluate environmental effects from offshore aquaculture, it must be tied with social considerations that come with food production and security. It is also important to note that aquaculture developments should be scrutinized on a case-by-case basis because projects vary considerably in terms of inputs, business plans, management, and can range from intensive to extensive systems. This study addresses some of the major legal frameworks offshore aquaculture practitioners must comply with if such developments were to occur within marine protected waters, specifically those of the Hawaiian Islands Humpback Whale National Marine Sanctuary. The main goal of the sanctuary is to promote the conservation of the humpback whales. Uncertainty regarding effects on certain marine mammals has yet to be fully investigated. Thus, further studies are needed.
to assess the compatibility of offshore aquaculture with biological conservation. This policy analysis is also accompanied with a spatial analysis to better understand relevant statutes and agency jurisdictions.
Acknowledgments

I would like to thank Dr. Joseph Mobley of the University of Hawaii at Manoa, for his contribution to the humpback whale sighting data. Also, I want to thank Dr. Malia Chow and Joseph Paulin of the Hawaiian Islands Humpback Whale National Marine Sanctuary for their guidance during my Ernest F. Hollings Undergraduate Scholarship and internship at the sanctuary. Lastly, I would like to thank Dr. Daniel Suman, Dr. Daniel DiResta, and Maria Estevanez of RSMAS for their support and assistance during the project.
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<td>Aquaculture and Livestock Support Services</td>
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<td>CAAP</td>
<td>Concentrated Aquatic Animal Production</td>
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<td>CWA</td>
<td>Clean Water Act</td>
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<tr>
<td>CZMA</td>
<td>Coastal Zone Management Act</td>
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<td>DLNR</td>
<td>Department of Land and Natural Resources</td>
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<td>DOC</td>
<td>Department of Commerce</td>
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<td>EA</td>
<td>Environmental Assessment</td>
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<td>EIS</td>
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<td>Habitat Conservation Plan</td>
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<td>HEPA</td>
<td>Hawaii Environmental Policy Act</td>
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<td>HIHWNMS</td>
<td>Hawaiian Islands Humpback Whale National Marine Sanctuary</td>
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<td>HOARP</td>
<td>Hawaii Offshore Aquaculture Research Project</td>
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<td>HRS</td>
<td>Hawaii Revised Statutes</td>
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<td>MHI</td>
<td>Main Hawaiian Islands</td>
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<td>MMA</td>
<td>Marine Managed Area</td>
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<td>National Environmental Policy Act</td>
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<td>NMSA</td>
<td>National Marine Sanctuaries Act</td>
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<td>NMSP</td>
<td>National Marine Sanctuary Program</td>
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<td>NOAA</td>
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<td>NPDES</td>
<td>National Pollutant Discharge Elimination System</td>
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<td>SMA</td>
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Chapter 1. Introduction

1.1 Humpback whale protection in the sanctuary and the role of aquaculture

1.1.1 Offshore aquaculture as a consideration by the Hawaiian Islands

Humpback Whale National Marine Sanctuary

Hawaii is considered one of the top seafood-consuming states in the country (Billig 1999). Fish is an essential part of Hawaiian culture and diet. People have turned to fish as a valuable source of protein not only in Hawaii but around the world as well. We have seen reductions of numerous wild fish stocks all over the globe. As a consequence, many have considered the possible benefits of open ocean aquaculture (OOA), also known as offshore aquaculture to provide a supply of fish that can keep up with the increasing demand. In this study, OOA is differentiated from fish pond development and nearshore aquaculture. OOA is defined loosely by the Congressional Research Service as the following: “the rearing of marine organisms in exposed areas beyond significant coastal influence (Upton and Buck 2010).” OOA varies from nearshore or onshore aquaculture due to its lesser control over organisms and the external environment, which are often enclosed within ponds. For that reason many start-up OOA projects begin in Hawaii’s waters due to its favorable climate, landscape, and proximity to avid fish-consumers.

In recent years there has been a general consensus among aquaculture scientists, federal and state resource managers, and aquaculture practitioners to provide an open forum for individuals involved with aquaculture. Federally sponsored workshops have been held to gather information from various actors. Workshops and information sessions
are meant to stimulate discussion relevant to aquaculture in Hawaii and share how participants envision aquaculture in the future. During a public comment period hosted by the Hawaiian Islands Humpback Whale National Marine Sanctuary (HIHWNMS), a number of comments revealed concern regarding aquaculture and the sanctuary. This study examines the general relationship between OOA activities and the HIHWNMS. Analyzing spatial and policy based factors was essential to examine this relationship.

1.1.2 Importance of the aquaculture industry on a global scale

In a 1995 edition of *The Ecologist*, author and professor at the University of Hawaii at Manoa, George Kent, declared fish to be food of the poor, but also claimed fish to be food of the rich as well (Kent 1995). In more ways than one, fisheries are of much importance to individuals of any economic class. Hawaiians are a fish-eating people, but unfortunately, an increasing population and demand for fish has contributed to the problem of food insecurity (SGCP 1923). This notion could not be more evident by the fact that Hawaii imports roughly 75% of its seafood (Billig 1999). Likewise, Hawaii is not the only place where access to domestically produced food is an issue. One billion people around the world live in extreme poverty, according to the Food and Agriculture Organization (FAO). That same one billion people live in chronic hunger, meaning they are unable to gain access to food and other necessities to preserve life. Deprived of essential nutrients and vitamins, many individuals acquire severe illnesses and simply lack the energy to carry out everyday tasks. To counteract the effects of a perpetually growing human population, scientists seek innovative ways to produce more food output; one of these ways is through aquaculture.
Various forms of aquaculture are prevalent all across the globe. Aquaculture alone accounts for nearly half the world’s fish consumed by humans (FAO 2011). Further, numerous studies from scientists, dieticians, and members of related fields have affirmed that fish are excellent sources of omega-3 polyunsaturated fatty acids and other nutrients conducive to a healthy functioning heart. So, why is there a need for aquaculture? Unfortunately, evidence has shown time and time again that a significant number of fisheries have been overfished; certain species have trouble keeping their rate of reproduction up with the rate at which they are extracted from the ocean. Prominent ichthyologists such as Daniel Pauly have indicated total fish catches have been on the decline since the tail end of the 20th century (Zeller and Pauly 2005.) In a separate and more recent study conducted by the FAO, diagrams demonstrate a stagnant production in capture fisheries. Figure 1 shows fish production in millions of tons from marine capture, marine aquaculture, inland aquaculture, and inland capture. Although the largest amount of fish comes from marine capture, the figure reveals capture fisheries are plateauing and actually slightly declining. Reported fish landings from capture fisheries peaked in 1996. Moreover, the FAO has stated total capture production has stayed consistently steady with the low 2001 levels, but aquaculture production has grown significantly since 2003 (FAO 2011).
1.1.3 Release of NOAA’s national aquaculture policy

On June 9, 2011, the National Oceanic and Atmospheric Administration (NOAA) released a marine aquaculture policy to address the future of aquaculture within the United States (NOAA 2011). Therefore, how aquaculture could impact the HIHWMS is a current and relevant topic as it relates to recent national policy decision-making. To date, aquaculture in the US is relatively limited in terms of production and number of operations. Coastal nations in Latin America and in the South Pacific see a greater number of aquaculture ventures due to more lax environmental restrictions compared to the US (Naylor et al., 1998). It is cheaper for many seafood distributors in the US to import fish from fish farming facilities abroad. Consequently, many potential US aquaculturists believe stricter rules regarding aquaculture will force their prices above those of international competitors. On the other hand, many foreign countries that produce large quantities of fish products commonly lack adequate environmental regulations to prevent degradation to nearby ecosystems; there needs to be a balance

Figure 1. Global Capture Fisheries and Aquaculture Production (FAO 2011)
between minimizing environmental impacts and providing safe fish products at an affordable price.

Even though the US is one of the largest seafood consuming nations, it still lags behind in aquaculture production. According to the FAO, global aquaculture reached 63.6 million tons in 2011, the US contributing close to 500,000 tons (FAO 2012). Although NOAA’s role mostly remains in federal waters (water exceeding 3 nautical miles), the national policy on aquaculture will guide coastal states to incorporate similar values in their own plans. The implementation of aquaculture policies is important, as aquaculture is an integral component of our country’s infrastructure as well as a major factor contributing to the development of coastal zones. The Department of Commerce (DOC) and NOAA strongly advocate sustainable aquaculture practices to spur domestic growth and production. Policies released by the DOC are more general than those released by NOAA. Regardless of scope, the policies from each agency represent input from over 500 stakeholders who voiced their opinions during a public comment period. An increasing aquaculture industry will essentially prevent the US to continue its heavy reliance on imports and form new jobs to establish domestic aquaculture as a major contributor of food within the country. In order to do so, however, there must be strong underlying regulations set forth to ensure environmental degradation does not occur. Thus, best available science and management practices are both needed for aquaculture to be compatible with the many other uses of our country’s oceans.

Led by the policy objectives expressed in the National Aquaculture Act of 1980, NOAA Aquaculture Program was established to accommodate for the increasing demand for aquatic food, reduce the seafood trade deficit, enhance dwindling fish stocks,
coordinate domestic aquaculture practices, and to carry out other national objectives (NOAA 2011). The Alternative Feeds Initiative launched in 2007 aims to develop new kinds of feed for hatchery-reared fish to replace fish meal and fish oil. Aquaculture is also being used as a tool for stock enhancement of species of fish that are either threatened or endangered or part of critical commercial and recreational fisheries. Also known as restoration aquaculture, the process entails replicating spawning processes of wild-caught species in a hatchery, providing ample time for offspring to develop to juvenile-size, and releasing the offspring into their natural habitats.

Furthermore, NOAA’s new Aquaculture Policy calls for continued sustainable aquaculture that ultimately creates US jobs, guarantees safe seafood, and maintains resilient ecosystems and coastal communities. As a result of enhanced aquaculture operations, aquaculture is considered one of the fastest growing industries in the food sector. Production growth through aquaculture has surpassed that of caught fisheries in the United States. Common US marine species used for stock enhancement include candidates such as red snapper, queen conch, blue crab, cobia, and others.

### 1.1.4 Nutritional benefits of fish

The aquaculture industry has evolved as a major contributor to fisheries around the globe. Leading into the 21st century, there has been a need for aquaculture. Unfortunately, evidence has shown time and time again that a significant number of fisheries have been overfished; certain species have trouble keeping their rate of reproduction up with the rate at which they are extracted from the ocean (Zeller and Pauly 2005). From extensive research and analysis, the findings of top ichthyologists demonstrate declining discard and landing trends overtime. Thus, aquaculture’s rising
importance and growing demand is due to humans’ insatiable appetite for seafood. Fish serve as a lean source of protein, Omega-3 fatty acids, and Vitamin D. The American Heart Association recommends people incorporate two servings of 3.5 ounces of cooked fish a week into their weekly diets (Hellwig 2010).

1.1.5 Hawaii’s past and present OOA operations

Aquaculture is not a new industry to the people of Hawaii (Costa-Pierce 1987). Primitive fish farming practices in Hawaii have prevailed as a major use of the ocean and land over centuries. Historians have stated aquaculture practices were introduced to O‘ahu prior to the 13th Century. The use of ancient Hawaiian fishponds was an integral component of the socio-cultural system at the time. In fact, many scholars believe Hawaii to be the birthplace of mariculture. Mariculture epitomized the sophistication and effective collaboration of the Hawaiian people. Encompassing not only the oceanic environment, native Hawaiians’ form of mariculture embraced agricultural watersheds and estuarine environments as well.

Fish consumption has always been inherent in Hawaiian culture; Hawaiians are a fish-eating people, but an increasing population and added pressure on wild capture fisheries have contributed to a food security issue (SGCP 1923). Hawaii’s vast seafood trade deficit is exemplified by the fact that as much as 75% of all seafood consumed on the Main Hawaiian Islands (MHI) is imported (Billig 1999). Increased aquaculture productivity is needed to meet the demand of the local market in Hawaii (Kama et al. 2003). Hawaii consumers have consumption rates twice the national average. As a result, there has been much interest in local production and distribution of fish in Hawaii.
Offshore aquaculture is a relatively new industry compared to most types of aquaculture (Kama et al. 2003). The open ocean environment is preferred to land-based aquaculture activities due to the many land constraints. Nonetheless, pioneers of OOA initiated development in the waters off of the coasts of Hawaii. The Hawaii Offshore Aquaculture Research Project (HOARP) was launched in response to increased consumption and demand for fish (Billig 1999). The Sea Grant College Program of the University of Hawaii partnered up with the Oceanic Institute to expand aquaculture-related research. Marine finfish technologies had not been explored much up to this point in time; the research and technology used was groundbreaking. The HOARP used a 50 by 80 foot biconical sea cage, called the SeaStation 3000. A diagram of the sea-cage is shown in Figure 2.

The first offshore mariculture operation within Hawaii involved 70,000 Pacific threadfin fingerlings, aka moi, stocked in the sea cage (Davidson 2006). Pacific threadfin is an attractive food and popular among sport fishing (Kama et al. 2003). Once a thriving fishery, previous fishing efforts eventually overfished the stock. As a result, local markets ultimately witnessed a decrease in supply. After amendments to the Submerged Lands Leasing Act, HOARP was transferred to Cates International (Davidson 2006). Thus,
Cates International is considered the first private OOA entity to be placed in the US. The company was granted permits in 1999 to establish operations in state waters. The necessary permits allowed for the installation of the company’s first sea cage. Soon after, Kona Blue Water Farms became the second OOA operation. Founded in 2001, Kona Blue Water Farms located its establishment off the coast of Kona, Big Island, where Kona Kampachi® was farmed. As a result of the state’s OOA initiatives, aquaculture development programs of Hawaii are generally carried out with greater scrutiny and expertise. Thus, Hawaii acts as one of the leading role models for OOA operations.

Two offshore aquaculture operations exist in Hawaii’s non-sanctuary waters today. Located off of the coast of O‘ahu, Hukilau Foods, is locally owned and farms moi (Polydactylus approximans). The second OOA development is Keahole Point Fish LLC, previously Kona Blue Water Farm which farms Kona Kampachi® (Seriola rivoliana). In addition, Hawaii Oceanic Technology is a private company, but it is still going through the necessary process to place aquaculture structures in the water.

### 1.1.6 Policy and governance of the HIHWNMS

The HIHWNMS was designated as an official marine protected area (MPA) in 1997. It encompasses approximately 1,370 square miles. Stated under the HIHWNMS Act are the provisions designed to prohibit certain activities from occurring within sanctuary waters (NMSP 1997). The following details provide a general summary of regulations that protect humpback whales (Megaptera novaeangliae). For instance, it is illegal to approach or pursue humpback whales within sanctuary boundaries closer than 100 yards except as authorized under the Marine Mammal Protection Act (MMPA) and
the Endangered Species Act (ESA). Furthermore, no aircraft may come within 1,000 feet of any humpback whale within the sanctuary unless the aircraft is landing, taking off, or authorized under the MMPA or ESA. Any disruption to humpback whales’ normal behavior in Hawaiian waters is considered harassment and is thus unlawful.

Although there are other regulations protecting humpback whales stated in the sanctuary’s 1997 Environmental Impact Statement (EIS) / Management Plan Review (MPR), the most relevant piece of legislation that would affect aquaculture operations is regulation regarding discharges. It is declared that the discharge or deposit of any matter in the sanctuary or matter outside that tends to migrate to sanctuary waters is prohibited unless that user has acquired a federal or state permit, license, lease, or other authorization. Therefore, aquaculture would be regulated under the provision, Discharges and Alteration of or Construction on Seafloor. Enforcement of regulations is coordinated by a number of agencies, including NOAA Office of Law Enforcement, US Coast Guard, State of Hawai’i Department of Land and Natural Resources (DLNR) Division of Conservation and Resource Enforcement, and the NOAA Office of General Counsel. In addition, the Environmental Protection Agency (EPA), Fish and Wildlife Service (FWS), and Army Corps of Engineers (USACE) are other examples of regulating agencies that may play a role in aquaculture development. The HIHWMS does not issue permits. Instead, the sanctuary works within the existing permit processes of federal and state authorities.
1.1.7 Current pressure on the HIHWNMS

Additional considerations that have come up during the most recent MPR process is to broaden the sanctuary’s resource management focus, specifically to protect other species known to frequent Hawaii’s waters (NMSP 1997). Presently only encompassing the single protection of the humpback whale, the sanctuary is likely to direct additional efforts towards protecting other species. For instance, the resident population of false killer whales (*Pseudorca crassidens*) around the main Hawaiian Islands (“Hawaiian insular stock”) is known to frequently inhabit the HIHWNMS waters (Baird et al. 2010). It is also the smallest stock of toothed whales in Hawaiian waters and cannot be found elsewhere. Furthermore, the population is currently being considered for placement under the ESA (Baird 2009). Top prey items that false killer whales prefer large pelagic game fish. As a result, the population must compete with recreational, commercial, and sports fisheries that exist in Hawaiian waters.

Although false killer whales are one of the most vulnerable species and a strong contender for additional protection under the HIHWNMS Act, they are not the only species that would benefit from sanctuary inclusion. Other species for possible inclusion include the spinner dolphin (*Stenella longirostris*), Hawaiian monk seal (*Monachus schauinslandi*), hawksbill sea turtle (*Eretmochelys imbricata*), and other endangered or threatened species. For this study, only the protection and behavioral patterns of humpback whales will be considered.

A significant cultural aspect of aquaculture in Hawaii exists, specifically related to fishpond development and restoration (Costa-Pierce 1987). Fishpond restoration has
also been of high importance for possible inclusion in the sanctuary’s management plan. Historians have stated aquaculture practices were introduced to O‘ahu prior to the 13th century. However, towards the 19th century, many native Hawaiians abandoned their ponds, leaving them unmanaged and unkempt. Pressure from a rising population most likely forced many natives away from their more primitive form of aquaculture. The use of ancient Hawaiian fishponds was an integral component of the socio-cultural system at the time. Aquaculture, agriculture, and animal-rearing provided the vast majority of goods in this subsistence and barter economy. The formation of such farms required great collaboration as well.

Fishponds operate and function differently than OOA technology in many respects, but the most apparent contrast is that fishponds act as self-sustaining ecosystems (Costa-Pierce 1987). Although the production yields are not as great as from OOA, they require minimal human interference and inputs to function properly. In conclusion, there is increasing pressure to incorporate fishpond restoration into the sanctuary’s management plan and not treat fishponds as merely relics of the past; they have proven to sustain local communities in the past with ample seafood and it is believed this notion may still hold true today if applied. The DLNR of Hawaii also has more experience with fish pond development. As a result, the HIHWNMS works closely with the DLNR to collaboratively analyze OOA developments.

In addition to scientific data, many moral and philosophical factors play a part when dealing with food shortages (HIHWNMS 2011). As a consequence aquaculture is seen as a possibility to alleviate hunger-related issues. The DLNR is trying to incorporate not only biological and cultural factors into its decision-making, but moral considerations
as well when managing aquaculture. Consequently, DLNR faces a number of growing problems; minimal funding and ambiguous legal frameworks add to the conflicts of rising demand for resource uses.

Through the midst of these troubles, DLNR is still determined to create self-sufficiency regarding food security and energy independence for Hawaii. Improvements to resource development and utilization are some of DLNR’s main goals it plans to achieve. In accordance with efficient resource utilization, the natural beauty and aesthetic qualities of Hawaii must be preserved, promoted, and protected at the same time. As a result, DLNR plans to account for and thoroughly analyze all possible effects associated with OOA. Two OOA facilities exist as of now, and a small number are still in the development and research stages of the process. In order for the DLNR to manage resources of Hawaii properly, it aims to protect and provide locals access to the resources first, and if these two priorities are met and upheld, there may be the possibility for commercial usages. As a consequence, there is a rigorous permitting process that commercial entities must abide by to ensure that cultural and natural resources are not negatively impacted throughout the course of development.

Aquaculture activities vary greatly within state and federal waters off of the coasts of the Hawaiian Islands (HIHWNMS 2011). A recent study has identified roughly seventy operations occurring within the state. Although Hawaii is a large consumer of seafood, it still relies heavily on imports from afar. Thus, there is a need to increase productivity and reduce the current fish and seafood trade deficit that exists. The Aquaculture and Livestock Support Services (ALSS) within the Department of Agriculture of Hawaii is primarily concerned with product health, herd concerns, and
land and water constraints. As a consequence, ALSS is focusing more effort to dealing with aquaculture-related activities since production peaked in 2008 with most if it mostly occurring on the Big Island. Specifically, algae harvesting has proven to be of major prevalence as a particular type of aquaculture.

1.1.8 HIHWNMS management plan review

The HIHWNMS has emerged as a safe haven for migrating humpback whales during brisk winter months. Protection under the MMPA and ESA has allowed humpback whale populations to steadily recover during the past decade (Barlow et al.) Thus, nearshore waters off the coasts of the main Hawaiian Islands serve as productive breeding grounds starting in mid to late November. Sanctuary waters provide a suitable area for the courtship of mature whales and development of calves before they endure the long and arduous journey back to sub-arctic regions near Alaska during the summer season. Ultimately, the main goal of the sanctuary is to protect the habitat and well-being of this endangered marine mammal.

Each marine sanctuary falling under the jurisdiction and management of NOAA is required to revise its management plan. This document serves as a general blueprint to outline and describe sanctuary operations. Thus, the HIHWNMS periodically undergoes an extensive MPR where it reassesses existing programs, updates the public with new developments, and summarizes overall activities the sanctuary is involved with. The HIHWNMS acts as a multiple-use MPA and is responsible for integrating concerns that arise from public input and scoping periods into management plans. One issue that has emerged as an interest by those who participated in the public scoping meetings is the possible inclusion of offshore aquaculture activities within sanctuary boundaries.
1.1.9 OOA as an emerging issue to impact whale protection within HIHWNMS

Effects on the environment from OOA operations are inevitable, and as a result, must be taken into account. In general, OOA requires intensive systems that utilize supplementary feeding techniques. Additional inputs are often used to ensure the survival and mature grow-out of the farmed fish (Wursig and Gailey 2002). With additional inputs such as feed in form of pellets and plankton, OOA cages may act as attractants to various marine mammals. Offshore cages and pens are more localized areas in a smaller area compared to extensive nearshore systems. Due to the high concentration of OOA systems, apex predators are often lured to the cages since they provide easy access to prey. Opportunistic feeders can drastically alter farmed fish reproduction and survivability. Farmed fish can be highly vulnerable to apex species, especially in natural ecosystems that promote high competition among predators. Although both toothed and baleen whales have not proven much of a problem for aquaculture practitioners, pinnipeds have taken advantage of farmed fish in past aquaculture operations.

Farmed fish in holding pens and OOA may pose problems of entanglement, sound and chemical pollution, traffic, and habitat loss (Wursig and Gailey 2002). One of the top concerns among OOA practitioners is the usage of chemicals. In addition to using various feeds, antibiotics sometimes may be necessary to prevent farmed fish from acquiring parasites such as sea lice. It is important to establish standard amounts of antibiotics to not exceed the environment’s capacity to assimilate the wastes. Large-scale competition between humans and predators is not uncommon. It has been documented that opportunistic dolphins and pinnipeds may feed on farmed species which often are similar
to natural prey items for predators in the area. Therefore, if the HIHWMS is to consider placing additional threatened or endangered species under protection within the sanctuary, marine mammals such as pinnipeds may be reason for concern.

On the other hand, species of dolphins and other marine mammals have been known to avoid aquaculturally farmed areas (Wursig and Gailey 2002). Pens, associated lines, and buoys may repel most cetaceans and cause them to aggregate their prey elsewhere. The HIHWMS’s Offshore Development Working Group (ODWG) has theorized aversion as a possible result of OOA near the sanctuary (ODWG 2011). The presence of mooring lines, pens, sounds of farming operations, and other associated equipment may repel most cetaceans and cause them to aggregate their prey elsewhere. Consequently, behavioral modification to humpback whales is possible and should be studied to greater extents.

Nutrient loading has also been associated with many OOA operations (Barton 1997). Excess nutrients typically stimulate algal growth which can smother communities and result in harmful eutrophication. Eutrophic environments can be distinguished by high water turbidity, increased sedimentation, and abundant algal growth. Consequently, a sparsely populated region is generally preferential for starting OOA operations. Oligotrophic areas in developing parts of the world have seen many similar instances.

OOA and mariculture have received little consideration by the National Marine Sanctuary Program. According to NOAA and Congress, each sanctuary identifies a region of “special national significance.” There has also been significant national debate regarding the impact OOA technology has on marine mammals. And because the
HIHWMS acts as a safe haven for breeding humpback whales, many locals, environmentalists, activists, and other groups at the individual and national levels are concerned with the sanctuary’s pending plans.

It is evident that there is no single approach towards preventing marine mammal interactions with OOA equipment and products. As a result, each case should be studied independently based on the study area’s own unique conditions. Past studies of marine mammal interactions with OOA are helpful but limited. There has been minimal research on OOA specifically near humpback whale breeding grounds. Consequently, experimental development projects should be meticulous and flexible when analyzing such effects.

1.2 Identifying the information gaps to lead to goals

The aim of this study is to provide a factual analysis of how OOA conforms to existing legal frameworks. A knowledge gap exists on the subject of OOA’s impact on cetaceans. The available information regarding aquaculture impacts to marine mammals is minimal and deserves further analysis. A limited number of studies exist that focus on marine mammal protection and OOA (Fredriksson et al. 2004). It would behoove the aquaculture industry to take a further examination at any possible effects aquaculture equipment has on migrating whales or other marine mammals. Furthermore, these studies should ultimately be recorded and documented for the public’s use. Many Hawaiian natives and environmental activists around the world are concerned for the well-being of the iconic humpback whale so OOA’s impact on cetaceans has become an emerging issue. The language in older laws does not reflect a concern for or mention of offshore
aquaculture. The legal analysis component of the paper highlights how OOA is impacted by existing policies.

1.3 Goals of the paper

The study had two objectives. The first goal was to produce maps that visually portray humpback whale concentrations, existing offshore installations, regulatory agencies’ jurisdictions, and other objective parameters based on accessible data. Geographic Information System (GIS) mapping software allowed for data modeling. The maps created a visual representation of biological factors and regulatory boundaries inside and outside the HIHWNMS. Conversely, the purpose of utilizing GIS was not to site potentially suitable locations for offshore aquaculture development, but to merely layout existing parameters on an objective basis to form baseline information.

After modeling the biological and regulatory factors, the subsequent goal of this report was to analyze state and federal legal frameworks that offshore aquaculture practitioners would have to address in order to comply with existing regulations and statutes. Existing regulatory frameworks were investigated to determine whether OOA would be consistent with existing laws, specifically the Clean Water Act (CWA), ESA, HIHWNMS Act, Coastal Zone Management Act (CZMA) and Hawaii’s Wildlife Law and Hawaii Environmental Policy Act (HEPA). Both spatial and legal analyses were conducted. Due to the nature of OOA, a holistic approach to analyze potential impacts was needed. Environmental, social, as well as economic interests were considered in this report’s discussion.
1.4 Significance and limitations of above goals

A number of limitations constrained this study. A major limitation was access to available GIS data. Although a hotspot analysis and whale population density plots were helpful in revealing concentrations of humpback whales, it cannot be assumed that humpback whale migration routes have not altered since the data were last recorded in 2003. Access to more recent humpback whale data was limited. However, the data provided by professor at the University of Hawaii at Manoa, Dr. Joseph Mobley, was more than sufficient in this study. Data ranged from a ten-year span from 1993 to 2003. Based on aerial surveillance and humpback whale spottings, there is always a degree of uncertainty whether whale migration patterns alter for reasons that are even lesser known. Effects from climate change and global warming or availability to mating sites in and around sanctuary waters may or may not have had an impact on population densities of humpback whales. There is still much more science needed to backup the policy making that protects these animals.

Studies of how marine mammals are impacted by aquaculture are limited. As the global population has hit seven billion people, a milestone in our planet’s history, food security tends to be a pressing issue among concerned scientists. As aquaculture has become a prominent aspect to food production as well as an emerging issue, studies in the future are needed to scrutinize the balance between social and economic impacts with environmental protection in regards to OOA.
Chapter 2. Methods

2.1 Study Location

The Hawaiian Island archipelago consists of eight islands situated in the North Pacific Ocean between latitude 22.3° and 18.7° north and longitude -160.8° and -154.1° west. The sanctuary consists of five MPAs which all extend from the shoreline to the 100-fathom isobath (600 foot depth) of each MPA. MPAs exist off of the north and south shores of O‘ahu, the northern coast of Kaua‘i, the north Kona and Kohala coasts of the Big Island, and in between the four-island area from Maui’s west coast (NMSP 1997). When determining suitable areas for OOA cage deployment, at least 2.5 kilometers from the coast was considered optimal. Based off of the scientific research carried out by Professor Barbaros Celikkol and his colleagues, 2.5 kilometers from most coasts provided enough distance between the OOA equipment and shoreline to minimize environmental deterioration and to allow ample water movement to flush out nutrients created near the fish farm site (Baldwin et al. 2000). Figure 3 shows a 2.5-kilometer buffer around each island. If proposed projects were to follow the projects carried out in the Gulf of Maine, they should occur outside this buffer area.

2.2 Geospatial and representative data modeling

In addition to humpback whale sightings, other GIS data were provided by State of Hawaii-sponsored website. Public records that were utilized included downloadable layers on sensitive habitat, offshore installations, and marine managed areas (MMAs). Sensitive habitat layers included geospatial descriptions of coral reefs and mangroves whereas offshore installations such as rafts and mooring buoys were also data layers applied. Furthermore, MMA layers show public fishing areas, canals, piers, etc. In order
Figure 3. 2.5-Kilometer Buffer
to facilitate data analysis and the overall sighting process, GIS hardware and software were utilized during the project. Version ArcGIS 10.0 was the preferred software. GIS has been beneficial in determining the project’s outcome by displaying spatial data on the common projected coordinate system, NAD 1983. Due to its practicality as a planning tool and its ability to display multiple layers at once, GIS has become an integral component to this research paper.

Other spatial factors were taken into account when determining optimal OOA locations. Most activities that take place around the islands are recreational and tourism-based. Commercial operations such as boating, fishing, diving, and other revenue-generating ventures were analyzed. In addition, many areas known to encourage non-commercial interests including swimming, snorkeling, bathing, kayaking, wind surfing, and vessel operations were taken into consideration as well.

2.3 Humpback whale aerial surveillance data

Data were collected previously by Dr. Joseph Mobley of the University of Hawai‘i at Manoa. Data layers were provided that represented whale migrations over a ten-year span. Based off of aerial surveillance, Dr. Mobley recorded sightings of various marine mammals off the coasts of the main Hawaiian Islands from the years 1993-2003. Each data point was accompanied with its respective latitude, longitude, species, and other pertinent attribute data.
2.4 OOA Cage Technology Information

Research and development studies carried out by Professor Barbaros Celikkol of the University of New Hampshire and his colleagues focus on OOA engineering and cage deployment (Baldwin et al. 2000). These studies are significant to the current study because the same structured cages have been utilized by OOA practitioners in Hawai‘i. Prior research was carried out in the Gulf of Maine off of the coast of the Isles of Shoals. Two main structural cages have been tested and concluded as suitable structures for aquaculture. The gravity-type fish cage is mostly used for nearshore fish farm operations whereas central spar cages are primarily used for OOA. Each structure measures 16 meters and 15 meters in diameter respectively. Central spar cages have been designed to withstand depths between 15 and 55 meters, allowing feasible access by divers. The mooring system consists of four chain or line components and the cage. This type of cage functions to contain and protect the fish during their grow-out stages of development. The cage effectively protects the fish from predatory and environmental threats and provides ample room to allow feces and waste food to pass through its nets. The comprehensive analysis of this cage technology was carried out in the Gulf of Maine so it was exposed to relatively strong wave action. The remote site was also isolated from much development, so the technology has proven to work even under harsh circumstances.
Chapter 3. Results

3.1 Humpback whale data

Data points representing humpback whale spottings were separated and a population density plot was performed. The population density map, as shown in Figure 4, represents the most frequented areas by humpback whales over the 10-year period. In addition, a hotspot analysis was performed to determine whether or not the location of the projected data points were due to random chance or for a particular reason. The results are shown in Figure 5. Therefore, four specific areas (circled on map) with a congregation of data points that exceeded a standard deviation of roughly 2.58 were deemed areas frequented by humpback whales for specific reasons. These areas represented regions where humpback whales tended to migrate due to preferences that have yet to be investigated. In other words, the chance of complete random distribution of humpback whale aggregations in these four areas was negligible.

The next step was to analyze competing or conflicting uses within the designated areas (Benetti et al. 2010). Downloadable data layers from the state of Hawaii’s public records provided GIS data ranging from political boundaries and physical features to offshore installations. Other areas to avoid that were incorporated into the analysis included those adjacent to sensitive habitats such as coral reefs and mangroves. In addition, offshore installations including mooring buoys, rafts, and other platforms were depicted using GIS. The last set of data examined existing MMAs. For instance, public
Figure 4. Humpback Whale Population Densities
Figure 5. Humpback Whale Hot Spot Analysis
fishing areas, piers, canals, and freshwater refuges are all obstacles to avoid for aquaculturists.

Figure 6 shows existing structures and sensitive habitat offshore and nearshore. The blow-up version of the same map, shown in Figure 7 reveals that most mangroves and corals are located around Big Island, Maui, and other centrally located islands. Mangroves and coral reefs are resilient ecosystems of invaluable importance (Moberg and Rönnbäck 2003). They provide people with numerous ecosystem services that are difficult to understand and quantify. Both ecosystems act as nurseries and feeding grounds for flora and fauna. Essential for breeding, juvenile fish and other animals take refuge and shelter in both ecosystems. Furthermore, they promote biodiversity and the maintenance of genetic resources. In addition to benefitting permanent inhabitants of the ocean, people gain advantages from the existence of reefs and mangroves. Both ecosystems act as natural breakwaters against waves, tides, and storm surge. The absence of these environments would cause severe damage to inland infrastructure, homes, and other manmade structures along the coast. Recreation and tourism are also inherent in the use of both ecosystems. Both habitats also allow for continuous educational and scientific research opportunities. As mentioned later, OOA practitioners may be subject to a Section 404 permit of the CWA if material is discharged near wetlands.
Figure 6. Sensitive Habitat and Areas of Concern

Figure 7. Sensitive Habitat and Areas of Concern (zoom)
3.2 Policy Analysis

The first step to performing a legal analysis of any kind is to identify the issue (Rowe 1999). In this case, the issue is offshore aquaculture’s potential conflict with the selected environmental statutes. The purpose of this analysis is to identify requirements that aquaculturists must address to comply with existing legislation. Although OOA is an emerging industry and some statutes were not written with the intention of addressing it, the next three sections examine offshore aquaculture’s relationship to four federal statutes as well as two state laws. There are a number of other relevant laws that may mandate consultation or permitting, some include: Ocean Dumping Act, Marine Protection, Research and Sanctuaries Act, Rivers and Harbors Act, National Environmental Policy Act (NEPA), Toxic Substance Control Act, Federal Insecticide, Fungicide, and Rodenticide Act, Safe Drinking Water Act, Magnuson-Stevens Fishery Conservation and Management Act, and the Marine Mammal Protection Act. The next few sections include secondary sources in the form of legal encyclopedias and law review articles, as well as primary sources such as statutes and administrative law.

3.2.1 Policy Analysis of the Clean Water Act

The EPA is given authority to set ocean disposal criteria as well as review environmental effects of aquaculture projects as stated under Section 403(c) of the CWA (Brennan 1999). The CWA has seen numerous amendments in its legislative history (HLSEELPC et al., 2012). Enacted in 1972, the CWA was a broad expansion of the Federal Water Pollution Control Amendments of 1948. Its main goal is to “is to restore and maintain the chemical, physical, and biological integrity of the Nation’s waters” (33 U.S.C. § 1251(a)). In order to preserve the quality of this nation’s waters, the CWA’s
primary control mechanism is to prohibit discharges into navigable waters unless
authorized by the EPA or a delegated state agency (Firestone and Reed 2008). Thus, a
quick look at the statutory language of the act is crucial to see how OOA applies to
provisions.

The CWA describes unlawful activities as “additions” of “pollutants” to the ocean
(HLSEELPC et al., 2012) Stated under the CWA, a “pollutant” includes solid waste,
sewage, garbage, chemical wastes, biological materials, heat, and several other materials
(33 U.S.C. § 1362 (6)). Under the law’s definition, a pollutant can include a wide array of
materials; it is broadly defined for the purpose of being flexible and far-reaching. OOA
facility discharges generally constitute additions of pollutants. Substances commonly
used in OOA can fall under almost any of the titles mentioned ranging from solid waste,
chemical wastes, biological materials, etc. The majority of modern OOA facilities may
release many substances into its natural surroundings including hormones, antibiotics,
pesticides, parasites, escapees, antifoulants, dietary supplements, fishmeal, fish oil, and
animal feces, and other substances which all have the potential to act as pollutants.
Factors such as equipment failure, storm damage, and external predation all have the
potential to release more pollutants into nearby waters. Furthermore, all these materials’
effects are magnified when they are used in excess and concentrated in enclosed zones.

Similar to the “addition” of “pollutants,” Congress intended for the definition of
“navigable waters” to essentially mean “all waters of the US” (Firestone and Reed 2008).
This broad interpretation of “navigable waters” was exemplified in the case, United
States v. Holland (373 F. Supp. 665). The case was brought up in 1974 when water
quality protection efforts were in their beginning stages. Defendants acknowledged they
discharged pollutants into man-made canals and wetlands. They presented the claim that they were not required to obtain discharge permits because the bodies of water that received their discharges were outside federal jurisdiction provided by the Constitution. After a thorough examination of the legislative history of the CWA from the House of Representatives and Senate, it became clear that Congress intended for “navigable waters” to not necessarily include waters that abided by the technical definition of “navigability.” To that extent, the CWA’s definition of “navigable waters” was intended to allow the EPA and relevant state agencies to control both navigable and non-navigable waters of the US. Consequently, OOA operations would fall under the classification of occurring in “navigable waters.”

The permit process will be triggered when a discharge is “added to water” (HLSEELPC et al., 2012). There is a reasonable chance that materials added to the water during OOA operations will affect the water quality of US waters. Although the degree of water quality alteration differs substantially among projects and should be analyzed on a case-by-case basis, any OOA operations should be subject to the permitting processes of the CWA. The first permit to be analyzed is the National Pollution Discharge Elimination System (NPDES) permit (Firestone and Reed 2008).

Under Section 402 of the CWA, the EPA has statutory authority to issue NPDES permits for “point sources” of pollution (Cicin-Sain 2001). A “point source” is defined as a discernible, confined, and discrete conveyance from which pollutants may be discharged (33 U.S.C § 1362(6)). Common examples include any pipe, ditch, concentrated feeding operation, channel, tunnel, well, conduit, vessel, or floating craft. OOA is considered a point source of pollution so the EPA has legislative authority to
issue permits for discharges into navigable waters of the US. Aquaculture facilities discharging into the federal ocean zone, specifically in relevant part, “the waters of the contiguous zone or the ocean from any point source other than a vessel or other floating craft” (33 U.S.C. § 1362(12)(B)) must obtain an NPDES permit.

Regardless of whether the OOA facility is public or private, an NPDES permit is required for any discharge of a potential pollutant (Firestone and Reed 2008). Potential pollutants have the ability to change various indicators of water quality including biochemical oxygen demand, suspended solids, total coliform, fecal coliform, phosphorus, nitrate, and pH, ultimately disturbing the water’s ecology. The EPA may enforce NPDES permits because OOA facilities fall under its jurisdiction as Concentrated Aquatic Animal Production (CAAP) facilities (HLSEELPC et al., 2012). CAAP facilities can be designated on a case-by-case basis if they are believed to be significant contributors to pollutants entering US waters. However, CAAP facilities are described more commonly as “cold-water facilities that discharge at least 30 days per year, produce more than 20,000 pounds of fish per year, and use 5,000 pounds or more of feed per month, as well as warm-water facilities that discharge at least 30 days per year and produce at least 100,000 pounds of fish annually (not including closed ponds that discharge only during periods of excess runoff).” As a consequence, any OOA facility that doesn’t fall under the CAAP facility definition is not considered a “point source” according to the EPA’s standards is does not need an NPDES permit.

Offshore aquaculturists may also have to comply with the Section 404 permit depending project details (Cicin-Sain et al., 2001). Section 404 of the CWA applies when dredge and fill materials have been discharged into waters of the US (33 U.S.C. § 1344).
The EPA and USACE ensure the protection of wetland habitats by establishing a joint-review process for Section 404. For the most part, the EPA has paramount authority over 404 permits; it has issued guidelines for reviewing of 404 permits by the Corps under 40 C.F.R. 230.10-80 and is also authorized to veto Corps permits and disposal sites under § 404(C) of the CWA (Cicin-Sain et al., 2001). Much emphasis is placed on the protection of wetland habitats for the numerous ecosystem services they provide. Figures 6 and 7 show nearby mangrove and wetland habitat of the MHI. The 404 permit is not applicable to every OOA project. The type of species harvested and cage technology used was determine whether aquaculturists would have to apply for a 404 permit. Cages that are tethered or attached to the seabed would most likely qualify for a 404 permit because the substrate would need to be prepared for attachment. Further, 404 permits are applicable generally when shellfish are fixed to the seabed as well.

Reform under the CWA is necessary to ensure responsible OOA. The EPA has established effluent guideline limitations for aquaculture activities but has not addressed water quality standards in federal waters (HLSEELPC et al., 2012). Thus, effluent restrictions are the only basis for NPDES permit terms and conditions. Further, the definition of a CAAP facility should be broadened to subject pilot projects to the NPDES permitting program. Kona Blue, during its pilot program, was not subject to the NPDES because it initially produced small volumes of high-value fish species in a towed, floating pen. Out of all the stages of an OOA project, the initial pilot program should be examined with even closer scrutiny compared to facilities that have run successfully for a longer period of time. Earlier projects are more susceptible to damaging the environment due to
the greater possibility of unproven/faulty technology, lesser-experienced workers, human error, and the greater chance of escapements.

The permitting process should also be better organized among the agencies conducting the review. A streamlined process that combines the permits would reduce ambiguity and the potential for statutory violations. Such permits that should be combined include the USACE under Section 10 of the Rivers and Harbors Act, the EPA under section 402 of the CWA (NPDES permit), the state discharge and water quality classification standards, the state’s aquaculture laws, and the state’s coastal zone management laws, etc. A consolidated process would also alleviate any overlap or redundancy, and provide a more coherent environmental review.

3.2.2 Policy Analysis of the Endangered Species Act

Administered by both the FWS and NOAA Fisheries, the ESA is intended “to provide a means whereby the ecosystems upon which endangered and threatened species depend may be conserved” (Fischman and Squillace 2000). Although this is not the only purpose of the ESA, it is most relevant here because habitat modification is the biggest threat posed by OOA. The other major threat that can lead to extinction is overhunting. Defined under the ESA, a species is endangered if the FWS or NOAA Fisheries finds that a species is “in danger of extinction throughout all or a significant portion of its range” (Salzman and Thompson 2010). Similarly, a species is considered threatened if is “likely to become an endangered species in the foreseeable future.” Most species receive similar protection under both the “endangered” and “threatened” status other than a few minor details described in section 9 of the act.
In general, the FWS has authority over the protection of terrestrial and freshwater species whereas NOAA Fisheries has control over marine species (Salzman and Thompson 2010). The MHI are home to a diverse array of both aquatic and terrestrial flora and fauna, especially a large number of threatened and endangered species as mentioned previously. Not only are many of these species endangered/threatened, but they are also endemic to the islands of Hawaii and found no where else. Coupled with high biodiversity and substantial habitat loss, Hawaii has the most endangered species in the US with a total number of about 330.

The ESA is considered to be “the most comprehensive legislation for the preservation of endangered species enacted by any nation.” TVA v Hill, 437 U.S. 153 (1978). Preservation of threatened/endangered species is of utmost importance and can be revealed in TVA v. Hill where the presence of an endangered fish with no known economic function ceased an entire multimillion-dollar dam project that was nearly 80% complete (Fischman and Squillace 2000). Investors had already spent close to $80 million constructing the dam. Recovery of species is the primary objective of the ESA, no matter what the cost. Approximately 60 species in the US have died out over the last century alone (Salzman and Thompson 2010). Human activity has been the major cause of most extinctions. Although habitat modification is the most common culprit of species extinction, other harmful activities include overhunting, urban sprawl, overfishing, logging, introducing new exotic species, and others. Unfortunately, the ESA is not a preventative solution; species only receive federal protection once they are placed on the threatened or endangered species list. The following few sections analyze the relevant
parts of the ESA that offshore aquaculturists and administrative agency officials must be cognizant of when managing OOA operations.

Federal agencies authorizing offshore aquaculture in Hawaii must comply with the section 7 interagency consultation process as a precautionary measure to prevent harm to endangered/threatened species (Salzman and Thompson 2010). Two sections in particular are relevant to federal offshore aquaculture ventures. Section 7(a)(1) of the ESA requires federal agencies to consult with their authorities to promote conservation of the would-be effected species. Moreover, section 7(a)(2) requires that all federal agencies to consult with the FWS or NOAA Fisheries if their future actions are reasonably foreseeable to affect the status of a threatened/endangered species. In general, section 7 is meant to ensure that no federal action is to likely “jeopardize the continued existence” of the species or “result in the destruction or adverse modification of the critical habitat of such species.” A Biological Opinion is issued by NOAA Fisheries as to whether they believe the federal actions will affect the existence of endangered/threatened or has the potential to adversely modify existing critical habitat. Although critical habitat designations do not offer the same protection as would a refuge or preserve, they come into play when federal funding, permits, or projects are involved.

As mentioned before, humpback whales, false killer whales, spinner dolphins, Hawaiian monk seals, hawksbill sea turtles, Hawaiian green turtles, leatherback sea turtles, loggerhead sea turtles, and olive ridley sea turtles are all endangered species that live near or migrate to the MHI. Designations are based on the best scientific information available and are a very public process (Salzman and Thompson 2010). If any OOA project coincides with a critical habitat, they will be subject to the section 7 consultation
process and may have to apply for an incidental take permit as discussed later. It is important to note that although critical habitat for many of these species is established around the MHI, designation does not necessarily prohibit development; most federal projects are merely adapted to minimize adverse effects to the areas. In addition to considering environmental factors, critical habitat sighting weighs national security issues, economic impacts, and other relevant political/economic elements from such designations.

Since waters within the HIHWNMS are considered federal, a consultation process with NOAA Fisheries is mandated by the ESA before any projects begin (Salzman and Thompson 2010). If a federal project or project that uses federal funds, federal permits, or federal authorization, neglects to carryout the required consultation process, it may result in an injunction whether completed or significantly completed for the purpose of protecting an endangered species or its habitat. The test for a preliminary injunction under the ESA is different than the traditional test. Loss of a single threatened species is considered to be an irreparable harm. Thus, harm to the entire species does not need to be proven. Also, public interest favors the imposition of an injunction. Protecting threatened and endangered species is of highest priorities under the ESA.

The language of the ESA is plain, direct, and has no room for exceptions (Salzman and Thompson 2010). There is no balancing of hardships or public interests; the value of a species is infinite. As a result, a consultation process must occur because it is reasonably foreseeable that the existence of threatened and endangered species is potentially affected by proposed OOA projects. After controversy erupted from *TVA v. Hill*, Congress amended the ESA to form a body commonly known as the “God Squad”
because of their ability to determine the fate of a threatened/endangered species ESA § 7(e), 16 U.S.C. § 1536(e). The God Squad was given the authority to vote to exempt a federal project from section 7(a)(2) if the committee deemed there were no “reasonable and prudent alternatives,” the benefits carrying on the project outweighed the environmental harms, or the project was of “regional or national significance.” ESA § 7(h), 16 U.S.C. § 1536(h) This relatively new ability essentially allows projects to continue even though they may pose a risk of harming species protected by the ESA.

In regards to the section 7(a)(2) exemption, OOA practitioners would most likely not be exempt because viable alternatives exist for project sighting to avoid endangering humpback whales and other species. Sanctuary boundaries cover a minimal percentage of nearshore waters off the Hawaiian coasts. For that reason, reasonable or prudent alternatives may exist in non-sanctuary waters or waters that see less humpback whale activity. Also, no investors would lose out because no projects have begun in sanctuary waters yet. In regards to projects of regional or national significance, the US is fortunate to have a bountiful supply of fish products for consumption. Although many states, such as Hawaii, must import a significant amount of fish consumed, there is currently no severe shortage of seafood products; thus, national security or regional concern is not relevant at this time. Similarly, the possibility of economic growth from OOA to Hawaii’s people should not outweigh the benefits from protecting the islands’ endangered/threatened species because Hawaii already has a relatively healthy economy. In a US Census Bureau 2010 census, Hawaii ranked 8th highest in the US in terms of median household income and 11th for per capita income (Sauter et al., 2012).
Consequently Hawaii maintains relatively low unemployment and poverty rates and OOA benefits would not exceed environmental costs.

Section 9 of the ESA deals with “takings” of endangered species (Gray 2007). Stated in section 9(a)(1) of the statute, no public or private entity may take a species of fish or wildlife (Salzman and Thompson 2010). A taking entails any of the following actions applied to endangered species: “harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect.” Habitat adversely modified by certain activities also applies to section 9; specifically, “significant habitat modification or degradation” that “actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering” violates section 9 as being unlawful “harm.” 50 C.F.R. § 17.3. Application of this rule applies to both state and private lands. It is important to note that section 9(a)(1) does not directly apply towards threatened species. And because OOA occurs offshore, aquaculturists do not have to be concerned with section 9(a)(2) that prohibits the taking of endangered plants on federal land.

In order to avoid violations of section 9 of the ESA, aquaculturists may apply for incidental take permits under section 10(a) (Gray 2007). NOAA Fisheries and the FWS may grant incidental take permits to allow the taking of individual members of protected species if the taking is incidental to an activity considered lawful, and the permittee has designed a habitat conservation plan (HCP) (Salzman and Thompson 2010). Acting as a form of mitigation, the HCP must minimize the effect of the taking to the “maximum extent practicable.” Potential habitats affected by OOA include wetlands, benthic communities, coral reefs, and other habitats specific to Hawaiian waters.
Incidental take permits water down the ESA because it permits what was originally prohibited. Also, some HCPs are inadequate if mitigation zones are scattered. If HCPs are going to happen they should be regional and established by communities. In effect, regional HCPs would promote larger areas or clusters of protected areas. Mitigation is most effective when the protected area encompasses multiple types of ecosystems since habitats are interconnected systems. Regional HCPs also reduce the burden on individual property owners or business owners by involving several participants to spread the responsibility over.

3.2.3 Policy Analysis of the HIHWNMS Act

The HIHWNMS is a product of the National Marine Sanctuaries Act (NMSA) that was enacted in 1972 (NMSP 1997). Under the NMSA, the Secretary of Commerce designated the HIHWNMS as an MPA for its ecological, cultural, recreational, and scientific qualities. The National Marine Sanctuary Program (NMSP) was delegated authority to manage daily operations of the sanctuaries. However, the Secretary still plays an important management role. Proposed OOA projects in the sanctuary may not possess a high probability that they will destroy, damage, or injure a sanctuary resource, i.e. humpback whales; if the likelihood is high, the Secretary requires the NMSP to recommend reasonable and prudent alternatives to the proposal stated under section 304(d) of the NMSA. Possible damages to humpback whales from OOA include entanglement with nets, behavior modification due to obstructions to migration, increased boat activity, etc. Sections 304(a) and 304(e) of the NMSA also mandate periodic revisions of the management plan which specifies activities permitted and prohibited in the sanctuary. Thus, if OOA is to be allowed in sanctuary waters, it would have to be
defined and described in the HIHWNMS’s most current management plan to ensure the goals of the sanctuary are still met. The HIHWNMS adopts the guidelines set forth in the NMSA and continues further with enacting laws specific to its site and resources.

The HIHWNMS Act regulates aquaculture under its provision, Discharges and Alteration of or Construction on Seafloor. Under the HIHWNMS Act, Title 15, Chapter IX, Part 922, Subpart Q, Section. 922.184 (a) (5) states that the following activities are unlawful: “discharging or depositing any material or other matter in the Sanctuary; altering the seabed of the Sanctuary, or discharging or depositing any material or other matter outside the Sanctuary if the discharge or deposit subsequently enters and injures a humpback whale or humpback whale habitat; provided that: such activity requires a Federal or State permit, license, lease, or other authorization, and is conducted without such permit, license, lease, or other authorization; or not in compliance with the terms or conditions of such permit, license, lease, or other authorization” (NMSP 1997). Depending on what technology is deployed, any alteration to the seabed requires consent by the HIHWNMS. Lines and moorings to the seabed stabilize many OOA cages so this would have to be taken into account during consultation. Furthermore, OOA operations must also comply with discharge restrictions to prevent any harm to the sanctuary’s resources. The five MPAs that make up the sanctuary, as shown in Figure 8, all extend from the shoreline to the 100-fathom isobath (600 foot depth).

It is important to minimize potential use conflicts. In Hawaii’s case, both historical and current uses of the marine environment should be included in coastal and marine planning. The social considerations also shown in Figure 9 are of strategic importance for various user groups. Traditional uses of Hawaii’s marine environment
include fishing, aquaculture, trade, and transportation (NMSP 1997). In addition to modern techniques to integrate coastal and marine management, Hawaii incorporates a
primitive form of use-rights. Developed by native Hawaiians, many regulations and customs established during the times of the Polynesian voyagers still persist today and
affect the management of the sanctuary. For instance, a number of the MMAs include what are known as “konohiki” fisheries and “koa huna” fisheries. Traditional fishing practices typically give the adjacent landowner control over access to fisheries.

Current uses within the HIHWNMS are varied and abundant (NMSP 1997). Acting as a multi-use marine protected area, the HIHWNMS allows certain activities to occur without jeopardizing the wellbeing of humpback whales. There is significant commercial fishing off the coasts of Maui, Molokai, and Lanai (HIHWNMS 1994). Known for recreation, Maui’s shoreline attracts tourists year-round. As a result, leisure activities and boating are prevalent off Maui’s coasts. The channels of the Maui County islands see a high level of activity. Tour boat businesses include activities ranging from snorkel and scuba cruises to day trips to Lanai. Eco-friendly whale watching tours continue to generate significant revenue. In fact, a few corporate sponsorships with the HIHWNMS donate a portion of their proceedings to the sanctuary for additional research. In 1990, snorkeling cruises on sail and motorboats accounted for about 79% of the revenue gained by the 30 companies active in the Maui County tour boat industry. In addition to providing most of the remaining revenue, whale watching excursions promote conservation and are active stewards of humpback whale protection.

Charter boat fishing fleets also bring much revenue to the island. The harbor of Kahului on Maui is considered a major port of Hawaii (HIHWNMS 1994). Shipping routes for harbors on Maui and Molokai islands intersect sanctuary waters through the channels close to Maui. Interestingly, the recreational fishing sector, although unquantified, is estimated to outnumber commercial fishers 50 to 1. MMAs are meant to
sustain regular fishing efforts by creating public fishing areas. A number of MMAs intersect sanctuary boundaries.

3.2.4 Policy Analysis of the Coastal Zone Management Act

The CZMA is intended to encourage coastal states to develop their own respective coastal zone management programs in order to protect, preserve, and promote natural resources within the coastal zone (CZMA 2009). Provisions under the CZMA provide incentives for states to comply with the statute by providing federal funds, federal consistency, and other forms of assistance. Offshore aquaculture projects should be consistent with Hawaii’s Coastal Zone Management Plan. Thus, the relevant section included in this discussion is Section 307 of the CZMA, which defines and describes federal consistency.

Federal consistency is one of the major incentives for coastal states to develop their own management plans under the CZMA (CZMA 2009). Section 307 states that federal actions that have reasonably foreseeable effects on land, water use, or natural resources of the coastal zone should be consistent with the enforceable policies of a coastal state’s federally approved management plan. Four categories of federal actions are classified under the CZMA: federal agency activities, federal license or permit activities, Outer Continental Shelf plans under the Outer Continental Shelf Lands Act, and federal assistance to state and local governments. However, OOA projects would fall under the classification of federal license or permitted activities because all proposed projects are private ventures that require federal authorization from the Sanctuary, among other federal agencies. Section CZMA § 307(c)(3)(A) states that a private individual, business, or a state or local government agency, or any other non-federal entity applying
to the federal government for authorization must be fully consistent with Hawaii’s coastal management program. First, the permit applicant determines whether its activity is consistent with Hawaii’s coastal management plan, and, subsequently, the State either concurs or objects to the applicant’s consistency determination. Aquaculture applicants that must obtain a Corps 404 permit, NPDES permit, Sanctuary permits, and other federal licenses apply to this section (15 C.F.R. part 930, subpart D).

Hawaii’s Office of Planning is the lead agency for the Hawaii Coastal Zone Management Program (HOP 2012). In 2012, it received a $250,000 grant from NOAA to strengthen its existing program and implement the National Ocean Policy. Federal authorities aim to streamline the permitting process for aquaculture operations under the plan. Hawaii has defined its entire state the coastal zone; for that reason, the CZMA applies to the entire state. The Office of Planning must determine whether or not a proposed OOA project passes the “effects test.” The effects test analyzes any reasonably foreseeable effect on a coastal use or resource due to an action carried out under a federal permit. The test may apply to coastal uses and resources outside the coastal zone as long as they are impacted directly or indirectly. Once applicant submits the Consistency Certification to the Office of Planning, the State of Hawaii has six months to respond and should provide public comment for further review. Lastly, if the Office of Planning rejects the plan, the federal agencies may not grant their permits. However, the applicant may appeal to the Secretary of Commerce for a Secretarial Override (CZMA sec. 307(c)(3)(B)(iii)).
3.2.5 Policy Analysis of the Hawaii Wildlife Law

On a state level, there are also a number of relevant laws passed by the legislature of Hawaii. Administered by the DLNR, Hawaii’s Wildlife Law provides added protection to other “indigenous wildlife” not federally listed as endangered or threatened according to the ESA. Prohibited activities listed under §13-124-3(A)(1) make it unlawful for any person, unless you are an authorized employee of the DLNR, Department of Agriculture, FWS, or a person authorized by the board of the DLNR, to “Catch, possess, injure, kill, destroy, sell, offer for sale, or transport any such species, or any young or egg, or the dead body or skin thereof.” Nor shall any person “Export any such species, or any young or egg. §13-124-3(A)(2). Appendix I lists aquatic indigenous wildlife that may be impacted by OOA practices. However, the State of Hawaii’s Wildlife Law must be modified to include offshore aquaculture. Under §13-124-2, “‘Aquaculture’ means the farming or ranching of aquatic life in a controlled salt, brackish, or fresh water environment; provided that the farm or ranch is on or directly adjacent to land.” The biological and chemical properties associated with offshore activities differ from nearshore. Because OOA can be distinguished from nearshore aquaculture, it should have its own definition and related rules.

3.2.6 Policy Analysis of the Hawaii Environmental Policy Act

Chapter 343 of the Hawaii Revised Statutes (HRS) describes the HEPA (OEQC 2012). HEPA’s provisions are similar but also differ significantly compared to its federal counterpart, NEPA. Similarly, when an action triggers 343, the agency responsible for compliance must prepare an Environmental Assessment (EA) or declare an exemption. From the EA, the agency then must declare a Finding of No Significant Impact, or
complete an EIS. On the other hand under NEPA, one federal agency carries out the entire procedural process; HEPA requires active roles from a number of administrative agencies. Further, HEPA divides the disclosure process from the implementation (permitting) process. Conversely, NEPA does not distinguish between the two processes since they are both carried out by a single agency. NEPA review becomes activated when a “major federal” project is anticipated to alter the “human environment,” whereas HEPA review can be triggered by several factors. OOA projects carried out in the HIHWNS would most likely have to comply with both federal and state statutes. In general, federal agency activities (Section 343-5(b), HRS) as well as private actions (Section 343-5(c), HRS) prompt an environmental review. The goal of HEPA is to essentially review effects to the environment from certain actions.

Nine triggers to activate HEPA review exist, however only a select few are relevant to OOA (OEQC 2012). HEPA will be triggered if state/county lands or state/county funds are used. Furthermore, any area designated as a conservation district will also trigger the HEPA process. The Office of Conservation and Coastal Lands within Hawaii’s DLNR is responsible for managing conservation districts based on land as well as those privately or publicly zoned districts that represent beach and marine lands out to three nautical miles. Thus, a DLNR board may grant a permit or issue a temporary variance or emergency permit. Nevertheless, more intensive projects require public hearings and/or an EA or EIS. Figure 10 represents Hawaii’s state waters. A third trigger occurs when there is a use within a shoreline as defined by Section 205A-41. Shorelines described in this section are defined by county ordinances, which specify a distance inland from the certified shoreline. Also, use within any historic sites designated by the
National Register or Hawaii Register, and use that requires an amendment to existing county general plans would trigger a HEPA review.

Figure 10. State Waters of Hawaii
Table 1. Summary of Statutes

<table>
<thead>
<tr>
<th>Act</th>
<th>Level</th>
<th>Agency Responsible</th>
<th>Required Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clean Water Act</td>
<td>Federal</td>
<td>EPA</td>
<td>NPDES/404 permit</td>
</tr>
<tr>
<td>Endangered Species Act</td>
<td>Federal</td>
<td>NOAA</td>
<td>Incidental take permit/consultation process</td>
</tr>
<tr>
<td>HIHWNMS Act</td>
<td>Federal</td>
<td>NOAA</td>
<td>Consultation</td>
</tr>
<tr>
<td>Coastal Zone Management Act</td>
<td>Federal</td>
<td>NOAA</td>
<td>Consistency certification</td>
</tr>
<tr>
<td>Wildlife Law</td>
<td>State</td>
<td>DLNR</td>
<td>Permit (research)</td>
</tr>
<tr>
<td>HEPA</td>
<td>State</td>
<td>DLNR/DOH</td>
<td>EA/EIS</td>
</tr>
</tbody>
</table>
Chapter 4. Conclusions and Discussion

4.1 Comparative Studies

It is recognized and understood that the top priority of the HIHWMS is to minimize any detrimental effect to humpback whales such as the risk of entanglement caused by the deployment of fish farming structures. A similar experiment investigating the same relationship was carried out in the waters near Maine. All lines on the cages were of a large diameter and ropes were pre-tensioned during the deployment process (Baldwin et al. 2000). The diameter of ropes used was designed to be between 44-52 millimeters (Fredriksson et al. 2004). Although there were no instances of marine mammal entanglement with the aquaculture equipment during the four years of deployment in the Gulf of Maine, no structural equipment can completely eliminate the risk. Marine mammals have been known to linger near fish farm sites due to the possibility of fish escapements. Whales and other Cetaceans are intelligent predators and have the capability to tamper with cage equipment in order to feed on the farmed stocks, so it is crucial to include every possible safeguard. It is also in the best interest of aquaculture practitioners to avoid areas with high densities of marine mammals and other predators (Benetti et al. 2010). Firms can experience huge losses to crops if predators are able to rip through netting and destroy cages.

According to the population density map in Figure 5, the concentration of humpback whales was highest in the four-island region near Maui. Thus, it is conducive for the prosperity of the business as well as the wellbeing of humpback whales to deploy
nets and cages a reasonable distance away from this vicinity. The large group of whales also tends to migrate further off the western coast of Moloka‘i.

Existing infrastructure is important for the long-term success of OOA operations (Benetti et al. 2010). Failure to address the logistics of a project can easily cause problems. Without adequate transportation routes, the transportation costs associated with a fish farm operation may exceed a reasonable amount. There must also be ample forms of communication such as telephones, mobile phones, and computer/internet access. The balance between environmental sustainability and economic feasibility is essential to acquire. Other components that must be examined are access to services, personnel, construction materials, and fuel.

Offshore central spar cages require regular maintenance, thus there is need for manpower to perform daily tasks. For instance, there should be concern to remove dead fish as well as any biofouling that accumulates on net structures (Baldwin et al. 2000). Regular cleanup is necessary to reduce the risk of disease outbreak and nutrient loading that may occur in and adjacent to the site area. It is important for aquaculture practitioners to not rely heavily on antibiotics or hormones since they may conflict with environmental regulations and create unsanitary conditions and fish products. In order to carryout necessary maintenance tasks, workers responsible for caring for the site should receive or already have proper diving and technical training.

It is evident that aquaculture site selection requires spatial data and information pertinent to the site under examination. Avoidance of conflicting uses, sensitive habitat, and offshore installations should be considered; site depth and distance from shore are
both integral components in the decision-making process as well. All in all, there is no such thing as a perfect site location; site selection entails making tradeoffs depending on what the top priorities of the project are (Benetti et al. 2010). GIS is an invaluable planning tool and plays a key role in identifying known areas with high concentrations of humpback whales. Even after cage deployment and fish farm operations are well underway, there still must be active monitoring and enforcement to ensure effluent waste standards are met. In the long run, fish farm operations should be carried out with transparency, consultation between stakeholder groups, and effective redress should a problem arise.

The Stellwagen Bank National Marine Sanctuary (SBNMS) faced a similar issue regarding resource protection and inclusion of mariculture. Recognized as an important feeding area for the endangered northern right whale and other endangered species, Stellwagen Bank has a reputation as being one of New England’s finest whale watching destinations (Barr 1997). The SBNMW received many concerns regarding mariculture within its proposed boundary. Although mariculture was a hotly contested subject, officials at the SBNMS believed mariculture should not be completely ruled from inclusion in sanctuary plans and warranted further study. Mariculture was not completely prohibited but was subject to regulation. Sanctuary staff researched bottom cage culture and other forms of OOA with great scrutiny. At this point in time, no offshore aquaculture projects take place within any of the sanctuaries. Much uncertainty about sustainable aquaculture still exists, so it is important for more study and to separate the potential environmental damages from the real ones.
4.2 Future Work

The HIHWNMS needs to act not only as a facilitator during discussions related to OOA, but also as an active stakeholder (ODWG 2011). Incorporating public discussion into decision-making is essential to enhance legitimacy and gain the trust of the public. Workshops and other techniques to bring various stakeholder, development, and regulatory groups together must be employed to come to a mutual understanding regarding the future of OOA and the HIHWNMS. It can be assumed that all individuals involved in the discussions agree on the same ends, specifically food security for the Hawaiian Islands, clean water, protection for the state’s iconic humpback whale, but it is generally the methods that are contested. Collaboration between groups is necessary to achieve mutually agreed-upon goals while keeping in mind a few important principles. There are many applicable laws, some more straightforward than others. Tables 1 and 2 provide an overview of other required federal and Hawaii State permits.

Table 2. Offshore Aquaculture Federal Permitting Process (ODWG 2011)

<table>
<thead>
<tr>
<th>Activity</th>
<th>Federal Agency</th>
<th>Legislation</th>
<th>Document/Permit Required</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>To carry out scientific research</td>
<td>NOAA Fisheries</td>
<td>Magnuson-Stevens Act</td>
<td>Letter of Acknowledgement</td>
<td>NOAA Fisheries</td>
</tr>
<tr>
<td>To hold juvenile fish for scientific research</td>
<td>NOAA Fisheries</td>
<td>Magnuson-Stevens Act</td>
<td>Exempted Fishing Permit</td>
<td>NOAA Fisheries</td>
</tr>
<tr>
<td>To carry out activities necessary for the continued operation of existing commercial aquaculture</td>
<td>USACE</td>
<td>Rivers and Harbors Act</td>
<td>Nationwide Permit 48</td>
<td>US Army Corps of Engineers, Honolulu District; Fax: 808-430-4060</td>
</tr>
<tr>
<td>activities*</td>
<td>USACE</td>
<td>Rivers and Harbors Act</td>
<td>Section 10 Permit (aka Department of the Army Permit)</td>
<td>USACE Headquarters</td>
</tr>
<tr>
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</tr>
<tr>
<td>To create “any obstruction” in federal waters to preserve unhindered navigational access of the nation’s waters</td>
<td>To discharge into navigable waters while carrying out aquaculture projects in the open ocean OR (1) to produce more than 9,090 harvest weight kilograms of cold water fish or (2) produce more than 45,454 harvest weight kilograms of warm water fish for concentrated aquatic feeding operations</td>
<td>To inject wastewater and sludge from wells associated with aquaculture (Class V wells) underground</td>
<td>EPA</td>
<td>Clean Water Act</td>
</tr>
</tbody>
</table>

* Activities include installation of buoys, floats, racks, trays, nets, lines, tubes, containers, and other structures necessary for the continued operation of the existing commercial aquaculture activity. It also authorizes discharges of dredged or fill material necessary for shellfish seeding, rearing, cultivating, transplanting, and harvesting activities.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Agency</th>
<th>Document/Permit Required</th>
<th>Contact</th>
</tr>
</thead>
<tbody>
<tr>
<td>To take regulated marine life including young mullet from the ocean or</td>
<td>Hawaii Department of Land and Natural Resources (Division of Aquatic</td>
<td>Aquaculture Facility License</td>
<td>O'ahu (Main Office); ph: 808.587.0100</td>
</tr>
<tr>
<td>to acquire regulated marine life from non-ocean sources to stock their</td>
<td>Resources (Division of Aquatic Resources)</td>
<td></td>
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<tr>
<td>pond or facility with the intention of raising the marine life for</td>
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<tr>
<td>commercial purposes.</td>
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<tr>
<td>For any dealer, retailer, wholesaler, or restaurant to resell</td>
<td>Hawaii Department of Land and Natural Resources (Division of Aquatic</td>
<td>Aquaculture Dealer License</td>
<td>O'ahu (Main Office); ph: 808.587.0100</td>
</tr>
<tr>
<td>regulated marine life raised in a licensed aquaculture facility</td>
<td>Resources (Division of Aquatic Resources)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To participate in aquaculture activities that may have a negative</td>
<td>Hawaii Department of Land and Natural Resources (Division of Aquatic</td>
<td>EA/EIS</td>
<td>O'ahu (Main Office); ph: 808.587.0100</td>
</tr>
<tr>
<td>impact on the human environment</td>
<td>Resources (Division of Aquatic Resources)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>To participate in aquaculture activities in the open ocean (aquaculture</td>
<td>Hawaii Department of Land and Natural Resources (Land Division)</td>
<td>Conservation District Use Application</td>
<td>Office of Conservation and Coastal</td>
</tr>
<tr>
<td>sited in the US Exclusive Economic Zone)</td>
<td></td>
<td></td>
<td>Lands</td>
</tr>
<tr>
<td>To discharge pollutants into surface waters of the US (point sources</td>
<td>Department of Health</td>
<td>A revised NPDES permit</td>
<td>Clean Water Branch</td>
</tr>
<tr>
<td>of pollutants)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>To discharge</td>
<td>Department of Zone of Mixing</td>
<td>Clean Water Branch</td>
<td></td>
</tr>
<tr>
<td>Activity</td>
<td>Agency</td>
<td>Permit</td>
<td>Agency</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------</td>
<td>---------------------------------------------</td>
</tr>
<tr>
<td>Pollutants into surface waters of the US (point sources of pollutants)</td>
<td>Health</td>
<td>Permit</td>
<td></td>
</tr>
<tr>
<td>To construct and operate convenience centers (only residential waste, not more than 40 tons per day), green waste composting facilities (not more than three thousand tons per year), land clearing, grubbing, and certain agricultural and inert waste landfills, recycling and drop-off and processing facilities using single source separated material for reuse</td>
<td>Department of Health</td>
<td>Solid Waste Permit</td>
<td>Office of Solid Waste Management</td>
</tr>
<tr>
<td>To carry out aquaculture activities in special management areas (SMAs)</td>
<td>County of Hawaii (Planning Dept.); County of Kauai (Planning Dept.); County of Maui (Planning Dept.); City &amp; County of Honolulu (Dept. of Planning and Permitting)</td>
<td>County Special Management Area (SMA) Permit</td>
<td>Look at County Agencies</td>
</tr>
</tbody>
</table>

A precautionary approach must be adapted when planning long-term investments such as OOA projects (ODWG 2011). OOA still requires further study and analysis so it would be common-sense to approach OOA developments with an adaptable and watchful attitude. If OOA were to exist in the HIIWNMS, the sanctuary must ensure accountability to locals, stakeholders, developers, fishpond restorers, and other interests.
In order to do so, a transparent process is crucial to include groups within the community. Periodic updates on the HIHWNMS’s website and regular newsletters are ways to enhance solidarity and inform community members. Furthermore, direct consultation with those affected by sanctuary plans and evaluation of such results are other key aspects of improving accountability. Lastly, redress or correction to developments that cause unfavorable effects is vital for long-term sustainability. As expected, significant effort into monitoring developments as they take form is central to achieving sound accountability.

All in all, offshore aquaculture has become an emerging issue. Although food security is not an imminent threat to Hawaii and much of the United States, OOA should still be part of the discussion of coastal and marine spatial planning. Similar to issues such as global warming, long-term environmental problems need to be planned out as early as possible. Offshore aquaculture may become more of a reality as the human population increases and resources such as fish stocks continue to deplete. However, the main purpose of the HIHWNMS is resource protection, specifically the protection of humpback whales. For that reason, it would seem there currently are other viable alternatives to OOA sighting compared to within sanctuary boundaries. In coastal and marine spatial planning, environmental considerations need to be taken into account in addition to social and economic factors. Based on the preliminary analysis conducted in this paper, OOA is a nascent industry and should be researched more thoroughly before it takes place in a zone dedicated solely for resource protection. However, OOA should still be part of the discussion to prevent future decision-makers from being unprepared when offshore aquaculture becomes a serious driver to combat food security.
APPENDIX I

EXHIBIT 1, CHAPTER 13-124 - INDIGENOUS WILDLIFE OF HAWAI‘I

Indigenous Reptiles

*Pelamis platurus* - Yellow-bellied Sea Snake

*Caretta caretta* – Loggerhead Sea Turtle

*Chelonia mydas agassizi* – Pacific Green Sea Turtle

*Dermochelys coriacea schlegelii* – Pacific Leatherback Sea Turtle

*Eretmochelys imbricata bissa* – Pacific Hawksbill Sea Turtle

*Lepidochelys olivacea* – Olive Ridley Sea Turtle

Indigenous Mammals

*Monachus schauinslandi* – Hawaiian Monk Seal

*Balaenoptera physalus* – Fin Whale

*Balaenoptera acutorostrata* – Minke Whale

*Megaptera novaeangilae* – Humpback Whale

*Physeter catodon* – Sperm Whale

*Mesoplodon densirostris* – Densebeaked Whale

*Orcinus orca* – Killer Whale

*Pseudorca crassidens* – False Killer Whale

*Peponocephala electra* – Melon-headed Whale
*Globicephala macrorhynchus* – Pilot Whale

*Kogia bereviceps* – Pygmy Sperm Whale

*Tursiops gilli* – Pacific Bottlenose Dolphin

*Steno bredanensis* – Rough-toothed Dolphin

*Stenella attenuata* – Spotted Dolphin

*Stenella longirostris* – Spinner Dolphin

*Stenella coeruleoalba* – Striped Dolphin
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FAO. 2012. The state of world fisheries and aquaculture.


SGCP (Sea Grant College Program). 1923. Hawaiian newspaper translation project: fisheries. University of Hawaii Sea Grant College Program.
