Social Constraints and Solutions to Progressive Development of the Nation's Offshore Aquaculture Industry

- Final Technical Report -

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i. Glossary of Species

Common Name (local name)	Scientific Name
Almaco jack (kahala)	*Seriola rivoliana*
American oyster	*Crassotrea virginica*
Atlantic Cod	*Gadus morhua*
Atlantic Halibut	*Hippoglossus hippoglossus*
Atlantic salmon	*Salmo salar*
Bigeye tuna (‘ahi)	*Thunnus obesus*
Blue mussels	*Mytilus edulis*
Bluefin tuna	*Thunnus thynnus orientalis*
California halibut	*Paralichthys californicus*
California yellowtail	*Seriola lalandi*
Cobia	*Rachycentron canadum*
Dolphinfish (mahi mahi)	*Coryphaena hippurus*
Giant kelp	*Macrocystis pyrifera*
Giant rock scallop	*Hinnites multirugosus*
Green sea urchin	*Strongylocentrotus droebachiensis*
Mediterranean mussels	*Mytilus galloprovincialis*
Pacific threadfin	*Polydactylus sexfilis*
Purple-hinge rock scallop	*Crassadoma gigantea*
Red abalone	*Haliotis rufescens*
Red drum	*Sciaenops ocellatus*
Sea scallops	*Placopecten magellanicus*
Steelhead trout	*Oncorhynchus mykiss*
Striped bass	*Morone saxatilis*
Wahoo (‘ono)	*Acanthocybium solandri*
White seabass	*Atractoscion nobilis*
Yellowfin tuna (‘ahi)	*Thunnus albacares*

ii. Glossary of Terms

Economic Enterprise Zone - the sea or ocean zone over which a nation has exclusive rights of resource extraction. It encompasses waters from the shoreline out 200 nautical miles.

Federal consistency review – under the Coastal Zone Management Act, states are granted the rights and responsibilities to review activities that may have effects on coastal resources or uses to determine whether they are consistent with a state's coastal management program. This act and review process may provide states an opportunity to influence the development of aquaculture in federal waters.

Fishery Management Councils - Fishery management councils are quasi-regulatory bodies that develops fishery management and conservation measures for the EEZ. These measures are then implemented by NOAA's National Marine Fisheries Service. There are eight regional fishery management councils. The Gulf of Mexico Fishery Management Council is the first regional council to develop a comprehensive plan for the management of offshore aquaculture.

Integrated multitrophic aquaculture (IMTA) – the farming of finfish species that require feed in combination with shellfish and/or seaweed species that extract inorganic and organic compounds from surrounding waters. IMTA is promoted as a mitigation strategy for environmental impacts of finfish aquaculture.

Mariculture - refers to the breeding, raising, and harvesting of marine species in onshore facilities or in the ocean.

Open ocean/ offshore aquaculture – the terms are frequently use interchangeably to refer to aquaculture that is conducted in waters that are unsheltered by land and that are exposed to high energy wind and wave environment. For the purpose of our report, we use the term offshore to refer to the area beyond coastal jurisdictions but within a nation's Exclusive Economic Zone, and as such, is regulated primarily by federal agencies.

Southern California Bight – refers to coastline and waters from Point Conception in the north to San Diego in the south.

Gulf of Maine - includes waters from the south and west of Cape Sable, Nova Scotia to north of Cape Cod, Massachusetts; as such, the Gulf includes waters off the US coasts of Maine, New Hampshire and parts of Massachusetts.

iii. Glossary of Acronyms

CMSP – Coastal Marine Spatial Planning

CUSP – Coalition of U.S. Seafood Production

CZMA – Coastal Zone Management Act

EEZ – Economic Enterprise Zone

EPA – Environmental Protection Agency

FDA – Food and Drug Administration

FMP – Fishery management plan

GIS – geographic information system

IMTA – integrated multitrophic aquaculture

NEPA – National Environmental Policy Act

NGO – non-governmental organization

NMFS – National Marine Fisheries Service

NOAA – National Oceanic and Atmospheric Administration

NPDES Permit – national pollutant discharge elimination system permit

PEIR – Programmatic Environmental Impact Report

PEIS – Programmatic Environmental Impact Statement

PSP – Paralytic shellfish poisoning

USDA – United States Department of Agriculture

Social Constraints and Solutions for the Development of the Nation's Offshore Aquaculture Industry

Final Technical Report

1.0 Introduction

This is a final report on findings for the research project titled *Social Constraints and Solutions for the Progressive Development of the Nation's Offshore Aquaculture Industry*. The project has been cooperatively administered by the U.S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA) Oceanic and Atmospheric Research, and California Sea Grant College, to identify and analyze social factors that are constraining progressive development of the nation's offshore aquaculture industry. The research has also been designed to identify strategies that could serve to mitigate such constraints. The multi-regional approach is intended to facilitate understanding of geographic variability in constraining factors and overarching social context, and to generate lessons useful for informing offshore marine aquaculture planning processes as these relate to potential development along the entirety of the nation's EEZ. The study has been conducted to provide public and private sector entities with important descriptive information about the development and current status of offshore aquaculture, and analysis of expert perspectives on the current nature and future of industry and related policy matters. The report is intended to inform policy decisions on the future of offshore aquaculture.

The two-year project described in the following pages involved delivery of a series of reports, each intended to summarize and build upon findings from ongoing archival and primary source research conducted in each study region; that is, in the main Hawaiian Islands, the Southern California Bight, and the Gulf of Maine. The first interim report described the history and current status of marine aquaculture and open ocean aquaculture, including important infrastructure related factors associated with the siting of offshore operations. The report also outlined legislative, regulatory, and industry trends and conditions pertinent to the development of offshore aquaculture in each study region.

This final report updates information provided in the interim document, further elaborates on select aspects of the aquaculture regulatory process, and provides an analysis of the current challenges, unmet needs, and possible solutions for the development of offshore aquaculture as reported by experts both in archival sources and during fieldwork. We analyze the degree of consensus regarding social, environmental, and regulatory factors constraining development of offshore aquaculture nation-wide and in the respective regions and options for mitigation of identified constraints.

Impact Assessment and NOAA/Sea Grant. The study described in this report is being conducted by Impact Assessment, Inc., a social-science research firm that specializes in meeting the information needs of public agencies that regulate and manage public trust natural resources. The firm and its principals have conducted objective socioeconomic assessment and monitoring work around the coastal zone of the United States since 1980. They have supported public sector

agencies acting under National Environmental Policy Act, the Outer Continental Shelf Lands Act, the Endangered Species Act, the Oil Pollution Act, the Magnuson-Stevens Fisheries Conservation and Management Act, and other natural resource policies and mandates.

Under the authority of the Magnuson-Stevenson Fisheries Conservation and Management Act, NOAA's Office of Aquaculture has primary responsibility for the permitting of offshore marine aquaculture activities in United States Exclusive Economic Zone. The agency works toward this end in conjunction and consultation with other federal agencies, such as the US Army Corps of Engineers, the EPA, and the regional fishery management councils.

1.1 Understanding the Research Problem

World and domestic fish supply and demand. It is widely recognized that levels of production in the world's capture fisheries are not likely to increase substantially in the years to come, and that aquaculture has the potential to provide a reliable source of seafood for the world. In 2012, globally capture fisheries remained stable with a production of approximately 80 million tons of seafood, globally aquaculture operations increased production to more than 66 million tons of seafood, valued at some US $138 billion, and almost 24 million tons of aquatic plants (Food and Agriculture Organization of the United Nations 2014).

In the United States, per capita consumption of commercially-landed seafood has steadily declined over the last decade (2000-2010) while that of imports has increased (Lowther 2012). Currently 91% of the seafood consumed in United States is imported and the U.S. seafood deficit annually exceeds $10. 4 billion. The United States ranks third in the world in terms of seafood consumption, and first in terms of seafood imports.

Although five of the top ten seafood choices in US—shrimp, salmon, catfish, tilapia, and clams—are commonly farm-produced, the United States ranks 15th in terms of world aquaculture production, with imports of farmed seafood far exceeding those domestically produced (cf. National Marine Fisheries Service 2011). In 2012, US contributed only .6% of the world production of aquaculture (fresh and marine, land and water based); whereas China contributed 61.7% (Food and Agriculture Organization of the United Nations 2014).[1] **Table 1-1** below indicates recent domestic trends in commercial landings; seafood consumption; and imports.

Table 1-1 Annual U.S. Commercial Landings, Edible Imports, and Per capita Consumption of Seafood: 2003-2012

Year	Commercial Landings* (in millions of lbs.)	Edible Imports (in thousands of lbs.)	Per Capita Consumption of Seafood (in lbs.)
2003	7,521	4,907	16.3
2004	7,794	4,951	16.6
2005	7,997	5,115	16.2
2006	7,842	5,400	16.5
2007	7,490	5,346	16.3
2008	6,633	5,226	16.0
2009	6,198	5,161	16.0

[1] In 2012, the 15 top aquaculture producing countries, with their percentage of world share, were as follows: China (61.7%), India (6.3%), Vietnam (4.6%), Indonesia (4.6%); Bangladesh (2.6%), Norway (2.0%), Thailand (1.9%), Chile (1.6%), Egypt (1.5%), Myanmar (1.3%), Philippines (1.2%), Brazil (1.1%), Japan (1.0%), Republic of Korea (.7%), and the United States (.6%) (Food and Agriculture Organization of the United Nations 2014)

Year	Commercial Landings* (in millions of lbs.)	Edible Imports (in thousands of lbs.)	Per Capita Consumption of Seafood (in lbs.)
2010	6,526	5,447	15.8
2011	7,909	5,349	15.0
2012	7,477	5,384	14.4

*Fish and shellfish landings for human consumption

Domestic Marine Aquaculture Potential and Benefits. According to a recent global assessment of marine aquaculture potential, the Unites States ranks high. The United State's Exclusive Economic Zone (EEZ), over which the nation has exclusive rights of resource extraction, is the second most expansive in the world (c.f. Kapetsky et al. 2013).[2,3] Assessed in terms of important siting criteria of cost effectiveness, current speed, and depth, US EEZ ranks 1st, 3rd, and 4th in size.[4,5] Integrating the three factors of depth, current speed and cost effectiveness, there is approximately 7,500 square kilometers of suitable area within US EEZ (Kapetsky et al. 2013: 25). Additionally, the zone encompasses a wide range of ocean ecosystems, including high Arctic, subarctic, temperate, subtropical, and tropical. **Figure 1.1** depicts the size of EEZ and current marine aquaculture production for 13 top aquaculture producing nations.

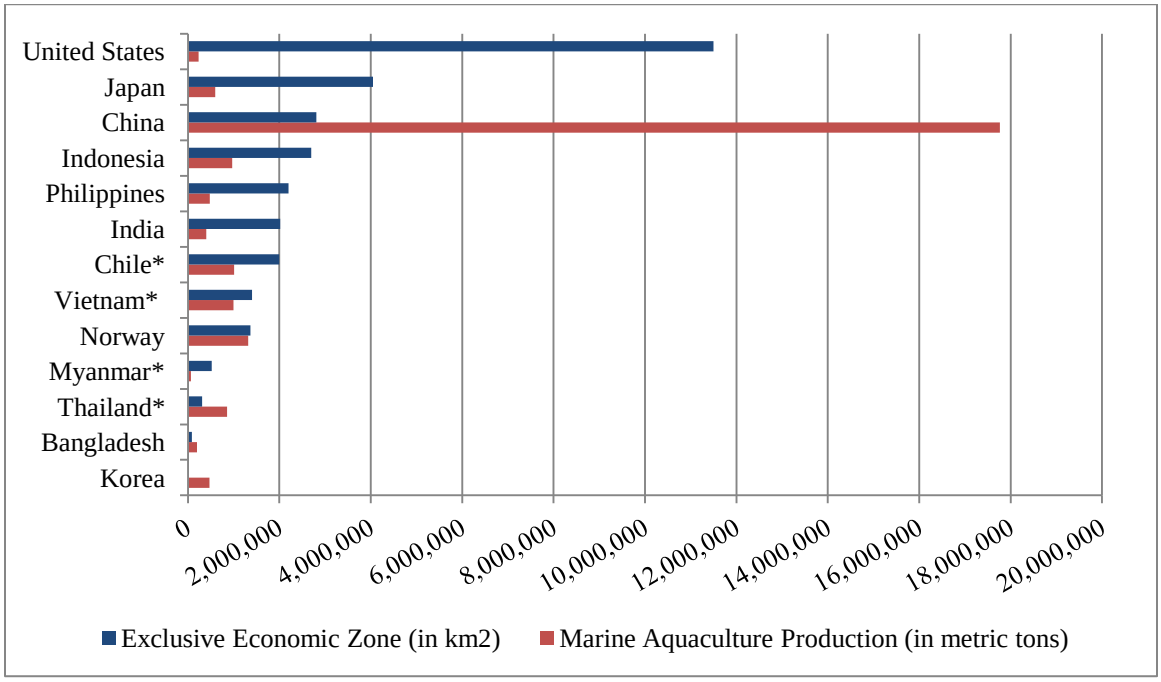


Figure 1-1 Marine Aquaculture Production in relation to size of EEZ
Sources: Sea Around Us Project n.d.; Food and Agriculture Organization 2014 and n.d. (* information regarding EEZ size was accessed from Sea Around Us Project)

[2] The Exclusive Economic Zone (EEZ) encompasses waters from the shoreline out 200 nautical miles.
[3] Only the French Republic has a larger EEZ and much of this area is associated with overseas territories.
[4] Suitability criteria were defined as follow: depths of 25-100 meters; currents of 10-100 centimeters per second; and areas within 25 nautical miles from an accessible port. The former two thresholds were based on manufacturer specifications and current practices of aquaculture operators.
[5] The United States has approximately 587,387 km^2 of suitable waters for mariculture based on cost-effectiveness; 1,190,441 km^2 based on depth; and 8,277,236 based on current speed.

There are many economic, social and ecological benefits associated with developing the marine nation's aquaculture industry. Marine aquaculture can reduce dependence on imports, increase national seafood self-sufficiency, supplement the economies of commercial fishermen, reinvigorate working waterfronts, support seafood producing and distributing infrastructure, and create new jobs. The development of the industry can increase the supply and year around availability of a healthy food choice. High in protein, low in calories and saturated fats, high in important omega-3 fatty acids, and rich in vitamins and minerals, seafood is a healthy food choice. New federal guidelines supported by leading health organizations recommend that adults eat 12 ounces of seafood weekly: currently Americans consume on average only 3.5 ounces per week (USDA and U.S. Department of Health and Human Services 2010).

Marine aquaculture may take the fish pressure off wild fish populations and reduce the demand on land and fresh water resources. Recent scientific findings indicate that the feed conversion ratios of fish rate favorably with those of chicken, pork, and beef suggesting that aquaculture is an efficient form of protein production[6] (cf. Goldman 2012, Hall et al. 2011). The consumption of locally produced seafood may also replace need to transport seafood caught or farmed abroad and thus has the potential to reduce carbon footprint of our seafood.

Although the United States has a long history of aquaculture research and technological expertise in marine aquaculture, the industry has faced challenges from competing marine users and opposition from shoreline residents, and in relation to concerns about the environmental impact of aquaculture operations. This has led aquaculture entrepreneurs and experts to explore industry opportunities abroad. The promotion of aquaculture, outside of the coastal and near shore areas, in open ocean waters has been promoted as a way to reduce many of these challenges.

The benefits and liabilities of offshore aquaculture as a means for meeting market demand for seafood in the United States have been the subjects of intense public debate and political contestation. To date, concerns regarding the potential impact to marine ecosystems, capture fisheries, and various ocean user groups have stalled the implementation of formal policy for guiding aquaculture activities in the nation's federal waters. The topical focus of our research was chosen based on the recognition that an in-depth social science research effort could improve understanding of: the issues around which public debates about offshore aquaculture are focused; the policies and practices of public sector agencies that maintain regulatory authority over offshore aquaculture; potentially competing uses of the ocean; and socioeconomic factors influencing the developing offshore industry.

1.2 Overarching Research Goal and Underlying Rationale

The overarching goal of this project is to examine existing regulatory policies regarding aquaculture activities as they could occur in the offshore ocean adjacent to the nation's coastal states, and to contribute pertinent information and analysis needed to develop an overarching federal policy framework in keeping with standards set by the National Environmental Policy Act (NEPA) and other existing legislation. In addition, the project provides specific understanding of the spatial parameters associated with active and prospective offshore

[6] Protein conversion ratios for fish (carp), chicken, pork and beef are 30%, 25%, 13% and 5% respectively. Additionally, shellfish –such as mussels, clams, and oysters require no feed as they filter nutrients from the ocean environment. The higher conversion ratios of fish are because they do not expend energy maintaining body temperature and do not have extensive and robust skeleton systems (cf. Hall et al. 2011:45).

aquaculture operations, and serves to identify mitigating solutions to potential spatial conflicts between such operations and other uses of the open ocean/near-shore zone, and land-sea interface. The research also provides information and analysis of social, economic, and cultural factors that have in the past limited, or are in the future likely to continue to limit, advancement of aquaculture in the nation's federal waters. Finally, the research generates strategies for mitigating any potentially deleterious impacts of offshore aquaculture development, especially as these relate to human populations—again, in keeping with the intent of the NEPA and other existing federal and state legislation and policy guidance.

1.3 Pertinent Research Questions and Associated Research Methods

The following research questions constitute the principal focus of the current study:

(1) What is the present status of federal and state regulatory policies regarding offshore aquaculture? Do the involved representatives of pertinent state and federal resource management agencies believe they possess sufficient understanding of key social, spatial, cultural, economic, and environmental aspects of the offshore aquaculture industry as needed to make fair and equitable regulatory decisions regarding its future status in the nation's federal waters? If not, what information do they require to develop a legal and effective regulatory structure?

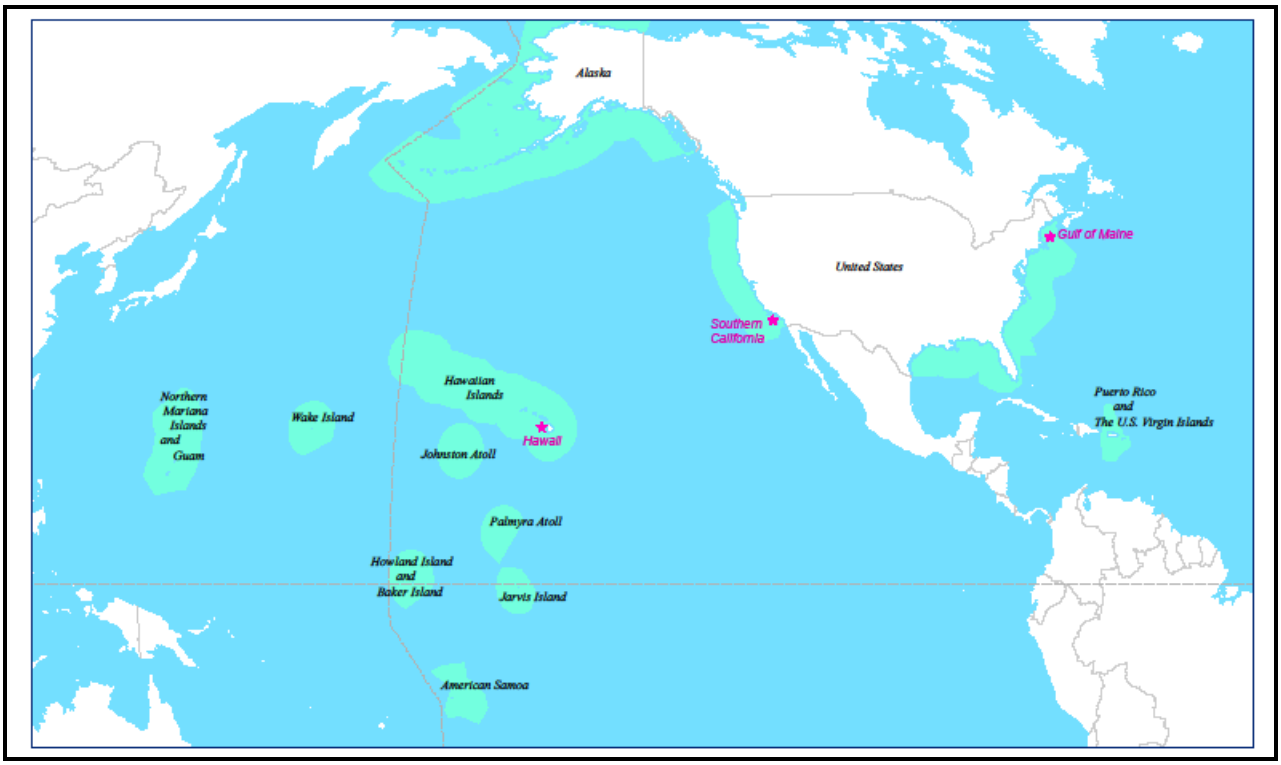
(2) What are the most critical social constraints on the progressive development of the industry—as envisioned or experienced by key industry representatives, involved public officials, and other concerned persons and groups; where such constraints include matters of policy, economic challenges or impacts, technical problems, opposing cultural perspectives, competition for ocean space, and/or potentially manageable ecological impacts?

(3) How might the principal social constraints on progressive development of offshore aquaculture identified in (2) above be obviated or alleviated to enable progressive development of the offshore industry—as indicated by the reported perspectives, knowledge, and experiences of key industry representatives, involved public officials, and other concerned persons and groups?

Our research efforts involve conduct of multiple in-depth interviews with key players, ethnographic observation, recording of field notes, and archival research. Potential partners for in-depth interviews are identified through a snow ball sampling method (cf. Bernard 2002). The sampling approach prioritizes identification of topical and technical experts involved in permitting, regulating, and developing offshore aquaculture, as well as public officials and key persons with an interest in offshore aquaculture. Our approach ensures that the research is conducted in a highly systematic way; that the data generated is qualitatively rich and quantifiable; and that the analysis is of direct utility for policy deliberations.

Case Study Approach. This research uses a case study approach focusing on three areas/regions of Hawaii, Southern California and Gulf of Maine. **Map 1-1** depicts the nation's Exclusive Economic Zone and our case study areas. A multi-regional approach was chosen to facilitate understanding of geographic variability in constraining factors and overarching social context. The three regions were chosen by consulting with knowledgeable persons within the field of aquaculture research; the aquaculture industry, and regulatory agencies. The regions were

chosen due to their varying degrees of involvement in marine aquaculture research and commercial production and the reported potential for offshore aquaculture development. The particular status of marine aquaculture research, regulatory management, and commercial operations for the three regions are outlined in the body of this report. This study also includes the documentation and analyses of information in select other regions where experts note existing development potential, for example, the Gulf of Mexico.



Map 1-1 United States Exclusive Economic Zone and Case Study Areas

Forms of Data. Research was conducted with an overarching ethnographic approach to ensure the validity and reliability of our research instruments, data, and final assessment. The components of this approach include: archival research; field observation; and in-depth ethnographic interviewing.

The objective of archival research was to identify ongoing factors affecting the development of offshore aquaculture; including developments in technology, scientific knowledge, stakeholder collaborations, policy formulations, and marine spatial planning; and outcomes of currently proposed offshore aquaculture projects. Archival research included the following types of materials:

(1) **Technical reports** developed by or for government agencies including environmental assessment/impact statements of proposed projects, legislative hearings, white papers, and aquaculture workshop proceedings, and lecture series;

(2) **Scientific journal articles** on environmental impacts, best management practices, economic evaluation, and consumer studies of aquaculture;

(3) **GIS data sources and software programs** for use in open ocean aquaculture siting projects; and,

(4) **Sociologically-informed theoretical research** on resource management in general and aquaculture more specifically.

Ethnographic fieldwork was conducted in two phases. Phase One was initiated in California, Hawaii, and the Gulf of Maine region in January, April, and September of 2013, respectively. Phase Two was conducted in California, Hawaii, and the Gulf of Maine region in June, April, and August of 2014, respectively. Additional interviews were conducted in California and Hawaii in October and December of 2014, respectively. 131 interviews were conducted; interviews varied in length from 30 minutes to one and half hours.

A wide range of experts in the various study regions and in various aquaculture sectors were consulted during the course of the project and thereby contributed significantly to development of the description and analysis. Meetings were held with staff members in county, state, and federal agencies that are involved in permitting and/or promoting aquaculture in state and federal waters; entrepreneurs, operators, and private consultants involved in the development of open ocean aquaculture in state and federal waters; and university affiliates currently involved in research germane to the development of aquaculture in federal waters. Some expert respondents were interviewed multiple times. In addition to one-one on interviews, researchers attended a Global Aquaculture Alliance Standards meeting, California Coastal Commission public hearing for proposed federally sited aquaculture operation in California, and World Aquaculture Society Meeting in Seattle. **Table 1-2** below depicts the distribution of respondents across geographical location and by sector.

Table 1-2 Interview Respondents by Category

Category of Respondent	Location				Total
(Quasi) Government Agency	California	Hawaii	Gulf of Maine	Other	
Federal	2	7	3	8	20
Regional	0	1	1	2	4
State	4	4	3	0	11
County	0	1	0	0	1
Aquaculture Industry	8	7	5	2	22
University/Research	3	4	8	1	16
Non-profit	5	0	5	4	14
Fishing Community	2	6	3	0	11
Other	2	2	3	0	7
Total	**26**	**32**	**31**	**17**	**106**

Objectives for phase one field work included: the development of working relationships with key industry representatives and staff at regulatory agencies; the conduct of focused preliminary interviews; and ongoing identification of pertinent literature and data collected by or produced for a variety of agencies active in the region. Preliminary meetings were also used to identify other topical and technical experts and assess opportunities to participate in local aquaculture development meetings hosted by government agencies, industry, universities, and non-profit organizations. Substantive discussions focused on the general topics of:

(1) The status of open ocean aquaculture activities in the region, including past proposals, current operations, and projects currently in the planning process;

(2) The history, current role, and recent activities of agencies and institutions involved in the regulation and/or promotion of aquaculture;

(3) Recent technological or regulatory developments in the industry and region;

(4) Siting factors associated with development of aquaculture operations in the nation's federal waters, including, but not limited to: climatic and oceanic conditions, bathymetric considerations, location in relationship to ports and markets, spatial conflicts, supporting infrastructure, and community response.

Respondents were also specifically queried on their understanding of regulatory, socio-cultural, and/or economic factors constraining the development of offshore aquaculture in the region; and understanding of possible solutions for mitigating such constraints.

Phase two interviewing focused on: previously identified pertinent regulatory and management developments at state and federal levels including the permit review process for aquaculture operations sited for federal waters. Some key respondents were interviewed again in Phase Two in order to update in the progress made in permitting specific projects or general regulatory issues. Iterative interviews with key respondents also allowed us to refine our understanding of key issues.

Phase two research also included the expansion of interview sample to include stakeholders within the environmental non-government organizations and other non-profit organizations. The primary topics of inquiry included: the organization's general history and mission; views on aquaculture in general and open ocean aquaculture more particularly; current strategies for and involvement in influencing the course of aquaculture development; and history of engagement/collaboration with other conservation groups, the aquaculture industry, and regulatory agencies. Analysis has focused on identifying consensus regarding the development of marine aquaculture; opportunities for agencies and industry to work with this stakeholder group; and strategies for conveying accurate messages to the general public regarding need for, possible impacts of, and current scientific knowledge of open ocean aquaculture.

Additionally, the second phase of research included: (1) the review and assessment of GIS data sources that constitute an essential element in siting projects, and (2) a consideration of the current status of marine spatial planning in each region. Interviews and literature review have been conducted to assess the current kinds, public availability, and usefulness of data to site operations and assess possible user conflicts.

1.4 Organization of the Document

Chapter Two provides an overview of the current status of marine aquaculture production nationally and the development of offshore aquaculture more specifically. The chapter also details the federal agencies with regulatory authority over offshore aquaculture and recent federal legislative and administrative attempts to develop a policy framework for the conduct of aquaculture in federal waters.

Chapter Three focuses on recent regional and local processes for permitting aquaculture operations in federal jurisdiction waters. We outline the provisions contained within the Gulf of Mexico Fishery Management Plan for Offshore Aquaculture and the permitting and monitoring requirements of commercial shellfish farms in offshore waters of Massachusetts and California. Additionally, we discuss debates regarding specific management measures and provide an analysis of different regional approaches to furthering the development of regulatory framework for offshore aquaculture.

In chapters Four through Six, we focus on our case study areas of Hawaii, California, and the Gulf of Maine, and assess the potential for aquaculture development in federal waters. Our assessment of the potential for offshore aquaculture development considers such factors as oceanographic conditions, demographics and market conditions, expertise in conducting and regulating open ocean aquaculture, shore-side support infrastructure, and current status of industry interest in establishing offshore aquaculture operations. One chapter is devoted to each study area. Appendix A provides in table form of comparative assessment of the three case study areas.

Chapter Seven focuses on the involvement of non-governmental organizations (NGO) in the development of aquaculture in United States. NGOs have been avid interlocutors in debates regarding the development of aquaculture in state and federal waters and have been influential in the creation and implementation of domestic marine aquaculture policies and regulations. The chapter includes summary discussions of: the principle environmental and social concerns held by NGOs; NGO engagement in and strategies to influence the development of marine aquaculture; and current NGO efforts to further the development of environmentally sustainable offshore aquaculture.

Chapter Eight focuses on factors that condition the siting of marine aquaculture operations in open ocean environments. Appropriate siting of aquaculture operations is well recognized as an important mitigation strategy for addressing potential environmental impacts as well as social conflicts. The purpose of this chapter is four-fold: 1) describe the kinds of criteria and the goals and rationale of siting; 2) explain the purpose of marine spatial planning and current status of efforts in our case study regions; 3) provide an overview of the availability and utility of GIS data and analytic models; and 4) analyze current debates regarding aquaculture zoning. The goal of the analysis is to help: prioritize future GIS data collection efforts and define the purpose of marine spatial planning to better serve agency and industry needs.

Chapter Nine provides a summary of the human/social dimensions which have constrained the development of offshore aquaculture in United States. The purpose of the chapter is to provide: 1) a summary of policy, social, and economic challenges to the development of the nation's offshore aquaculture industry; 2) a discussion of the efforts to resolve these challenges; and 3) an overview of strategies to mitigate environmental impacts.

2.0 Marine Aquaculture Production in the Nation

2.1 Definitions

Aquaculture encompasses the cultivation of a wide variety of species of fish, mollusks, crustaceans, and plants through a variety of different methods and for different purposes, including human consumption, bait, stock enhancement, medicinal use, and aquarium decoration. Marine aquaculture, also commonly called *mariculture*, refers to the breeding, raising, and harvesting of marine species.

Mariculture can be conducted on land, in enclosed tanks, ponds or channelized systems, called raceways, or in the ocean. Ocean mariculture is further distinguished by environmental zone – *inshore, nearshore* or *coastal*, and *offshore* or *open ocean*. Inshore and coastal waters are afforded degrees of shelter by the land in contrast to waters of the open ocean or in the offshore zone. Relative to coastal waters, the offshore is exposed to relatively high energy wind and wave environment. As one moves from the shelter of land, the absolute force of oceanographic conditions varies considerably in different regions of the United States. For example, the oceanographic conditions in the coastal zone of the Gulf of Maine may frequently exceed the intensity found in the offshore zone of Southern California.

It should be noted that the terms offshore and open ocean aquaculture are frequently used interchangeably and refer to an environmental zone. Offshore aquaculture, however, is also often used to refer to that subset of marine aquaculture that occurs beyond the jurisdictions of states and within a nation's Exclusive Economic Zone, and as such is regulated primarily by federal agencies. This is the intent of our usage. In the United States, the offshore designation encompasses areas from three miles to 200 miles from the shoreline, with the exception of Western Florida and Texas, where state jurisdiction extends to nine miles offshore. To avoid possible confusion, we occasionally refer to offshore aquaculture as aquaculture occurring in federal jurisdiction waters.

2.2 Select Aquaculture Statistics

In 2013, there were 3,093 aquaculture farms within the United States, with a total production value of approximately $4 billion.[7] This represents a 28% decrease in number of farms but 26% increase in production value from the last aquaculture census, which was undertaken in 2005 (cf. USDA 2006). Marine, or saltwater, aquaculture makes up a minor percentage of aquaculture in the United States. In 2013, as in 2005, approximately 28 percent of the farms in United States were located in natural or sourced saltwater. Also in 2013 24 states had at least one farm that engaged in marine aquaculture, up from 22 in 2005. **Figure 2-1** below depicts the number and percentage of saltwater farms relative to the total number of aquaculture farms for the 24 states.

[7] In 2013, the U.S. Department of Agriculture conducted the third national census of the aquaculture sector, providing a comprehensive and comparative view of aquaculture across all states.

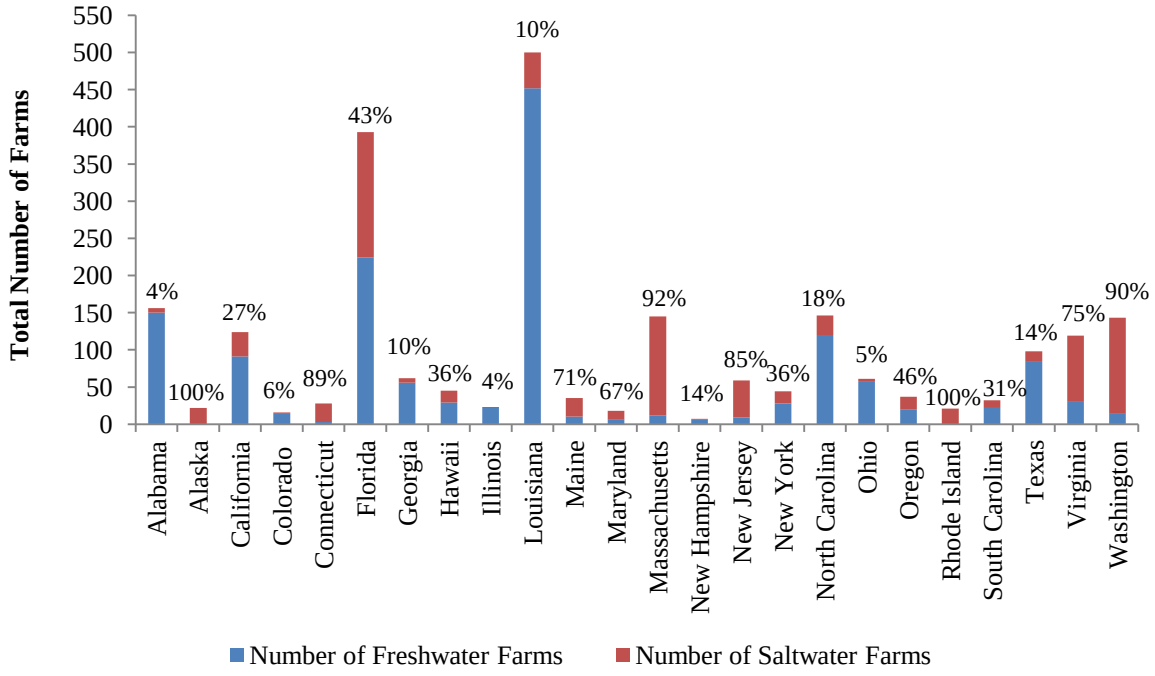


Figure 2-1 State Participation in Marine Aquaculture (2013)
Source: USDA 2014

Marine aquaculture in the United States has largely been limited to sheltered and shallow nearshore waters, inshore bays, onshore facilities where saltwater is pumped into tanks, channelized systems (often called "raceways"), and saline ponds. To date, few farms have been proposed or operated in deeper less sheltered open ocean waters and only recently has one been emplaced in federal waters. **Figure 2-2** below depicts the number of farms (freshwater and marine) by select production method (2013) for the five states of Hawaii, California, Maine, New Hampshire and Massachusetts; the latter three lie solely or partially within the Gulf of Maine. We also depict data for Florida, which has been identified by industry respondents as having potential for the development of offshore aquaculture.

Massachusetts, California, Hawaii, Maine and New Hampshire ranked 6th, 8th, 17th, 20th, and 40th in the United States, respectively, in terms of the total number of farms, and 16th, 5th, 9th, 10th, and 39th, respectively, in terms of total production value. Florida ranked 2nd in terms of total number of farms and 6th in terms of total production value. Of the five states, California has the highest percentage of farms (10 percent) producing fish for recreational stock enhancement; Florida had the highest percentage of farms (3 percent) producing bait fish. Florida also led the United States in the production of ornamental fish with 127 farms producing over 27 million dollars.

The percentage of farms located in natural or sourced saltwater are as follows: Massachusetts (92%), Maine (71%), Hawaii (36%), California (27%), and New Hampshire (14%). The majority of marine aquaculture in the United States is focused on the cultivation of mollusks (USDA) 2014).

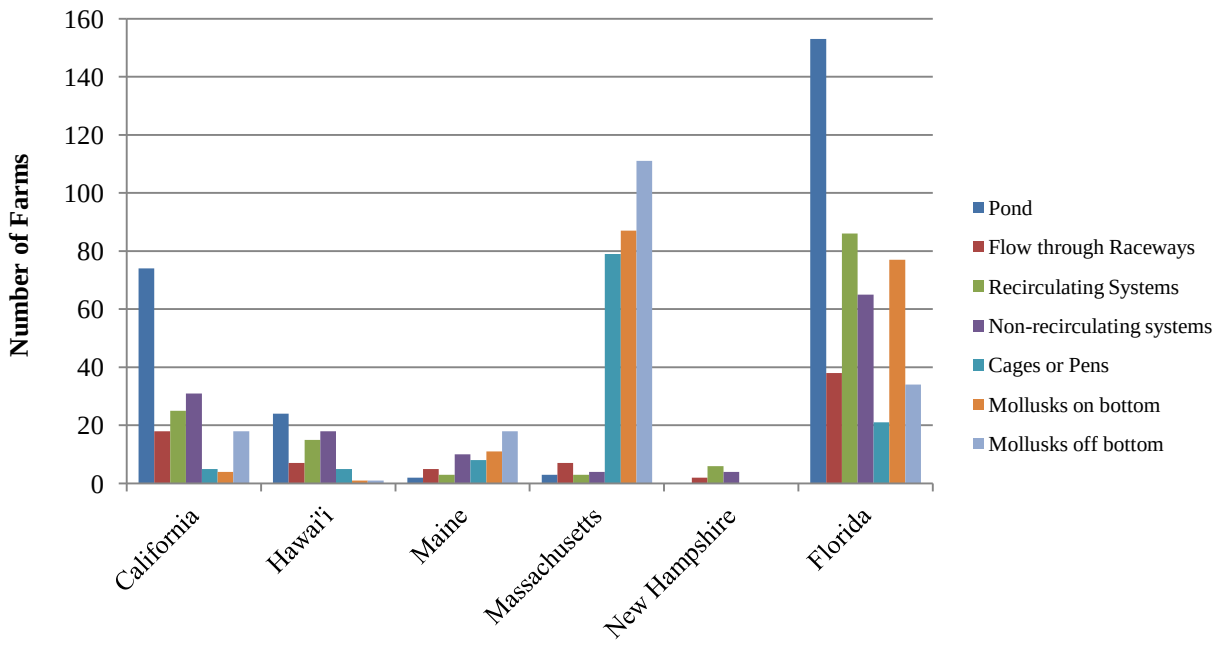


Figure 2-2 Aquaculture by Production Method (2013)
Source: USDA 2014

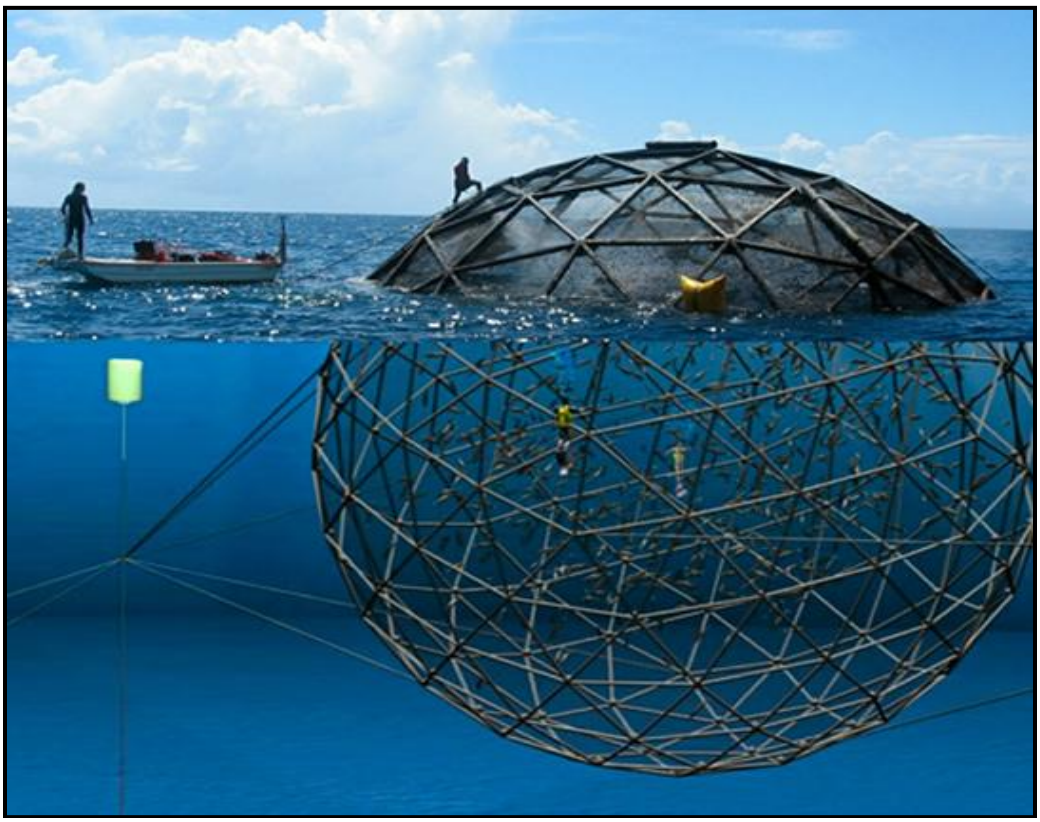
2.3 Status of Offshore Aquaculture Development

The open ocean environment requires aquaculture systems and servicing vessels that can sustain severe sea conditions. Technological advancements in cages –such as the Ocean Spare, the telemetry controlled Oceansphere, the surface predator resistant Aqualine system for finfish, and the Cupod submerged long lines shellfish aquaculture - are enabling expansion into open ocean environments. Depicted below is the Cupod.

Relative to inshore operations, offshore aquaculture systems, particularly those for finfish, are highly capital intensive and require large investments. The more exposed, deeper, and more distance conditions associated with offshore aquaculture translate into higher engineering and operating costs and may require the use of automated systems to carry out operational functions. The more advanced technology in turn requires better trained and more expensive personnel, usually with ability to dive, handle large boats, and utilize advanced technology (cf. Kapetsky and Aguilar-Manjarrez 2007). To make up for these higher costs, generally operations must be larger in scale and/or culture high valued species.

Although operating in the offshore environment is challenging and costly due to exposed conditions, unpredictable weather, and distance from land operations, development is being promoted as a way to reduce many of the challenges that have been associated with marine aquaculture in coastal waters, for example, space use conflicts; aesthetic concerns expressed by contiguous landowners and residents; and environmental problems associated with nutrient loading (cf. Bridger 2004; Watson and Drum 2007; Price and Morris 2013). Studies indicate that

impacts to water quality, benthos, micro and macrofauna communities related to nutrient pollution and fish metabolic functions are minimal in offshore locations where greater mixing occurs because of stronger currents and greater depths (cf. Price and Morris 2013). Offshore waters also tend to have less fluctuation in water temperature and salinity, higher dissolved oxygen, and lower nutrient levels than inshore waters, characteristics which are beneficial to farmed finfish health (cf. Bridger 2004). Additionally, offshore waters may hold promise for increased fish growth and improved health while being more suitable for ocean species that also offer higher market values (cf. Bridger 2004; Kirchhoff et al. 2011; Corbin 2010).



Photoillustration 2-1 Cupod Offshore Aquaculture System
Source: National Geographic News 2010

Federally funded research has been conducted to support the development of aquaculture in open ocean environments. Through NOAA, the USDA, National Science Foundation, and Department of Commerce Small Business Administration, the federal government has supported aquaculture research at regional science centers and universities and in the private sector Research has been conducted to advance: hatchery technology; brood-stock development; cage design; feed formulations; and software modeling of environmental impacts (cf. Cicin-Sain et al. 2005; McVey 2007; Rust et al. 2011). Additionally demonstration farms have been placed in open ocean environments to examine species viability and grow rates, test operational systems, and monitor environmental impacts

While some federal agencies, universities, and entrepreneurs have actively promoted the expansion of aquaculture activities into offshore federal waters, an uncertain regulatory climate

has complicated the development of an industry. Until recently, aquaculture operations sited in federal waters have been permitted only for short-term research purposes.

Regulatory Framework. Currently, multiple laws extend federal authority across multiple agencies including: the National Marine Fisheries Service, United States Army Corps of Engineers, the United States Coast Guard, the EPA, US Fish and Wildlife Services, the FDA, and the Department of Agriculture (cf. Cicin-Sain et al. 2001; United States Commission on Ocean Policy 2004). These agencies have different statutory authorities and functions regarding the regulation of aquaculture. **Table 2-2** below provides an outline of the primary federal agencies, their authority, and functions vis-à-vis aquaculture.

Table 2-1 Federal Agencies involved in Permitting, Regulating, or Supporting Offshore Aquaculture

Regulatory Agencies	Statutory Authority	Function
National Oceanic and Atmospheric Administration-National Marine Fisheries Service and National Ocean Services	• Endangered Species Act • Marine Mammal Protection Act • National Marine Sanctuaries Act • Magnuson-Stevens Fishery Conservation and Management Act	• Reviews operations for impacts on marine mammals, protected resources, essential fish habit and sanctuaries resources • Issues permits with regional fishery management councils for federally managed species.
U.S. Army Corps of Engineers	• Rivers and Harbors Act • Clean Water Act • Marine Protection, Research and Sanctuaries Act • National Historic Preservation Act • National Environmental Policy Act (NEPA)*	• Issues permits for activities taking place in or on structures located in navigable waters; discharge of dredge or fill materials in U.S. waters; and any device attached to the seafloor that may pose a threat to navigation. • Issuance of permit requires consultations with: NOAA, U.S. Fish and Wildlife Service; Coastal Zone Management; Historic Preservation Department; and Environmental Protection Agency.
U.S. Coast Guard	• Outer Continental Lands Act • Merchant Marine Act	• Requires structures be properly marked/lighted to ensure safe navigation. Certifies vessels over five tons.
U.S. Environmental Protection Agency	• Clean Water Act • Marine Protection, Research and Sanctuaries Act • National Environmental Policy Act	• Issues NPDES** permits required by certain facilities, depending on aquaculture species and production size, and permits for discharge of dredge or fill materials in U.S. waters.
U.S. Fish and Wildlife Service	• Endangered Species Act • Lacey Act	• Reviews operations to determine no impact on recovery programs for endangered species. Prohibits the introduction of non-native and potentially harmful wild species.
Advisory Council on Historic Preservation	• National Historic Preservation Act	• Reviews operations to determine effect on historic resources.
Food and Drug Administration	• Federal Food, Drug, and Cosmetics Act • Public Health Service Act	• Approves drugs or feed administered to animals. Also regulates seafood shipped or received in interstate commerce for safety and accurately packaging.

Regulatory Agencies	Statutory Authority	Function
U.S. Department of Agriculture, Animal and Plant Health Inspection Service	• Animal Health Protection Act	• Responsible for preventing, controlling, and eliminating aquatic animal diseases.
Bureau of Ocean Energy Management, Regulation and Enforcement	• Outer Continental Lands Act • Energy Policy Act	• Issues permits for alternative use of platforms on the Outer Continental Shelf • Collects royalties for leased federal lands in the Outer Continental Shelf
Office of Ocean and Coastal Resource Management	• Coastal Zone Management Act	• Conducts federal consistency review of operations • Issues guidelines and assists states with aquaculture components of state coastal zone management plans.

*National Environmental Policy Act ** National Pollution Discharge Elimination System
Sources: United States Commission on Ocean Policy 2004; Cicin-Sain et al. 2001; Aquaculture Planning and Advocacy LLC 2011

The National Marine Fisheries Services, within NOAA, has an extensive role, interest, and expertise in commercial and recreational use of the ocean and conservation and protection of marine resources. As such it has been identified in major reviews of US ocean policy as the most suitable federal agency to create and oversee a public permitting process (cf. Cicin-Sain et al. 2005; United States Commission on Ocean Policy 2004).

Federal agencies are faced with how to apply their regulatory responsibilities as a nascent industry seeks to use federal waters to respond to seafood demand. Federal agencies will not be alone in facing the challenge of regulating and managing the developing offshore aquaculture industry. Regional regulatory agencies—such as the regional fishery management councils[8]—and state agencies also have an interest. The Coastal Zone Management Act confers to states the authority to undertake a federal consistency review for activities proposed for federal waters that may potentially impact state waters and/or adjacent coastal lands (cf. National Sea Grant Law Center 2014).[9],[10]

[8] Fishery management councils are quasi-regulatory bodies that develops fishery management and conservation measures for the EEZ. These measures are then implemented by NOAA's National Marine Fisheries Service. There are eight regional fishery management councils.

[9] To receive the right to review an aquaculture permit application, the state agency with CZMA authority must make a request within 30 days of the public notice of the application submission and present a case that that project would impact state resources to the Director of NOAA's The Office of Ocean and Coastal Resource Management. Should the review be granted, the applicant and the permitting agency, the Army Corps of Engineers, must agree to all conditions set by the state agency that are within its authority. If the state agency objects to the project, the applicant may appeal to the Secretary of Commerce. The Secretary of Commerce can override the state's objection if a project is deemed consistent with the objectives or purposes of the Federal Coastal Management Act, or is in the interest of national security (cf. National Sea Grant Law Center 2014). The ultimate determination of the applicability of state laws within the EEZ thus lies with the Department of Commerce. The granting of the right to review a given activity does not set precedence for future requests.

[10] Within our study regions the following state agencies have the authority and responsibility to conduct federally consistent reviews: California Coastal Commission; Office of Planning, Hawaii Coastal Zone Management Program; Maine State Planning Office; New Hampshire Department of Environmental Services, Coastal Program; and Executive Office of Environmental Affairs, Coastal Zone Management. Of note, California and Rhode Island

Recent Legislative and Administrative Efforts. Various attempts have been made over the past decade to develop a policy framework for offshore aquaculture. In 2004, following a US Commission on Ocean Policy recommendation to increase support for marine aquaculture development, President Bush issued the U.S. Ocean Action Plan, committing the administration to transmitting offshore aquaculture legislation to the 109th Congress. National legislation was subsequently introduced in 2005 and 2007 (as H.R. 2010 and S.1609).

The Acts proposed authorizing the Department of Commerce to issue offshore aquaculture permits; establish requirements for environmentally responsible aquaculture; and develop a coordinated and streamlined process with other agencies. The 2007 National Aquaculture Act was heard before the House Committee on Natural Resources. Objections were raised regarding economic, environmental, and health impacts and concerns were also expressed regarding the inability to adequately monitor and provide public and government oversight to the new industry, amongst other issues (cf.US Government Printing Office 2006). The bills were opposed by commercial fishing, environmental, and food safety organizations. No further action was taken on these bills.

In 2009 (H.R. 4363) and 2011 (H.R. 2372), another attempt was made to pass national legislation, this time modeled on legislation passed at the state level in California in 2006, California's Sustainable Ocean Act. The requirements and provisions within both the state and national acts sought to addresses significant problems with marine finfish cage aquaculture as understood by the environmental community. The two acts promote a "precautionary approach," establishing a priority for the protection of marine ecosystems, habitats, and wildlife, as a guiding principle for the development of the aquaculture. The National Act also sought to rectify what some perceived as a lack of specificity regarding previously proposed national legislation. The National Act (of 2009-2011) required that the marine planning as a part of or precursor to siting offshore aquaculture facilities; conduct of coordinated regional programmatic environmental impact studies (PEIS); establishment of numerical standards to assess environmental effects of nutrient waste; and tagging of stock to monitor escapes. Additionally, the Act sought to prohibit: (1) the farming of genetically modified fish, non-native fish species, and broodstock further than two generations removed from wild stock; (2) the locating of aquaculture on offshore oil and gas platforms; (3) the establishment of exclusive permit sites (which would impede the access of commercial and recreational fishermen); and (4) the employment of marine mammal deterrent devices. Limitations on use of fish feed, therapuetants, anti-fouling paints on in-water structures were also included in the Act. Furthermore, the Act allowed for states to opt out in advance of any consideration of aquaculture species or farm locations.

From the perspective of those in favor of development of the industry, the Act contained requirements that would demand considerable additional regulatory efforts before the industry could establish itself – such as marine planning, conduct of regional PEIS, and establishment of numerical standards for environmental monitoring. Additionally, the industry reportedly opposed the ten year time limits for permits. The bill was withdrawn before voting based on opposition on the part of the aquaculture industry. Also in 2009, a bill was introduced - the Consolidated Land,

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are the only two states in which consistency judgments are made by a politically appointed board, the California Coastal Commission, rather than through an agency or interagency process.

Energy, and Aquatic Resources Act (H.R. 3534) – aimed at rescinding the Secretary of Commerce's authority to develop, approve, permit, or regulate offshore aquaculture (cf. Buck and Upton 2010).

These acts presented different visions for the development of offshore aquaculture; none, however, successfully passed through legislation to be adopted. Thus currently the nation has no overarching legislative framework through which to regulate the development of offshore aquaculture. Others bills that could have consequences for the development of offshore aquaculture continue to be introduced at both the state and federal level. For example, in the 112th Congress, federal bills were proposed that dealt with: seafood safety; sale of genetically engineered fish; tax credit for investments in small scale aquaculture businesses; eligibility of shellfish for non-insured crop disaster assistance program; and research programs for offshore aquaculture (cf. Buck and Upton 2011).

While various legislative attempts were being made to clarify a regulatory framework, NOAA has released various plans and initiative to support the development of offshore aquaculture. In 2006, NOAA released a 10-year plan for its aquaculture program, which proposed to:

(1) Establish a comprehensive regulatory program for marine aquaculture;

(2) Develop appropriate technologies to support commercial marine aquaculture and enhancement of wild stocks;

(3) Influence the development and international adoption of sustainable practices and standards for marine aquaculture; and

(4) Improve public understandings of marine aquaculture (Oregon Coastal Zone Management Association 2008).

In 2009, the federal government issued policy guidelines for aquaculture, reaffirming that aquaculture is an important component of NOAA's mission. And in 2011, NOAA established the National Sustainable Aquaculture Policy, which calls for streamlining of regulations, related to the development of aquaculture in federal waters, and a series of funding initiatives aimed at advancing science and technology to ensure sustainable aquaculture - the Aquaculture Technology Transfer Initiative; the National Shellfish Initiative; and the Alternative Finfish Feed Initiative. Also in support of the development of marine aquaculture, the National Ocean Council released, in 2013, an implementation plan for National Ocean Policy that recognizes government inefficiencies in the siting and permitting of marine aquaculture. The Policy establishes priorities to facilitate data and information sharing at the federal and regional levels in support of the development of the industry (cf. National Ocean Council 2013a). **Table 2-3** below depicts a timeline of important dates for the development of offshore aquaculture policy.

Table 2-3 Timeline of Select Dates in the Development of Open Ocean Aquaculture in State and Federal Jurisdiction Waters

Year	Event
1980	Passage of the National Aquaculture Act of 1980 declaring the development of aquaculture is in the national interest.
1996	A international Open Ocean Aquaculture Conference is held in Maine bringing together scientists, policy maker, economists, regulators, investors, fishermen and aquaculturalists.
1997	The University of New Hampshire initiates its Open Ocean Aquaculture Demonstration Project

Year	Event
1997	The New England Fishery Management Council amends their scallop fishery management plan to allow for scallop aquaculture. The Council subsequently creates an "abbreviated framework adjustment process" to allow for future amendments to fishery management plans.
1998	The University of Hawaii and Oceanic Institute initiates the Hawaii Offshore Aquaculture Research Program.
1999	The Department of Commerce's Aquaculture Policy calls for a five-fold increase in domestic aquaculture production to 5 billion dollars.
2001	Universities of Miami and Puerto Rico in collaboration with Snapperfarm Inc. initiate the Puerto Rico offshore aquaculture research program.
2001	Cate's International Inc. becomes the first commercial open ocean aquaculture facility, located in state waters.
2004	The U.S. Commission on Ocean Policy recommends increased support for development of marine and open ocean aquaculture.
2004	The Gulf of Mexico Fishery Management Council initiates the creation of a Fishery Management Plan for Offshore Aquaculture.
2005	The National Offshore Aquaculture Act of 2005 (S.1195) is submitted to Congress.
2007	The National Offshore Aquaculture Act of 2007 (S.1609/H.R. 2010) is submitted to Congress (no further action is taken).
2007	NOAA releases its Ten Year Plan for a Marine Aquaculture Program.
2008	The Bush Administration considers giving the Minerals Management Service authority to grant leases to aquaculture facilities located on oil and gas structures.
2009	The National Sustainable Offshore Aquaculture Act (H.R. 4363) and The Consolidated Land, Energy, and Aquatic Resources Act (H.R. 3534) are introduced to Congress.
2009	The Gulf of Fishery Management Council Fishery Management Plan is finalized and is sent to the Secretary of Commerce for approval.
2010	The Research in Aquaculture Opportunity and Responsibility Act of 2010 (S. 3417) is submitted to Congress.
2011	The Department of Commerce and NOAA release a National Sustainable Marine Aquaculture Policy and an associated set of research initiatives.
2011	The Western Pacific Fishery Management Council creates an amendment to Ecosystem Fishery Management Plans to permit aquaculture as a gear type.
2011	The National Sustainable Offshore Aquaculture Act of 2011 (H.R. 2372) is introduced.
2013	Gulf of Mexico Fishery Management Plans for Aquaculture are approved by the Council.
2014 (January)	The first commercial offshore shellfish farm is permitted in federal waters off California.
2014 (August)	A second commercial offshore shellfish farm is permitted in federal waters off Nantucket Sound, Massachusetts.
2014 (August)	Gulf of Mexico Fishery Management Rules are published for public review.

3.0 Regional and Local Approaches to the Development of Offshore Aquaculture

As detailed in Chapter Two, to date legislation to regulate aquaculture in federal jurisdiction waters has failed to pass because of a lack of agreement regarding: the potential benefits and impacts of marine aquaculture; best ways to ensure the mitigation of environmental problems and negative socioeconomic impacts; and necessary conditions to ensure commercial feasibility. With attempts to create overarching federal legislation unsuccessful, the process for permitting aquaculture operations in federal jurisdiction waters has become regionalized and localized, with creation of a Fishery Management Plan for Offshore Aquaculture in the Gulf of Mexico and the permitting of two commercial shellfish farms in offshore waters of Massachusetts and California.

Below we outline the provisions contained within the Gulf of Mexico Fishery Management Plan for Offshore Aquaculture and the permitting and monitoring requirements of commercial shellfish farms in offshore waters of Massachusetts and California. Additionally, we discuss debates regarding specific management measures and provide an analysis of different regional approaches to furthering the development of regulatory framework for offshore aquaculture.

3.1 The Gulf of Mexico Fishery Management Plan for Offshore Aquaculture.

At the regional level, the Gulf of Mexico Fishery Management Council began, in 2004, developing guidelines whereby aquaculture could be permitted for the federal waters of Gulf of Mexico. In 2009, NOAA approved the Offshore Aquaculture Fishery Management Plan proposed by the Gulf of Mexico Fishery Management Council and a rule-making process was initiated (Kalo et al. 2009). In February of 2013, the rule-making process was completed by NOAA and approved by the Gulf of Mexico Fishery Management Council. Currently the draft rules are being reviewed by the public and by various federal agencies that also have authority over aquaculture. NOAA foresees initiation of the permit application process in 2016, at the earliest.

The Gulf of Mexico Fishery Management Plan (FMP) for Offshore Aquaculture, henceforth the Plan, represents one regional approach to creating a permitting framework for aquaculture operations in federal waters. Of note, the Plan does not obviate the necessity for applicants to meet requirements for other permits from, for example, the Army Corps of Engineers and the EPA, and to abide by the regulations and/or reporting requirements of other agencies. That is, the Plan, if enacted, represents a necessary step toward permitting offshore aquaculture of federally managed species but does not create a streamlined one-stop permitting process. It is also not clear whether the completion of this plan will also obviate the necessity for additional reviews under NEPA or if proposed operations may still have to undergo a federal consistency review.

Additionally, the use of an Aquaculture FMP to regulate aquaculture in federal waters only applies to species that are federally managed. In the case of species that are not federally managed, a permit from NMFS would not be required. NMFS involvement would be limited to consulting with the Army Corps of Engineers regarding the potential impact of proposed operations to Endangered Species and Essential Fish Habitat (cf. National Sea Grant Law Center 2014).

The Plan allows only for federally managed species native to the Gulf to be farmed in federal waters —not including corals, shrimps, or any endangered or threatened species. Shellfish

species are not included in the plan as they are not federally managed.[11] The proposed rules allow for an individual operator to harvest of 12.8 million pounds (approximately 5.8 metric tons) annually and a total annual harvest for the Gulf of Mexico of 64 million pounds (approximately 29,000 metric tons).[12] Initial permits are valid for 10 years and renewals are for five years.

Various alternatives were considered in regards to: permissible species and types of aquaculture systems; permit duration; siting and zoning restrictions; recordkeeping and reporting requirements; and maximum total industry and individual production capacity. The proposed permit length was established at 10 year with a five year renewal versus various alternatives in order to: encourage industry development and sustainability; preclude the long-term exclusion of others from the permit area; and establish periodic permit review. The particular species proposed for permitting were decided on the basis of biological suitability for offshore aquaculture and the need to maximize the economic benefit of offshore aquaculture to the industry and nation while also minimizing any detrimental economic impacts to fishermen that could potentially result from overt competition in the marketplace. The limit of 12.8 million pounds was decided on in recognition of: the need for individual operators to achieve an appropriate economy of scale and the benefit of encouraging market competition within the offshore industry. Rules regarding aquaculture systems were based on the recognition of: the rapid rate of technological innovation in cage systems; permit holders' need to use the most economically beneficial and suitable systems; and the importance of reducing detrimental environmental impacts. Siting criteria were established in recognition of: industry needs for flexibility in determining economically feasible locations; potential impacts to other marine users, specifically commercial and for-hire fishing businesses; and conservation priorities.

The Plan calls for the creation of an Aquaculture Advisory Council to evaluate the impacts of aquaculture operations on the human and natural environment and recommend changes, as needed, in production levels, allowable system technologies, and siting and monitoring requirements (cf. Emmett Environmental Law and Policy Clinic, Environmental Law Institute, and The Ocean Foundation 2013). To date the Gulf Council has had a number of ad hoc aquaculture panels, the last of which was disbanded in 2013.

The following provisions are of note (cf. Gulf of Mexico Fishery Management Council 2013; NOAA 2014):

To minimize risks to wild fish from escapement, farmed animals must be of a species native to Gulf waters; progeny of brood stock of the same (sub) population of the facility locations; and may not have been genetically modified. To prevent the spread of disease and pathogens to wild fish, all stocking fish have to be inspected and verified healthy by an aquatic animal health expert and in accordance with the National Aquaculture Health Plan. In addition, on the report of

[11] Good candidate species for regulation under the fishery management plan, based on grow-out rates and market potential, include: snapper, grouper, jack, cobia (*Rachycentron canadum*), and red drum (*Sciaenops ocellatus*).

[12] Due to ocean bathymetry and weather conditions within the Gulf of Mexico and based on candidate farm species, the National Marine Fisheries Service has estimated that offshore aquaculture facilities that will be established as a result of the plan will require the operation of at least six cages and an initial investment of approximately $3 million (see Bridger 2004 for an assessment of economic feasibility of offshore aquaculture in the Gulf of Mexico region for three candidate finfish species).

an emerging pathogen risk, operators may have to remove all cultured animals if required by NMFS and USDA. Operators are required to maintain an assurance bond to cover any costs associated with the removal of operational facilities and animals. All aquaculture facilities must also be spaced a minimum of three kilometers to minimize the possibility of transmission of disease between farms. Operator must also maintain records on introduction and removal of farmed species and report any fish escapements.

To protect water quality and human health, the use of therapeutants must comply with rules and requirements of the USDA, EPA, and FDA. To mitigate water pollution and benthic impacts, the use of feed and environmental monitoring must comply with EPA management guidelines and NPDES requirements. As a necessary precursor to monitoring, applicants must undertake a baseline environmental assessment that includes information from diver/video surveys and benthic and water quality sampling and on hydrographic conditions.

As part of a mitigation strategy for protected species, operators are required to inspect systems for marine mammals, other protected species, and migratory birds and report any entanglements or interactions to NMFS. Each permit will detail the frequency of inspection, and other operational requirements (such as the use of particular cage technologies and mooring equipment and the array of pens or nets, mooring equipment, etc.) to mitigate risk. Also are also required to report any fish escapements and outbreaks of certain specified pathogen outbreaks. Permit holders are required to take additional steps in the management practices to avoid escapements and pathogen outbreaks.

The plan requires that a restricted access zone, the size of the permit site, be established around the aquaculture facility. The purpose of establishing a restricted zone around the facility is to decrease risk of collision of vessels with the aquaculture facility and associated risks of economic loss, personal injuries, and environmental impact of escaped farm fish. The zone was also considered necessary to protect the financial interests of the permit holder in securing property from theft. The size of restricted zone was also chosen to minimize the loss of ocean area to other users, specifically commercial fishing vessels.

Of note, the Plan does not include the following requirements or rules:

The proposed rules do not require the utilization of specific aquaculture systems, configurations, or materials. Review of the application does, however, include an assessment of the structural integrity of the system to withstand extreme oceanographic and weather conditions that can occur in the Gulf of Mexico.

There are no designated zone(s) within which offshore aquaculture operations must operate. As discussed in Chapter Eight, a marine zoning alternative was rejected for both economic and environmental reasons: zoning could "require the use of inferior sites with higher start-up and operational costs" and result in potential crowding of operations in established zones (cf. Gulf of Mexico Fishery Management Council and NOAA 2009 :405). Rather, the plan prohibits siting in marine protected areas, marine reserves, habitat areas of particular concern, Special Management Zones, permitted artificial reef areas, and coral areas. The presence of or proximity to marine mammal migration routes; important recreational and fishing grounds; and important natural habitats will be considered in the permitting process. Depth, substrate, and dissolved oxygen levels are also considered important siting factors. The plan also requires that sites must

be twice the size of operational structures to allow for fallowing (a commonly recognized practice for mitigating benthic impacts).

The Gulf of Mexico FMP for offshore aquaculture does not establish any regulations regarding the composition of fish feed. The regulation of fish feed is favored by many in the conservation community and was included in the 2009 and 2011 proposed national offshore aquaculture legislation. The Plan instead restricts its discussions of fish based feeds to NOAA's existing goal of ensuring fishery resources are managed sustainably. In declining to expand NOAA's regulatory powers to fish feed, the plan notes: reduced demand for fishmeal and oil for aquaculture globally; industry efforts to replace feed sourced from wild stock with alternatives; and feed manufacturer's successful commercial production of fish meal free feeds.

The Plan was created through a multi-stakeholder process and involved extensive public hearing and solicitation of public comments. The proposed rules represent a trade-off of benefits and impacts to different stakeholders. At the time of this writing the proposed rules are still being commented on and litigation is likely to follow.

Debates continue regarding both broad regulatory issues and specific management measures such as: the necessity for national legislation versus regional approaches; which agency should manage permitting; NOAA's use the Magnuson Stevens Act to regulate aquaculture as a form of fishing; the adequacy of the Clean Water Act to regulate offshore based aquaculture discharges; the necessity of conducting marine zoning as a precursor to permitting offshore aquaculture; the utilization of legislative means to regulate use of fish feed (rather than a market-based approach or existing stock assessments); the appropriateness of limiting farmed species to native second generation brood stock; the prohibition of non-genetic modified species, and the appropriateness of best management practices versus numerical based monitoring.

In 2010, NOAA's use of the Magnuson Stevens Act to define and regulate aquaculture as "fishing" was legally challenged by the Gulf Restoration Network, Food and Water Watch, and Ocean Conservancy. The case, however, has not yet received judicial review and cannot until a permit is issued (cf. Etheridge 2011; Jeans 2011). Additionally, in 2011, a suit was filed against the National Marine Fisheries Service for granting of a one-year "Special Coral Reef Ecosystem Fishing Permit" for an aquaculture project (the Velella Beta) in the offshore waters of Hawaii Island. The latter challenge was heard at the district court level. The judicial review concurred with NOAA's interpretation of the Magnuson Stevens Act and upheld the permit (cf. Emmett Environmental Law and Policy Clinic et al. 2013). In light of the recent court validation, the Marine Fisheries Advisory Committee of NOAA has recommended that the forthcoming reauthorization of the Magnuson Stevens Act include a formal definition of aquaculture thus establishing NOAA as the lead permitting agency, clarifying roles of federal agencies and coastal states, and highlighting the importance of aquaculture to a national policy of ensuring sustainable domestic seafood sources (cf. Marine Fisheries Advisory Council 2014a).

Respondents in the industry and research sector, regulatory agencies, and NGOs within our case study regions have expressed concerns regarding rules and the possible ramifications for the development of aquaculture in other regions. NGOs that pushed for national aquaculture legislation have expressed concern over the current efforts to advance the industry through a Gulf of Mexico Fishery Management Plan for Offshore Aquaculture, and the permitting of commercial projects in California and New England. Critics assert that the current approach is

"piecemeal" in so far as permit review do not consider potential cumulative impacts of individual farms and the permitting of aquaculture operations is not taking place within a larger effort of coastal spatial planning (Ocean Conservancy 2011). In addition, some critics continue to oppose NOAA's efforts to regulate aquaculture under the Magnuson-Stevens Act as a form of "fishing" and/or do not believe that the environment will be adequately protected without additional national legislation (cf. Ocean Conservancy 2009 a,b).
The NGO Environmental Law Institute has recommended the following modifications be made to the Gulf Plan:

- Requirement that all stock juveniles are first generation of brood stock that are collected for each "spawning event";
- Establishment of numerical guidelines for optimal yields and allowable "catch" limits that are scientifically based in reference to biological and ecological factors;
- Expansion of the range of environmental impacts under permit review to include: the impact of operational design and location on the environment and on all organisms and habitats – not just those that are endangered, protected, or essential;
- Increase environmental protection from that of "likely significant risk" to a standard of lower probability
- Increase in the scope and specificity of monitoring and reporting requirements and remedial actions available to the NMFS regional administrator;
- Establishment of shorter term permit length for novel technologies;
- Increase financial guarantees to cover natural resource damages; among others;
- Expansion of permissible farm species to include shellfish currently managed at the state level (Environmental Law Institute and Emmett Environmental Law and Policy Clinic 2014).

On the industry side, the primary concerns relate to: permit duration; individual and total harvest limits; the establishment of restricted zones around aquaculture operations; prohibition against siting in marine protected areas; limitations on the use of stock that have been selectively breed; and prohibitions against all genetic modifications (cf. CUSP 2014; Ocean Stewards Institute 2014; Marine Fisheries Advisory Committee 2014b). As noted by members of the Marine Fisheries Advisory Committee, commonly used practices of selective breeding and hormonally induced spawning would be considered genetic modifications and thus prohibited. Additionally, there have been calls for clarification of the Council's intent to utilize wild stock thresholds to determine the impact of offshore aquaculture and on criteria for permit renewal.

Industry respondents in Hawaii and California reported that current permit durations are too short and harvest limits are too low to attract investment interest and support the capitalization needs of an operation in federal waters. Industry respondents note that due to expenses associated with the initial establishment of operations and typical production cycles, companies will not be able to recoup costs for three to four years and may not attain adequate profitability for seven years. Additionally, an industry respondent in Hawaii expressed concerns that the ten

year permit length coupled with a lack of clear criteria for renewal reportedly may lead companies to overcapitalize to maximize profit in the short term rather than be motivated by long term environmental and economic sustainability. The Coalition of U.S. Seafood Production (CUSP), an organization of aquaculture industry stakeholders, has recommended: initial permit duration of ten years be abolished or be extended to twenty years; renewal permit duration be extended from five to ten years; and current individual harvest limits be abolished. Additionally, CUSP members report that total harvest limits established by the plan are not adequate for addressing the nation's seafood trade deficit (cf. CUSP 2014).

The Ocean Stewards Institute, a trade organization for the open ocean aquaculture industry, has similarly recommended removing individual harvest limits or expanding them to a minimum of 20 million pounds, and extending and/or and removing limits on the duration of renewed permits. Additionally, the Institute has expressed concerns regarding the Plan's establishment of restriction zones around aquaculture facilities. President of Ocean Stewards Institute expressed a concern that the establishment of exclusionary zones will increase opposition from fishermen. The Institute recommends that access to permit area should be decided on a case-by-case basis, in consultation with the fishing sector, and taking into consideration the operational configuration of the farm and production constraints. The Institute also objects to the plan's prohibition of siting aquaculture operations in all marine protected areas noting that aquaculture operations may result in ecosystem benefits congruent with the goals of marine protected areas (c.f. Ocean Stewards Institute 2014).

Respondents in aquaculture research, the industry, and staff in aquaculture development programs have expressed concerns about the plan's brood stock requirements. Selective breeding is essential to improving growth efficiency, feed conversion rates, stock health, and stock suitability for farm conditions. In contrast to limiting brood stock to first or second generation to reduce potential impacts to wild species, critics assert that selective breeding may result in reducing survivability of stock fish in the wild.

In 2015 the rules for Gulf of Mexico FMP will be finalized. At this time, the workability of the provisions will become more apparent as aquaculture companies submit applications and the legality of the Plan will be judicially reviewed.

Fishery Management Plans in other regions. New England and Western Pacific Fishery Management Councils have also developed management approaches to offshore aquaculture. Currently the New England Fishery Management Council has an "abbreviated framework adjustment process" whereby aquaculture of species currently under management can be permitted through an amended fishery management plan. To date, no projects have been proposed that require an amendment and the process has not been employed. In 2011, the Western Pacific Fishery Management Council amended their fishery management plans to enable the permitting of aquaculture cages and other infrastructure as a gear type. No commercial projects have yet been proposed that would require a federal permit and as such the process has not yet been used. The duration of the permit is also not yet clear.

3.2 California and Massachusetts: Permitting Process and Requirements for Offshore Shellfish Farms

In 2014, two shellfish farms sited in federal waters off California and Massachusetts' Nantucket Sound were permitted. An additional offshore shellfish farm sited for federal waters off Massachusetts' Cape Ann is reportedly pending approval at the time of this writing. The process by which and requirements associated with the currently permitted offshore shellfish farms differ. The California project underwent a federal consistency review by the California Coastal Commission in addition to the review process conducted by the Army Corps of Engineers. Neither projects sited in federal waters of Massachusetts were required to undergo a federal consistency review.[13]

The requirements, established by California Coastal Commission, for the former farm include: Monitoring Program; Wildlife Entanglement Minimization Plan; Gear Compensation Program; Letter of Credit (for $100,000 to ensure removal of any farm structures); Marine Debris Management Plan; and a Spill Prevention and Response Plan prior to the commencement of construction. The Monitoring Program assesses potential changes in the benthos and water column and includes consideration of biotic, infaunal, epifaunal, marine animal, and human communities in the project area.

Requirements for the longline mussel operation sited for federal jurisdiction waters off Massachusetts are fewer and reportedly less onerous; they focus on the potential entanglement of marine mammals. The following mitigation strategies are required: phased deployment of mussel lines; reduction in number of vertical lines; incorporation of breakaway links; enclosure of surface lines with stiff plastic piping; minimum line tension of 200 kg; and minimum long-line bottom and surface depths. Lines must also be marked with permit number to allow for identification should lines come loose and/or entangle marine wildlife. Additionally, the operation must be visited at minimum on a bi-monthly basis manned by an observer who is trained in marine mammal identification[14]. If operators observe any interactions with or entanglements of protected marine mammals species, NOAA's Protected Resource Division and two hotlines must be contacted. The permit also provides information on how observers can resuscitate sea turtles (cf. Department of the Army 2014; NOAA Fisheries: Greater Atlantic Region 2014; Cassidy 2014).

Of note, no benthic or water column monitoring or inland waste disposal plan is required as is the case with requirements for the California farm. Additionally, operation inspection can be carried out through sonar equipment and does not required video or scuba monitoring. Although the Massachusetts operation is required to have a decommissioning plan, the company need not acquire a bond cover the financial costs of decommissioning farm structures.

Respondents involved in aquaculture research and the industry have expressed concerns regarding the permitting and monitoring requirements established by the California Coastal Commission. Of particular note, researchers with expertise in shellfish aquaculture in California and New England assert that the monitoring requirements and requirements for handling marine

[13] Respondents report that the state did not seek a federal consistency review for the project sited for federal waters of Nantucket Sound. The state did, however, seek a federal consistency review for the project sited for federal waters off Cape Anne. The review request was denied by the Office of Ocean and Coastal Resource Management because the "state's failure to clearly articulate how the project would impact state coastal resources and uses." (National Sea Grant Law Center 2014: 15-6).

[14] The farm operator and/or staff can reportedly be trained to serve as the observer. That is, the operator is not required to hire a specialist to serve this function.

debris (fouling organism and other biological material) have arisen from invalid concerns and will impose inappropriate if not impossible conditions for the operator. Reportedly, the requirement to dispose of fouling organism and other biological material removed during the equipment stripping process in on-land facilities is costly, a waste of upland disposal space, and deprives the ecosystem of food. Respondents also report that video and in-water (SCUBA) monitoring required as part of the Commission's Wildlife Entanglement Minimization Plan is costly and unnecessary and have recommended instead the use of sonar equipment, standard equipment in commercial fishing vessels.

The Gear Compensation program reportedly was established in response to concerns expressed by the commercial fishing fleet; current open ocean operations within our study regions do not, however, have such a requirement.[15] Additionally, there is some debate within state agencies and NOAA's Office of Aquaculture about the appropriateness of the permit and monitoring requirements for the offshore farm and the ability of the requesting agency (the California Coastal Commission) to manage the amount of data requested.

Industry respondents in California also have expressed concerns that the Commission's permitting and monitoring requirements shall establish a precedent for future projects proposed for federal jurisdiction waters off California and/or be retroactively applied to the existing open ocean farm in state waters.

3.3 Comparing Regulatory Approaches

Advancement of the offshore industry is occurring through different regulatory approaches. The creation of a FMP in the Gulf of Mexico "frontloads" the informational effort required to regulate and permit offshore aquaculture by considering general impacts, weighing regulatory alternatives, and establishing general mitigation measures. The creation of the FMP did not necessitate the existence of a particular proposed operation but required considerable commitment of staff time and labor on the part of the agencies. The resulting plan will serve as an education document for regulatory agencies, and will lessen the burden on the individual project applicant to provide information. (The conduct of programmatic environmental impact reports or studies (PEIR/S) can serve a similar function).

In contrast to the establishment of FMPs, the promotion of demonstration or commercial projects, as in the case of the shellfish farms sited for federal jurisdiction waters of California and Massachusetts, creates an ad hoc agency response. The initial applicant has the burden of negotiating the regulatory process. The successfully permitting of an aquaculture operation can, however, provide a template and timeline for future applicants and may set a precedent for future (similar) operations.

The development of the Gulf of Mexico Fishery Management Plan for Offshore Aquaculture and recent permitting of non-federally managed species suggests that federal policy guidance is being clarified and implemented to achieve the development of some forms offshore aquaculture. Much, however, remains to be understood regarding the conditions—regulatory, climactic, socio-economic—under which development is most conducive. We now turn to describing the

[15] The oil and gas industry in the region also have program to compensate the commercial fishing fleet for damage or loss of gear.

current status of marine aquaculture and factors that potentially affect development of offshore aquaculture in California, Hawaii, and the Gulf of Maine.

4.0 California

4.1 Characterization of Southern California Bight for Development of Offshore Aquaculture

Key respondents noted the suitability of the Southern California Bight for offshore aquaculture in terms of oceanic conditions, regional expertise in finfish and shellfish aquaculture, and availability of coastal support infrastructure (cf. Schubel and Monroe 2008). The Southern California Bight is characterized by good ocean circulation to mitigate potential water quality and benthic impacts of aquaculture operations; suitable bathymetric conditions for current conventional open ocean cage technology; warm water temperatures conducive for the growth of candidate species; weak prevailing winds, and low frequency of storms. For shellfish cultivation, the Southern California Bight also reportedly has rich upwelling of nutrients conducive to good growth rates and meat yields.

California has research expertise in finfish mariculture and extensive commercial experience in coastal shellfish mariculture. Hubbs-SeaWorld Research Institute, located in San Diego, has a forty year history of finfish aquaculture. The institute staff have hatchery experience with white seabass, striped bass, California halibut, and California yellowtail. The institute has conducted growout trials and environmental monitoring on white seabass farmed in netpens in California state waters and on California yellowtail and striped bass in waters of nearby Baja Mexico. The institute has collaborated with researchers on the development of the Offshore Aquaculture System Investment and Siting and environmental model (AquaModel). Additionally, staff have scientific expertise in disease prevention, identification, and diagnosis. The institute has a fish diet research and development research and has conducted feed trials of sustainably produced microalgae and soy-based protein diets and research on the use of seafood processing trimmings in aquaculture feed (cf. Hubbs-SeaWorld Research Institute, Aquaculture Program 2007; 2010; 2011a-c; Kiefer et al. 2011).

There is one operational open ocean aquaculture operation in state jurisdiction waters of California, Santa Barbara Mariculture. The operator utilizes a longline technology for growing shellfish that is appropriate for offshore farming. Santa Barbara Mariculture was established in 2002; the first farmed product was marketed in 2003. The owner/operator currently leases 72 acres from the California State Department of Fish and Wildlife. In 2012, the farm produced 78,000 lbs. of Mediterranean mussels and 53,000 Pacific oysters. The product is sold locally by the owner/operator of the firm at the Santa Barbara Farmers market and at local retail locations.

In support of the shellfish industry, research is also currently being conducted on purple-hinge rock scallop to evaluate triploid seed production and grow-out methods. This native species has a high market value but has not yet been harvested commercially and would reportedly be suited for offshore farming.

In addition to expertise in aquaculture, Southern California has technical experts working on challenges associated with the siting of offshore aquaculture operations. Currently, researchers at the University of Santa Barbara are creating a software model to evaluate the suitability of offshore areas and associated economic and social trade-offs of siting aquaculture operations in the region.

The Aquarium of the Pacific, located in Long Beach, California has public education experts working on outreach messages regarding the benefits of developing marine aquaculture in the region. The Aquarium of the Pacific has held workshops on the development of offshore finfish aquaculture in the region and accurate messaging by aquariums regarding marine aquaculture. The aquarium also provides educational outreach in the form of aquarium displays, articles in their quarterly newsletter, and online webcasts (c.f. Schubel et al. 2007; Schubel and Monroe 2008; Aquarium of the Pacific 2010, 2013, 2014a,b).

Additionally, Southern California has shore-side infrastructure necessary to support an offshore aquaculture industry. Coastal access and support infrastructure are important, if not primary, criteria in siting projects (cf. Benetti et al. 2010; Kapetsky et al. 2013). With the exception of hatchery facilities, the needs of offshore aquaculture operations overlap with those required of the commercial fishing and seafood processing industries. There are ten harbors/ports that currently provide services to the commercial fishing fleet. Of note, five of the above ports currently handle commercial landings equivalent to that of a small-scale aquaculture facility (3000 metric tons or approximately 6.6 million pounds). The harbors lie in close proximity to an extensive transportation system of intra and interstate highways, and regional and international airports. In many ports, however, commercial fishing fleets face competition from competing users, for example, cruise or cargo ships, or recreational vessels. And in many locations, support infrastructure is in decline and/or disrepair.

Santa Barbara currently supports and benefits from the only open ocean shellfish farm located in state jurisdiction waters. Los Angeles, provides shore side support to KZO Seafood/Catalina Ranch, the region's only open ocean shellfish farm located in federal jurisdiction waters. In June of 2012, the Port of Los Angeles announced plans for a major renovation, to include a 200,000 square-foot marine research and innovation center. AltaSea is expected to house numerous laboratories and classrooms devoted to marine research; plans also include the possible establishment of fish hatcheries (Sahagun 2013). If permitted, the proposed *Rose Canyon Fisheries Sustainable Aquaculture Project* will locate shore-side support facilities in San Diego. The Interim Technical Report provides an overview of the existing coastal infrastructure that could potentially support and benefit from offshore aquaculture development.

Within the Southern California Bight, there are 23 offshore oil platforms, many of which are expected to cease production within ten years (Mineral Management Service 2007: 6-1). Aquaculture industry representatives in California, Gulf of Maine, and Gulf of Mexico have identified potential benefits of locating offshore operations on oil, gas and natural energy platforms. These benefits include: availability of infrastructure to locate aquaculture systems; opportunity to accommodate workers, research facilities, hatcheries, and feed on site; minimization of other user conflicts; and existence of leasing structure (cf. Bridger 2004).

Southern California Bight borders coastal counties with a population exceeding 17 million persons. Key experts in aquaculture industry and seafood distribution sector report that farmed seafood currently grown in neighboring Baja California, Mexico has been well received by local consumers.

To date, applicants who have proposed projects within federal waters have noted the following challenges: the costs to fulfill permitting requirements; overlapping regulatory jurisdictions with redundant review processes; limited experience by agency staff permitting finfish operations;

lack of agreement on a set of environmental factors that must be required for baseline studies and monitoring; and lack of a lease structure for federal waters. Interviews with staff at agencies involved in the regulation and/or promotion of offshore aquaculture have revealed various concerns about the lack of expertise, funding, manpower, leadership, and/or will in agencies to effectively oversee the simultaneous requirement to promote and regulate offshore aquaculture. Respondents also reported a lack of familiarity with missions of other agencies and knowledge of expertise or role of specific individuals involved in permitting or regulatory decisions.

The review, and subsequent approval, of the first federally-sited shellfish farm *Catalina Sea Ranch*, in 2013-14, has provided an opportunity for agency staff to familiarize themselves with various agency missions and develop expertise in aquaculture. The submission of an application for a commercial-scale finfish operation *Rose Canyon Fisheries Sustainable Aquaculture Project* will provide further opportunities for federal and state agencies to work in a coordinated fashion in a permitting process.

Also of note, with the exception of a stock enhancement program, the state of California does not allow the farming of finfish in state waters. Respondents within the industry and research sector report that passage of the California Sustainable Oceans Acts, in 2006, presented significant challenges to the establishment of finfish aquaculture in state waters. The California Sustainable Oceans Act required the preparation of a Programmatic Environmental Impact Report (PEIR) that would outline the basic environmental issues and recommend the scale to which finfish aquaculture be developed in state waters.

The PEIR is by viewed by staff in the Department of Fish and Wildlife and NOAA as an important tool to facilitate the development of sustainable finfish aquaculture in state waters. The report will: provide scientific guidance to regulatory agencies; reduce burden on applicants to provide scientific information; and create a more efficient and focused environmental review process. In addition, the document can serve as a guidance document for prospective project sponsors and as an education tool for the public. The PEIR will provide information on: regulatory requirements; permit conditions; potential aquaculture impacts; and mitigation strategies. Projects will be permitted to undergo an abbreviated California Environmental Quality Act (CEQA) review, thus potentially saving entrepreneurs time and money.

Although the Sustainable Ocean's Act and PEIR will determine the conditions under which finfish aquaculture can develop in state waters, it is not clear the extent to which they will influence offshore aquaculture development. Staff at the California Coastal Commission, the agency which has authority to request a federal consistency review for any aquaculture operations located in federal waters, has reported that they will "take advantage of the document when it is completed." Respondents note that a production limitation of 3,000 metric tons poses challenges for acquiring investors and ensuring economic viability. The ten year lease limit imposed by the California Sustainable Oceans Act is also considered by industry respondents to be a deterrent for potential investors.

4.2 Overview of Proposed and Permitted Offshore Operations

To date, four aquaculture projects have been proposed for federal waters of the Southern California Bight. Three separate sites have been proposed for finfish aquaculture projects by Hubbs-SeaWorld Research Institute—the first two proposed projects were halted before a full

permit review was conducted. Permit applications for the third project were submitted to the Army Corps of Engineers and EPA in October 2014. One shellfish project, proposed by KZO Sea Farms/Catalina Sea Ranch successfully completed review by the Army Corps of Engineers and California Coastal Commission in January of 2014.

Hubbs-Sea World Research Institute. Hubbs-SeaWorld Research Institute (HSWRI), a public non-profit organization, was established in 1963. Initial aquaculture efforts conducted at HSWRI were geared toward hatchery programs for stock enhancement. The institute's first release of juvenile white seabass, as part of California's Ocean Resources Enhancement and Hatchery Program, occurred in 1986.

In 1998, Hubbs-Sea World initiated its first research into the commercial feasibility of raising white seabass while also testing the utility of open ocean, semi-exposed net cages in state waters off Santa Catalina Island, California. In 2003, Hubbs-Sea World proposed its first offshore aquaculture project, the Grace Mariculture Project. The proposed project was sited for 10.5 miles off the coast of Ventura on the offshore oil and gas platform, Grace, owned by Venoco Inc. The project proposed testing the cultivation of white seabass, striped bass, California halibut, California yellowtail, bluefin tuna, red abalone, and Mediterranean mussels. Lack of a defined permitting process and various ecological concerns, however, brought the project to a standstill. Hubbs-Seaworld did not renew its lease of Platform Grace and the wells were returned to production in 2007 (Bernstein et al. 2010).

In 2006, the institute turned to collaborators in Baja California, Mexico to initiate an offshore demonstration grow-out project for California yellowtail and striped bass (Hubbs-SeaWorld Research Institute, Aquaculture Program 2007). The project was deemed a success and they subsequently began deliveries of fingerlings to Mexico. In 2012, twelve aquaculture farms located in Mexico requested 2.5 million juvenile fish from Hubbs-SeaWorld Research Institute (Kent 2012). In addition, that year Hubbs-Sea World white seabass fingerlings, raised by Pacifico Aquaculture offshore of Ensenada, Mexico, were made available in the Southern California seafood market (Living Ocean Productions n.d.).

The Platform Grace project was followed in 2008 by a project proposed for five miles off the coast of Mission Bay, San Diego in depths of 80 to 140 meters. Hubb-Sea World proposed an initial construction of eight floating pens, measuring 11,700 cubic yards, which could produce 1,000 metric tons. Once demonstrating the efficacy of production and passing economic evaluation, they proposed expanding the project to 24 pens capable of producing 3,000 metric tons. Species were chosen due to their local presence and high market value. Included were white seabass, striped bass, California halibut, and California yellowtail (Kent 2010b). In late 2009, after one year of planning, public outreach, consultation with agency staff, and approximately 500,000 dollars invested, Hubbs-Sea World announced that the proposal was put on hold due to concerns regarding the social and political climate towards offshore aquaculture (cf. Kent 2010a). In 2009, Hubbs-Sea World also expanded their operations to Florida, where they continue to work on hatchery technology for red drum (Hubbs-SeaWorld Research Institute, Aquaculture Program 2010).

And most recently in October 2014, the research institute in partnership with US based aquaculture investment firm Cuna del Mar have submitted a permit request to the Army Corps of Engineers, the EPA, the California Coastal Commission, and NOAA for a commercial scale

project in the federal waters off Mission Bay, San Diego. At maximum capacity, the Rose Canyon Fisheries Sustainable Aquaculture Project will be configured to utilize two mooring grids with 24 cages of 11,000 cubic meters each. Once fully operational, the facility will have an annual production rate of 5,000 metric tons of white seabass, striped bass, and/or California yellowtail. The proposed project has been designed to examine the environmental and economic sustainability of finfish open ocean aquaculture in the region and will assist government agencies, key decision makers, scientists, and the public to develop national guidelines for offshore aquaculture. The NEPA review required of the project will also provide a record of the permitting process that may serve as a template for future applicants elsewhere in federal jurisdiction waters. Applicants estimate that the permit process will take 12-18 months and first production will occur within approximately two years of permit approval (cf. Leschin-Hoar 2014).

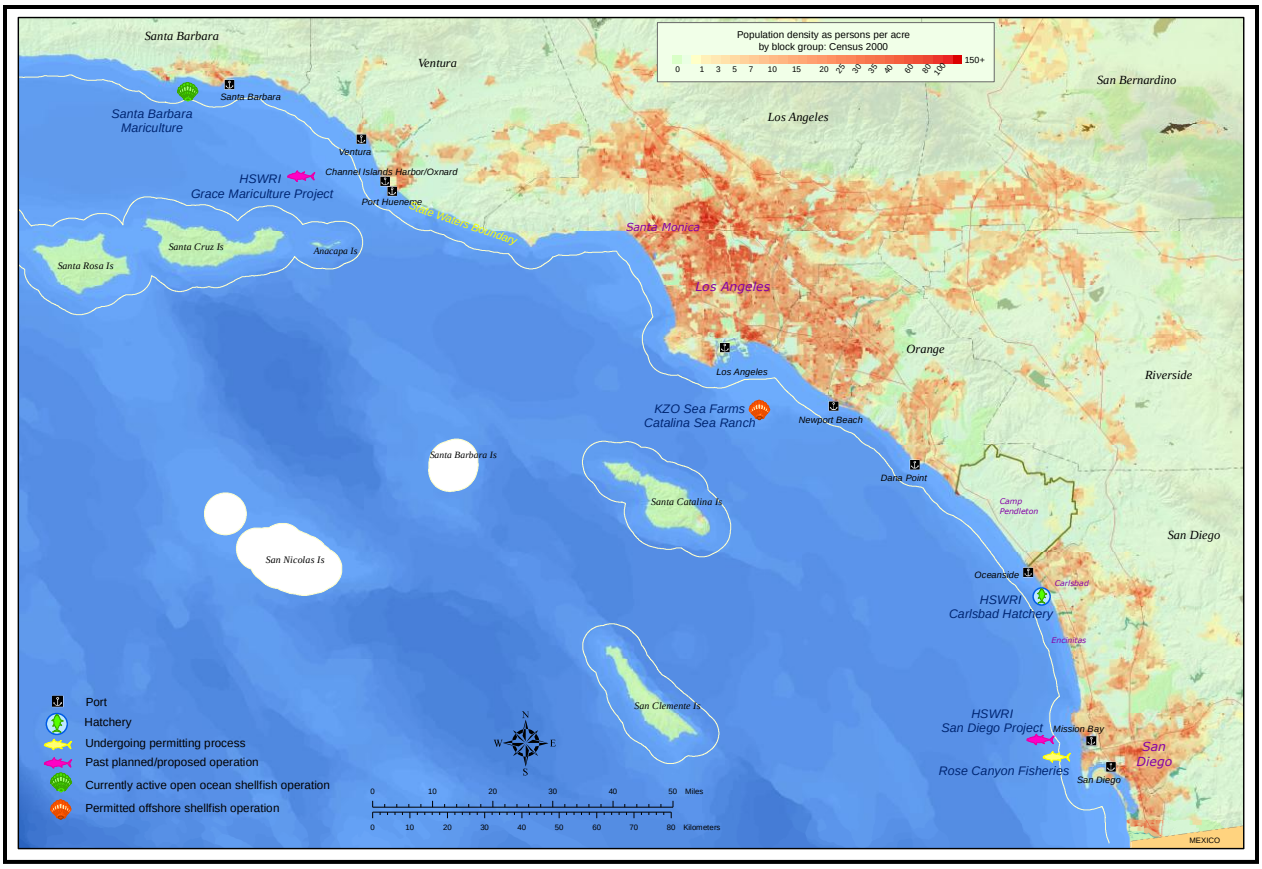
KZO Sea Farms/Catalina Sea Ranch. KZO Sea Farms was established in 2010. After conducting initial community outreach and consultation with staff at NOAA and the Army Corps of Engineers, the owners submitted an Army Corp of Engineers permit in 2012 for a 100 acre site to cultivate shellfish. KZO's initial plan was for a project of 1,076 acres. Initial consultations with agency staff resulted in a scaling down of the project.

The site of the shellfish farm was initially proposed for federal waters five miles off Huntington Beach and nine miles off Long Beach. To mitigate concerns regarding user conflicts with a commercial purse seine fleet, operations were moved approximately two miles further off shore, in closer proximity to an existing oil platform (California Coastal Commission 2013).

A provisional permit was awarded in July of 2012 by the Army Corps of Engineers; the permit required a federal consistency review be undertaken and a concurrence be authorized per the Coastal Zone Management Act. In January of 2014, the California Coastal Commission completed its review of the application and delivered a concurrence.

The 100 acre farm will employ up to 45 longline ropes to grow Pacific oysters and Mediterranean mussels. The requested permit also covers cultivation of Olympia oysters, giant rock scallops, and giant kelp. The 100-acre farm will reportedly produce over 600,000 pounds of mussels and 70,000 pounds of oysters per harvest, once fully operational (California Coastal Commission 2013).

Map 4-1 depicts the location of permitted and proposed offshore operations and major ports within the Southern California Bight.



Map 4-1 Southern California Bight: Permitted and Proposed Offshore Operations and Major Ports

5.0 Hawaii

5.1 Characterization of Hawaii for Development of Offshore Aquaculture

Key respondents noted the suitability of the Hawaii for aquaculture development in federal jurisdiction waters in terms of regional expertise in open ocean aquaculture, public and private hatcheries, research and development of advanced cage technology, state economic incentives to promote the development of marine aquaculture, and market conditions.

The state has been at the forefront of marine aquaculture research in the United States and internationally. The public and private institutions of Oceanic Institute, Hawaii Institute of Marine Biology, Pacific Aquaculture Coastal Resource Center, University of Hawaii, Hilo, the University of Hawaii-Manoa, and the Center for Tropical and Subtropical Aquaculture (established by the USDA) have a history of active research and technology transfer devoted to marine species. In 1998, the University of Hawaii established the Hawaii Offshore Aquaculture Research Program (HOARP) to test the feasibility of open ocean aquaculture operations in state jurisdiction waters. Successful completion of the research resulted in the operations being transferred to the private sector and becoming the nation's first commercial open ocean aquaculture facility, Cates International.

The state has promoted open ocean aquaculture through the passage of legislation in 1999 that allows for aquaculture leasing of open ocean sites in state waters and state agencies have created a process for permitting, leasing, and regulating cage culture in state waters (cf. Corbin 2007, 2010). In 2011, passage of SB 1511 expanded the lease permit for aquaculture from 35 to 65 years (Seafood Source 2011). To date, nine commercial open ocean aquaculture operations have been proposed for state jurisdiction waters; three were granted leases and permits and two have operated successfully at a commercial scale. One operation is not yet operational. One operation is currently undergoing permit review.

There is extensive corporate experience in hatchery operations for species suitable for open ocean aquaculture farming and/or operating submersible finfish cages in open ocean environments. Companies have successfully developed hatchery techniques for and commercially farmed Pacific Threadfin, known locally as moi, and Almaco jack, known locally as kahala. Additionally, company operators and staff have experience farming with the submersible cage systems Cupod and SeaStation. The aquaculture industry is also supported by aquaculture consultants with national and international experience.

The state has also provided generous financial support for the commercial development of aquaculture through tax incentives and funding of the National Energy Laboratory Hawaii Authority situated on Hawaii Island. As a result of tax incentives, Hawaii has been developing a pool of angel investors and venture capitalists interested in high technology aquaculture projects (Animal Industry Division, State of Hawaii 2013b). Aquaculture businesses have also taken advantage of pre-permitted and subsidized leases offered at National Energy Laboratory Hawaii Authority (NEHLA). The 870 acre facility currently houses the hatchery facilities for companies involved in open ocean aquaculture operations.

And finally, with seafood consumption rates of three times the national average, high rates of tourism, and heavy dependence on food imports, the state has high demand for quality seafood.

Although survey results show that residents generally prefer wild-caught and fresh seafood over farmed and frozen seafood, the reception to locally farmed Pacific Threadfin has been positive, suggesting that the local production coupled with active industry promotion are strong factors in favor of farmed seafood (Davidson et al. 2012). Hawaii is also proximate to Asian markets where there is a high demand for seafood and acceptance of farmed fish.

Although the state has generally been supportive of well thought out open ocean aquaculture projects in Hawaii, growing social opposition to operations sited in state waters and declines in state and federal funding for aquaculture research and development programs reportedly may impede the continued development of open ocean aquaculture in the near future. The apparent stalling of state's open ocean aquaculture development is noted in a 2012 report to the legislature which cites the need for "at least two more sustainable operations to establish a sustainable industry that will generate significant tax revenue and protein production" (Department of Agriculture and Department of Land and Natural Resources, State of Hawaii 2012:5).

Growing opposition to aquaculture is reflected in the introduction of two anti-open ocean aquaculture bills into the state legislature[16] and the number of opposition letters submitted in response to aquaculture operations proposed to state jurisdiction waters. Although neither passed, the bills reportedly reflect the increasing oppositional forces within the state. Aquaculture consultants reported that the number of opposition letters submitted in response to proposed aquaculture operations have increased over the decade, as have the length of permit applications. In a 2012 report to the legislature, the Departments of Agriculture and Land and Natural Resources noted the need for a way to disseminate authoritative information in light of the increasing amount of misinformation circulating regarding open ocean aquaculture (Department of Agriculture and Department of Land and Natural Resources, State of Hawaii 2012).

Public opposition has varied by proposed site location and aquaculture species. The following kinds of social opposition may be germane to the development of aquaculture operations in federal jurisdiction waters. Some members of the small boat based fishing community in the islands have expressed opposition towards proposals to ranch or farm tuna based on fears that market prices will be impacted. Certain fishermen have also expressed concerns regarding the potential for limitation of access to traditional fishing grounds that could result from offshore aquaculture projects. In addition, public concern from parts of the native Hawaiian community has focused how projects may impact traditional fishing practices and cultural resources. Some members of the native Hawaiian community also have long standing grievances regarding the state and federal government making decision about what they perceive as native Hawaiian's resources.

Respondents in the aquaculture industry report the following challenges for the development of open ocean aquaculture in both state and federal jurisdiction waters: oceanographic conditions; limited availability of coastal support infrastructure; and "unrealistic" environmental monitoring requirements required for deepwater projects.

[16] HB 221 called for a moratorium on permits for new operations and expansion, and SB 626 called for a requirement that all open ocean aquaculture permits require the completion of an environmental impact statement (rather than environmental assessment) (Fidell 2011).

Prevailing wind directions create rough oceanic conditions on the north and west sides of Oahu. Reportedly current and wave conditions also constitute negative siting factors for Nihau and Kauai. To date, open ocean ventures have been sited off the south coast of Oahu, which is sheltered from the prevailing Northeast trade winds by the Koolau and Waianae mountain ranges; and the Kohala Coast of Hawaii, which is sheltered by Mauna Loa, Mauna Kea, and the Kohala Mountains. Projects have also been proposed for other leeside locations on the west coast of Oahu, the southwest corner of Lanai, the midwest coast of Maui, and the northwest side of the Island of Hawaii. Whereas Molokai, Lanai, and Maui have more areas that are oceanographically suitable for open ocean and offshore aquaculture, Hawaiian Islands Humpback Whale National Marine Sanctuary encompasses significant stretches of waters to the south and southeast of these islands. The aquaculture industry has requested a clarification of NOAA's Sanctuary policy regarding the compatibility of aquaculture operations within boundaries.

A narrow shelf and deep bathymetry of the coastal region, particularly offshore of the Big Island, provides limited siting opportunities for conventional open ocean aquaculture technology. Developments in cage technology—including unmoored cages, and expansion of farmable species, to include high value product such as tuna - increase the feasibility of future commercial expansion into federal waters.

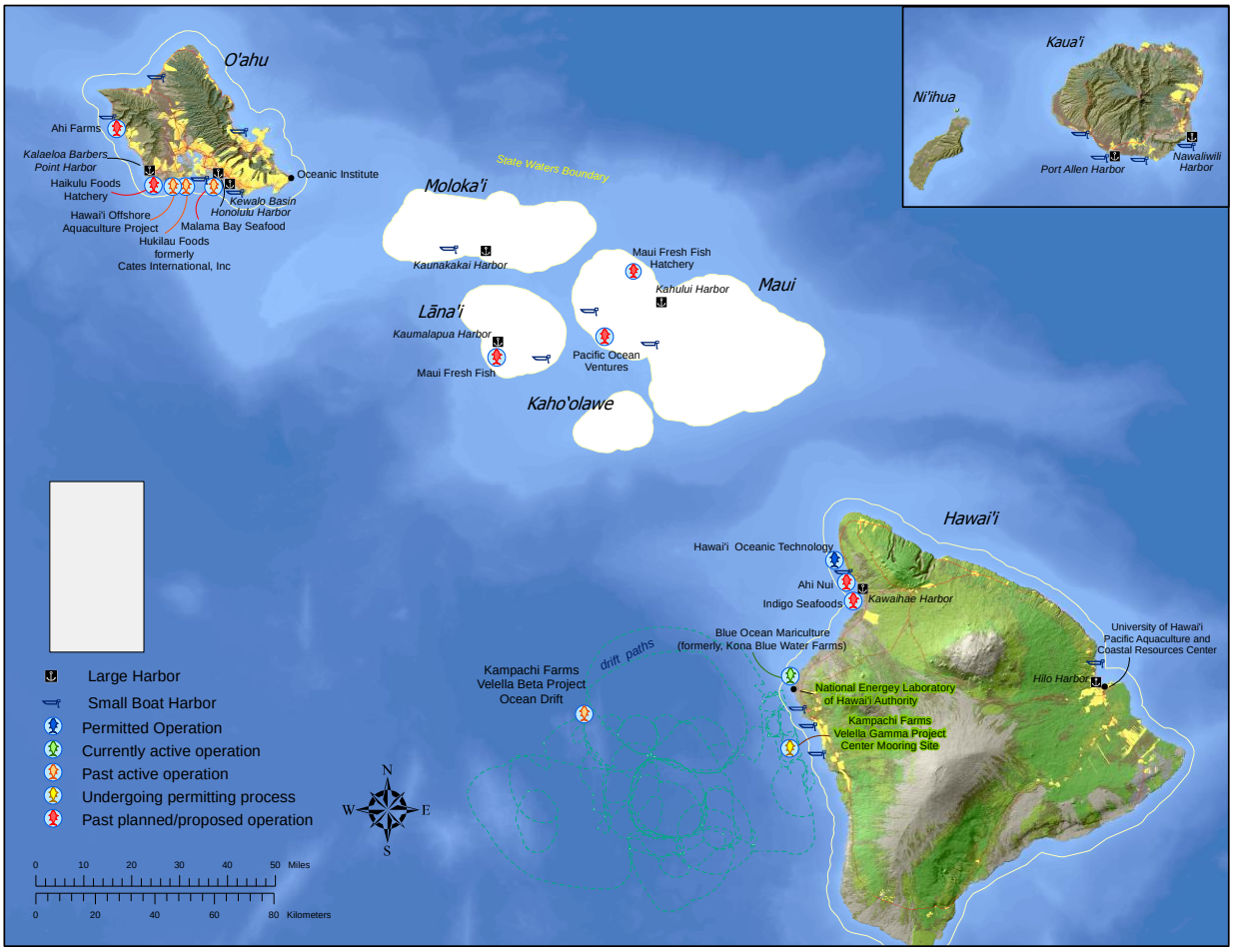
The development of the industry is challenged by limited shore-side support infrastructure. On Oahu, limited suitably-zoned land has created challenges for the building of private hatcheries (Department of Agriculture and Department of Land and Natural Resources, State of Hawaii 2004). On the Big Island, facilities at the Kawaihae Commercial Harbor are congested such that the proposed use of the shore-side facilities by Hawaii Oceanic Technology reportedly will require amendments to the Harbor Master Plan (Tetra Tech, Inc. 2009). In addition, staff at Blue Ocean Mariculture report that harbor infrastructure at Honokohau Harbor, Kailua-Kona limits their ability to expand their operations. Molokai, Maui, and Lanai also reportedly suffer from the lack of, or distance from, needed infrastructure—in particular, hatchery support. There is increasing competition between cruise ships, cargo, and fueling activities at Hawaii's ten large commercial harbors—and as a result many facilities are congested. The Interim Technical Report provides an overview of the existing coastal infrastructure that could potentially support offshore aquaculture development in Hawaii.

Agency staff and aquaculture operators report the need to re-evaluate environmental protocol for Hawaii's deepwater. To this end, an interagency Offshore Aquaculture Monitoring Working Group has been established. The goal of the group is to create a standardized monitoring protocol to guide the development of the industry that ensures mitigation efforts effectively reduce pollutants and monitoring programs most efficiently measure pollution impact and show operational compliance. In the course of our research, working group effort has reportedly been transferred from the region to the federal level.

5.2 Overview of Proposed and Permitted Offshore Operations

To date, two aquaculture projects have been permitted for one year research purposes in federal waters of Hawaii. Both projects were undertaken by a private entity, Kampachi Farms. The firm is interested in continuing research on the commercial viability of offshore aquaculture. **Map 5-1**

depicts the location of proposed and permitted open ocean aquacultures in state and federal jurisdiction waters that have occurred to date as well as the location of harbors.



Map 5-1 Hawaiian Archipelago: Open Ocean Operations in state and federal water jurisdictions

Kampachi Farms. Kampachi Farms was established in 2011 by the owner/operators of Kona Blue Water Farms with the purpose of continuing innovative research in offshore aquaculture. In 2011, Kampachi Farms initiated the Velella Beta project to test the operation and grow out results for an untethered aquapod. Measuring 21 feet in diameter, the pod was deployed in May 2011 for nine months to float in eddies along the Kona Coast of Hawaii Island. The pen was stocked with 2,000 Almaco jack fingerlings, also known as *kahala*. According to the owner of Kampachi Farms, tracking and controlling the movement of the untethered aquapod proved difficult. The fingerlings, however, showed increased rates of growth and decreased mortality rates in comparison to when farmed in coastal locations.

In March 2013, Kampachi Farms submitted another permit application for federal waters, this time to test the use of a single moored pen, which would overcome problems associated with untethered aquapod. The proposed project was site off of the Kona Coast of Hawaii, seven nautical miles south-southwest of Kailua Bay and six nautical miles west of Keahou, at depths of approximately 1,800 meters. The project was permitted again by the National Marine Fisheries

Service through a one year Special Coral Reef Ecosystem Fishing Permit (SCREP). Neither operations required NPDES permit from the EPA due to limited production scale.

As noted in Chapter Two, a lawsuit was file against NOAA by two NGOs asserting the agency's lack of authority to permit the project. A federal judge, however, affirmed NOAA's authority under existing Magnuson-Stevens legislation (cf. United States District Court for the District of Hawaii 2012).

At the time of this writing, the firm is applying for a third one year SCREP permit and planning to apply for a commercial permit to farm mahi-mahi. Reportedly, the species will not require a permit from the National Marine Fisheries Service.

6.0 Gulf of Maine

6.1 Characterization of Gulf of Maine for the Development of Offshore Aquaculture

The Gulf of Maine includes waters from the south and west of Cape Sable, Nova Scotia to north of Cape Cod, Massachusetts; as such, the Gulf includes waters off the US coasts of Maine, New Hampshire and parts of Massachusetts. Key respondents noted the suitability of Gulf of Maine for offshore aquaculture in terms of: presence of aquaculture research programs; existing well-developed coastal aquaculture industry; expertise in permitting and management of aquaculture operations in state waters; aquaculture training programs for the commercial fishing industry; and high market demand for fresh seafood.

Gulf of Maine has a diverse aquaculture industry and includes multiple species of finfish (salmon, trout, and cod), shellfish, and seaweed and encompasses all three sectors of hatchery, grow-out, and production. Finfish species have been grown commercially inshore waters and for research purposes in open ocean environment.

Longline mussel aquaculture has been identified as an ideal candidate for offshore expansion due to the ease of technology; low capital investment required, and the ability of commercial fishermen, particularly lobstermen, to conduct both activities together. With niche marketing, mussels have also been shown to high marketing value thus enabling operators to reach profitability with small scale operations. Researchers in Massachusetts and Maine are initiating research to create a phenotypically different local mussel variety that can be used to differentiate local produced mussels from imported product thereby enhance market value. Researchers report the need to establish a hatchery; the availability of hatchery produced spat will enable the rotation of crops outside of their natural spawning areas and thereby increase production. Currently, there is one active and one additional permitted open ocean longline mussel farm in state waters outside of the Gulf of Maine, in the Nantucket Sound region.

The Gulf of Maine's diverse marine aquaculture industry is supported by numerous public research facilities, educational programs, and development organizations. In addition, the region has key private companies that have supported the marine aquaculture industry with hatchery facilities and cage technology.

University of Maine's School of Marine Science, Darling Marine Science Center, the Center for Cooperative Aquaculture Research, Food Sciences Laboratory, Maine Aquatic Animal Health Laboratory, and the Maine Aquaculture Innovation Center all support the research in marine aquaculture. Together, the research programs work closely with the aquaculture industry supporting: new species development, hatchery and broodstock programs, animal health, and business incubation (Alves 2009). The University of Maine's Darling Marine Science Center houses an oyster broodstock program, and the Center for Cooperative Aquaculture Research houses a marine hatchery for Atlantic halibut, Atlantic cod, green sea urchin, and seeding facilities for edible red algae. The National Cold Water Marine Aquaculture Center, operated by the USDA, houses an Atlantic Salmon Broodstock program (cf. Morse and Pietrak 2010).

The non-profit organization Maine Aquaculture Innovation Center supports the aquaculture industry by: promoting needed applied research; assisting in policy formulation; serving as an informational clearing house; and liaising with government organizations, aquafarms and the

general public. Private firms specialize in the research and development of: submersible aquapod containment system; transfer process of smolt to sea water; salinity regulation in saltwater fish; and vaccines (cf. McDougall 2008).

In New Hampshire, the University of New Hampshire has been a pioneer in the development of open ocean aquaculture testing the operability of open ocean cage and automatic feeding technology and the viability of halibut, haddock, cod, steelhead trout, and blue mussels. The New Hampshire Open Ocean project, later renamed Atlantic Marine Aquaculture Center, operated a 30 acre site, near the Isle of Shoals, in state jurisdiction waters of New Hampshire, from 1997 until 2011. The University's Judd Gregg Marine Science Center offers hatchery facilities, pier and office facilities for aquaculture research. Farmed blue mussels subsequently were well received on the market and the Center supported technology transfer of mussel longline technology to the commercial sector. Technological advancements made in longline mussel aquaculture are currently further being developed by the Atlantic Marine Aquaculture Center in conjunction with the aquaculture and commercial fishing industry in Massachusetts. The New Hampshire-based company Great Bay Aquaculture has collaborated with researchers in the region working in marine demonstration farms.

There are three state-funded aquaculture centers in Massachusetts: the Northeastern Massachusetts Aquaculture Center; the Southeastern Massachusetts Aquaculture Center; and the Western Massachusetts Center for Sustainable Aquaculture. Aquaculture research is also conducted by University of Massachusetts's Dartmouth School of Marine Science and Technology, the Marine Biological Laboratory in Woods Hole, the non-profit Martha's Vineyard Shellfish Group, and Cape Cod Cooperative Extension, in addition to private hatcheries (cf. Reitsma et al. 2012). Researchers affiliated with the Northeastern Massachusetts Aquaculture Center and the Marine Biological Laboratory in Woods Hole have carried out extensive grow-out trial for longline mussel cultivation in state waters. In 2009, these research efforts resulted in the successful permitting of commercial operations in state waters off Martha's Vineyard (Marine Biological Laboratory n.d.). Researchers at both institutions have in collaboration with commercial fishermen worked on permit applications to conduct long-line mussel aquaculture projects in federal waters off Massachusetts. Information regarding these proposals is provided below.

Agencies in New Hampshire and Maine have experience in permitting finfish and shellfish aquaculture operations in coastal and open ocean environments within state waters. In New Hampshire, state agencies developed a permitting process for finfish and shellfish aquaculture as a result of the University of New Hampshire's Open Ocean projects. Permit applications have recently been submitted ensuring that agency staff continue to have experience in reviewing applications; there is, however, a concern regarding staff turnover rates and the need to ensure "institutional memory" for permitting aquaculture operations.

Maine's permit and management framework for marine aquaculture occurring in state waters has been refined over approximately 35 years; the state provides a streamlined permit application process for shellfish and joint application process for finfish. Maine's Pollution Discharge Elimination System permits (DPES) has been refined a number of times since its initial establishment in 2003. The most recent revision went into effect March 2014 and results in a reduction of monitoring required by the state based on increased understanding of environmental impacts and valid indicators. The permit modification establishes a tiered response wherein

second level impact analysis (of benthos) are required only when first level analysis (of sediment sulfide levels) are exceeded. The modifications reportedly recognize the effectiveness of standard industry based mitigation strategies; lessen the requirements for the industry; and reduce the amount of monitoring data that the department must manage.[17] In addition, in response to a Governor's Task Force on aquaculture and since the 2006, the lease process has been altered to reduce conflicts between the industry and communities in which they are situated.[18] The state has responded to conflicts regarding individual siting decisions by increasing outreach on how the public can weigh in on lease applications (cf. Maine Sea Grant n.d.). Staff at regulatory agencies have knowledge of each other's role and functions and decision making criteria and processes have reportedly reached a status of institutionalization. Shortage of staff, however, has resulted in a delay in approving permit applications.

Loss of commercial fishing opportunities, due to declines in fishing stock, has reportedly resulted in a growing receptivity of the commercial fishing sectors to marine aquaculture. A review of permit application data and Maine Aquaculture Association membership suggest a strong interest among commercial fishermen and fishing families to engage in aquaculture as a fulltime job or to supplement current fishing incomes. Approximately 75 percent of association members are former commercial fishermen or from commercial fishing families. For some families, aquaculture is being viewed as way to continue one's maritime heritage when a commercial fishing permit is not readily attainable (WRFR Community Radio, Rockland, Maine 2012).

Marine aquaculture training programs for commercial fishermen have been conducted in Maine, New Hampshire and Massachusetts (cf. Maine Office of the Governor 2004; Department of Legislative Services, Office of Policy Analysis 2013). Training in cod net pen, shellfish, and sea weed aquaculture has or is currently being provided in Maine through the Aquaculture in Shared Waters programs; technology transfer for long-line mussel aquaculture and pen poly-culture of trout, mussels and seaweed has occurred in New Hampshire; and classes in long-line mussel aquaculture are currently being conducted in Massachusetts. Recent training programs have focused on aquaculture species that can allow fishermen to supplement their incomes through diversifying their operations while maintaining participation in wild catch fisheries. Mussel, trout, and seaweed farming have received particular attention because of little capital is required to start a farm and the farming is suitability for small/family based enterprises akin the scale and manner of commercial fishing. Additionally, respondents with the aquaculture industry and research report that there are large and unmet local, regional and national demands for mussels; and high market demand overseas and diverse market opportunities for seaweed.

The purpose of the training programs has been to provide commercial fishermen with the technical knowledge, business models, and first hand exposure to aquaculture. But those involved in conducting training programs also recognize that without the knowledge of the ocean,

[17] Changes include: the expansion of the permit applicability to all species of finfish; elimination of video/photographic screening; removal of the requirement to maintain reference sites; reduction in number of indicators to be monitored; and reduction in frequency of sulfide monitoring (cf. Maine Department of Environmental Protection 2014).

[18] Various changes to aquaculture regulations include: provisions concerning emerging species; lighting and noise standards; municipal leasing of intertidal areas; lease sizes, options, and conditions; and requirements regarding benthic monitoring and notice of antibiotic use, amongst others (Maine State Planning Office 2011).

equipment, and buy-in of commercial fishermen, aquaculture will not likely develop in the region. As one respondent noted, the intent of the programs is also "to integrate the two industries on the water and in the market place and the identities [as both fishermen and farmer.]"

Fishing cooperatives have played an important role in supporting technology transfer; university researchers in the region have worked with Portsmouth and Yankee Fishermen's Cooperatives (in New Hampshire) and Harpswell and Corea Lobster Cooperatives (in Maine). In Maine, industry members have also worked in partnership with the Maine Lobsterman's Association on the working waterfront coalition (WRFR Community Radio, Rockland, Maine 2012). Researchers suggest that the fishing cooperative structure also holds promise for securing capital necessary for large scale operations – including costs of undertaking larger permit applications; procuring equipment, vessels, and processing facilities. In addition, cooperative relationships between the farming and wild catch sectors could empower both industries as they negotiate the potential loss of working waterfronts.

The aquaculture industry in Maine has also conducted outreach to non-governmental organizations and regulators. The industry is active in providing on-the water opportunities for the NGOs and key decision makers to understand the nature of aquaculture operations in the region, the improved environmental practices of the industry, the need for increased seafood supply, and economic opportunities for development (cf. Maine Aquaculture Association and NOAA 2013).

The Gulf of Maine is in close proximity to large population centers that create a high demand for quality seafood. Respondents in Maine note the importance of a locavore food movement to supporting the local wild catch and farmed fishing businesses. Local residents and vacationers value and expect locally produced food and seafood and restaurants reportedly play a crucial role in "sell[ing] the story of seafood."

And finally, extensive shore-side support infrastructure is located in communities along the Gulf of Maine. The topography of the coastal region, contemporary commercial fishing activity, and current demographic patterns give rise to widely dispersed coastal infrastructure in the northern part of the Gulf of Maine. A 2005 study of the Maine coastline identified 888 saltwater access points that supported commercial fishing. Of these access points, 38 also supported aquaculture operations (cf Island Institute n.d.). In many areas of the Gulf of Maine, however, commercial fishing fleets face challenges associated with: ongoing access to the coast, competition from competing users; and deteriorating support infrastructure. In Maine, the continued assurance of public coastal access has been identified as particularly problematic. Boat launches and piers that have traditionally serve commercial fishing fleet are being converted to private resident use, yachting marinas, cf. Maine Coastal Program 2000; Sheehan and Cowperthwaite 2002; Sunrise County Economic Council 2003). Tourism and increasing gentrification in the Cape Cod area of Massachusetts also threaten commercial fishing access to affordable coastal real estate. The Interim Technical Report provides an overview of the existing coastal infrastructure that could potentially support and benefit from offshore aquaculture development in the Gulf of Maine region.

The proposed Northeastern Massachusetts Aquaculture Center/Salem University project sited for federal waters off Cape Ann will be supported by vessels and fishermen associated with Rockport. Farmed product will be landed in either Rockport or Gloucester. Gloucester is the

highest ranked commercial fishing port in the Gulf of Maine; the port is considered a full service hub for commercial fishing in the region (Massachusetts Department of Transportation 2013; Mt. Auburn Associates 2009). Currently there are no processing facilities located in either port, and the farmed product may be trucked to North Kingston Rhode Island, the location of an existing processor. Open ocean aquaculture operations in New Hampshire state waters have been or are currently supported by coastal infrastructure in Portsmouth, Seabrook Harbor, and Rye.

The factors above, and in particular, the existence of a robust and growing coastal aquaculture industry and advanced research facilities are favorable for the expansion of the industry into federal waters. Although necessary factors, they may not however be sufficient. The primary constraints for the development of offshore aquaculture in the Gulf of Maine reportedly arise from challenging ocean and weather conditions and attending scale requirements and financial demands, particularly for finfish aquaculture. In addition, respondents report challenges related to siting projects to avoid other user conflicts, including marine mammals, and increasing competition for access to limited waterfront facilities.

Respondents report that finfish farming in the challenging open ocean conditions of the North Atlantic Ocean is currently not economically viable. The slow grow-out rates of finfish species in coldwater conditions coupled with the high costs of the technological systems required suggest that costs cannot be easily recouped. In response to oceanic and financial challenges associated with offshore aquaculture in the region, researchers in New Hampshire have, subsequent to the conclusion of the Atlantic Marine Aquaculture Center's open ocean project , turned their attention to inshore trout poly-culture demonstration projects as a different more "user friendly" model. Respondents within the industry, research, and regulatory agencies in Maine also report a socio-cultural preference amongst residents for small scale aquaculture operations owned and operated by locals.

User conflicts with commercial fisheries have been reported as a problem for state water operations in Maine and Massachusetts. In particular, the lobster fishery in Maine was characterized as having a high degree of territoriality with individuals and "lobster gangs" staking out what they perceived as their entitled space and place in the waters. Urchin and scallop fisheries, which are both conducted by dredge, have difficulty working around aquaculture sites and have also registered strong opposition to farms. Reportedly opposition from the wild catch fishing community is one hindrance to the expansion of the mussel industry. The territoriality particularly disadvantages non-locals and necessitates extensive site scoping. Lack of proper consideration for commercial fishing patterns when siting aquaculture operations can reportedly result in violence, retribution, and vandalism. According to state agency staff in Maine, mandated scoping sessions are means for avoiding violence that can be associated with territorialism.

Respondents were no more sanguine about potential user conflicts in federal waters. The federal waters are also characterized by "layers of conflict" between fixed gear fisheries of lobster and mobile gear of midwater trawl fisheries and also scallop dredgers. A respondent from the commercial fishing industry noted that in so far as federal waters are utilized by highly mobile fleets from different states, "there is no community to speak to and get acceptance [for the siting of an aquaculture operation]" Unattended aquaculture operations "would likely be run over by mobile gear and you would never know who it was."

Respondents within regulatory agencies and industry also note that gentrification of coastal communities has led to increased opposition to coastal aquaculture; opposition frequently centers on "quality of life" issues, property values, and perceived aesthetics or "viewshed." Social opposition in relation to gentrification portends two possibilities for the expansion into federal waters. On the one hand, respondents note that this kind of social opposition could encourage expansion offshore and result in local growth for high valued seafood. On the other hand, gentrification can affect the availability of shore side property and coastal access necessary for farming operations.

Researchers in Massachusetts noted siting challenges in relation to the marine mammal presence and the Stellwagen Bank National Marine Sanctuary. The federal waters of Cape Cod have been identified as Right Whale habitat and as such the use of all fixed fishing or farming gear is prohibited through the winter and spring. In addition, an Atlantic Large Whale Take Reduction Plan pending for waters from Maine to Florida may impact the potential development of offshore aquaculture in so far as fixed year around gear would likely not be permitted in many areas (cf. Northeast Regional Office, NOAA Fisheries 2013).

Staff at the regional office of NOAA are currently conducting interagency workshops regarding the issues associated with mooring technology and marine mammal protection. Agency staff within NOAA's Office of Protected Species report currently creating internal guidelines for assessing the potential risk of aquaculture gear to protected marine mammals and to provide technical assistance to applicants regarding suitable site locations and gear configurations to mitigate entanglement risks. Additionally, a white paper regarding aquaculture and marine mammal entanglements is in preparation; the paper focuses particularly on longline mussel technology. Reportedly, information gained from this regional effort may assist other regions in assessing the risks of marine mammal entanglement and formulating appropriate mitigation strategies.

6.2 Overview of Proposed and Permitted Offshore Operations

To date, two aquaculture projects have been proposed for federal waters of the Gulf of Maine. A proposed commercial finfish (Atlantic salmon) farm was under permit consideration between 1987 and 1992. Currently, one long-line mussel project for the offshore waters of Cape Ann is currently pending approval.

Maine. Currently there are no aquaculture operations proposed or planned for federal waters off the coast of Maine. A functioning state regulatory framework, adequate space for expansion in state waters (should the social and political will continue), and the cost of establishing operations in federal waters have been cited as reasons for the lack of need or interest to expand into federal waters. Reportedly, the largest (and only) salmon farming operation, Cooke Aquaculture is not currently considering expansion into offshore waters within the United States waters of the Gulf of Maine, due to the availability of sufficient coastal waters in Maine and Canada. Added space requirements for IMTA or warming of inshore waters may, however, create an impetus to move offshore.

In regards to the mussel industry, reportedly challenges in the inshore environment are not considerable enough to demand expansion into offshore waters. In addition, respondents

expressed concern about the increased potential presence of toxins in federal waters that give rise to paralytic shellfish poisoning (PSP).

New Hampshire. Currently there are no aquaculture operations proposed or planned for federal waters off the coast of New Hampshire. Recent applicants interested in establishing open ocean operations have applied for permits in state waters – taking advantage of the permit process established by the Atlantic Marine Aquaculture Center's Open Ocean Research Project.

Massachusetts. There are no current offshore aquaculture operations within federal jurisdiction waters of Massachusetts's Gulf of Maine. In 1987, a proposal was developed by American Norwegian Fish Farm, Inc. for a commercial salmon farm with two facilities. One facility for smolts was sited in inshore waters and a grow out pen was sited in federal waters off Cape Ann. In 1988, the company filed a permit application with the Army Corp of Engineers for a 47-acre site, which would hold 90 90-foot diameter pens, 27 miles east of Cape Ann. To mitigate potential significant impacts to the fishing community, the site was relocated a further ten miles east and an Army Corp permit was issued in 1990. The permit was subsequently withdrawn due to conflicts with Navy operations; objections were also expressed by the EPA, and a suit was brought against the Army Corp by the Conservation Law Foundation (Sunday Telegraph 1992). In 1994, the company resubmitted a proposal for a smaller project (involving ten pens) to be located 47 miles offshore. The Army Corps did not permit the project due to concerns about the robustness and safety of the mooring system. The applicants did not pursue any further proposals (cf. Stellwagen Bank National Marine Sanctuary 1993; Associated Press 1992)

Building on successful nearshore demonstration project, researchers at Northeast Aquaculture Center in conjunction with Salem State College submitted a permit application to the Army Corps of Engineers in spring of 2013 for a 33 acre site in federal waters 8.5 miles off Cape Ann (cf. Maney et al. 2010). The project proposes deploying 40 500-foot submerged lines, when fully operational (cf. Maney et al. 2013). The site and operational configurations were based on proximity and ease of access for fishermen to service the site, and location outside of the Stellwagen National Marine Sanctuary. The site also benefits from not being in an area of high migratory duck presence, which is associated with predation challenges, and low rates of pea crab infestation of mussels, which lowers the market value.

The reported benefits of the Cape Ann project include employment for commercial fishermen negatively impacted by current fishery regulations and a reduction in dependence on Canadian-grown mussels. Should the demonstration project indicate the future feasibility for longline mussel farming, researchers plan to transfer technology to members of lobster cooperatives in the Rockport area. In addition, researchers are documenting the permitting procedure for future potential applicants and preparing a business plan for the marketing of mussels.

The proposed project has received funding from the federal government and significant support from staff at NOAA's Office of Aquaculture Greater Atlantic Regional Fisheries Office in negotiating the permitting process. To date, the project has faced challenges in relation to the Marine Mammal Protection Act. To mitigate the possibility of whale entanglements, the operational configuration has been changed, resulting in a decreased number of vertical lines, incorporation of breakaway links, and establishment of proper clearances above and below long-lines. Further discussions are being held with NOAA agency staff within the Division of

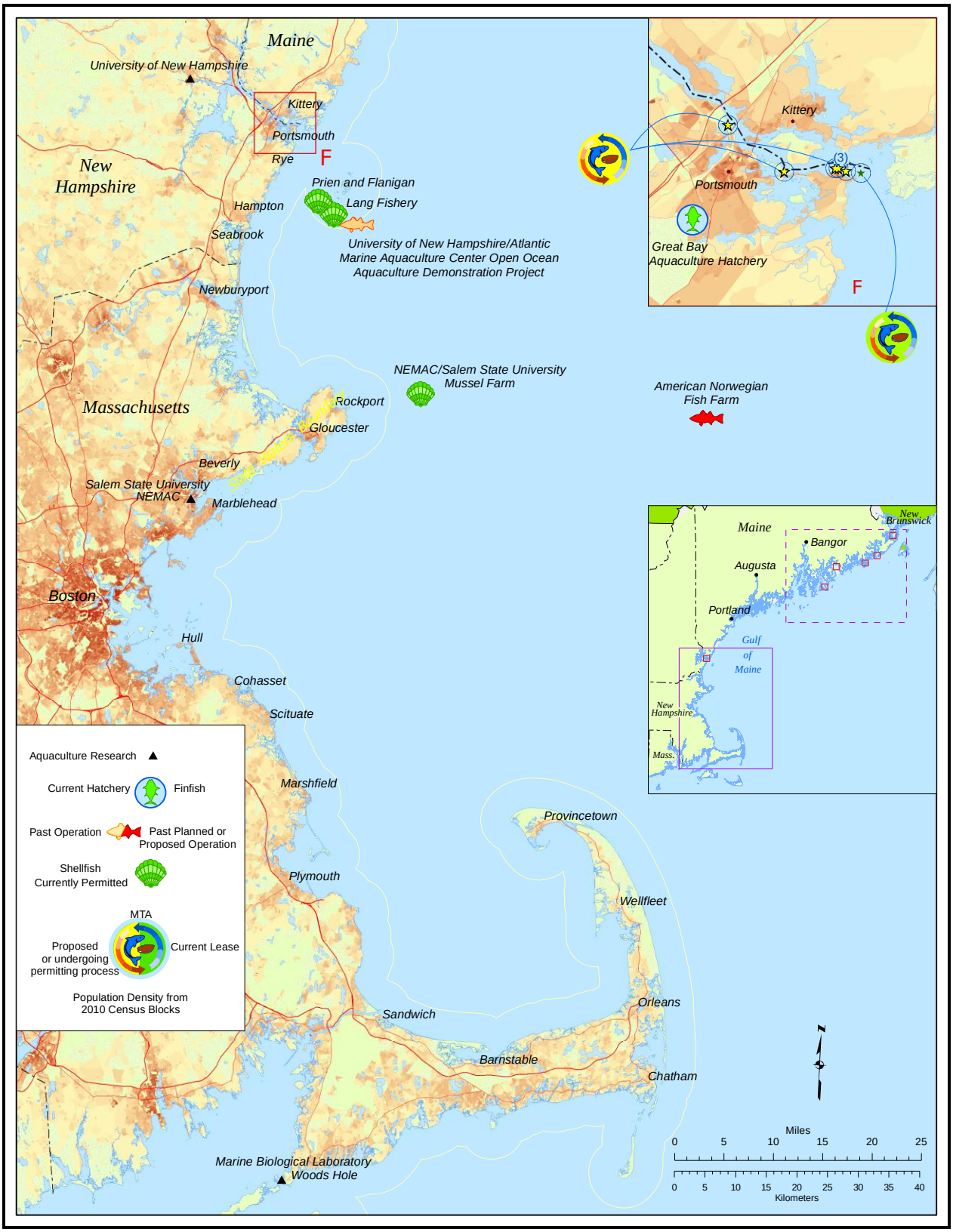
Protected Resources to mitigate entanglement dangers and augment whale tracking data by attaching time lapse cameras on the farm structures.

The project has also faced permitting challenges in relation to a PSP closure enacted by the (FDA). In 2005, National Marine Fisheries Service closed an area of federal jurisdictions waters in the Gulf of Maine due to the detection of toxins that cause PSP. The Northern Temporary PSP Closure Area, as it was referred to, prohibited the harvesting of all bivalve shellfish. In 2014, the ongoing need for the closure was reviewed and the closure was lifted in October of the year, for select species (cf. United States Government Printing Office 2014). The Commonwealth of Maine has subsequently agreed to conduct PSP monitoring of bivalves harvested from the closed area thus allowing for the resumption of commercial harvesting in the area and the potential permitting of the NEMAC/Salem State College offshore demonstration project.

In offshore waters south of Massachusetts, and thus outside of the Gulf of Maine, a sea scallop demonstration project—the Seastead Project – was operated in federal waters between 1995 and 1998. The demonstration project was a collaborative effort between aquaculture research scientists and local fishermen, the purpose which was to investigate the technological feasibility and growout results for various farm methods (cf. Westport Scalloping Corporation 1998). An economic and site suitability analyses were subsequently performed on the most promising method – bottom seeding (cf. Kite-Powell et al. 2003; Anamarija and Edmundson n.d.). These analyses suggest that offshore sea scallop farming could be profitable. Challenges, however, remain regarding obtaining seed and determining rates of retrieval of scallops. Additionally, the lack of clear regulatory framework for aquaculture in federal waters for this region may be a deterrant (cf. Anamarija and Edmundson n.d.). There are not recent reports of parties interested in pursuing commercial development.

In October 2014, the first shellfish farm sited for federal waters of the East Coast was permitted by the Army Corps of Engineers. The mussel farm will be located four mile off Cape Cod in proximity to the Cape Wind, offshore wind farm. The permit site is for 28.5 acres with an initial deployment of three lines and utilization of 25 lines, when fully operational. Initial production is estimated at 30,000 pounds with full production at 500,000 pounds annually (cf. Shekhtman 2014).

Researchers involved in the project report that there were some permitting challenges in relation to Marine Mammal Protection and concerns regarding whale and turtle entanglements. Mitigation strategies were identified through consultation with the staff at NOAA's Division of Protected Resources. The strategies that will be employed include: decreased number of vertical lines; incorporation of breakaway links; and establishment of proper clearances above and below long-lines. **Map 6-1** depicts the location of (proposed and permitted) offshore operations within the Gulf of Maine. (The lower right inset depicts the location of inshore salmon aquaculture operations in Maine.)



Map 6-1 Gulf of Maine Open Ocean Operations in State and Federal Waters

Our research reveals not only that the potential for development of offshore aquaculture differs by region but that the drive to develop offshore aquaculture is originating from different kinds of parties. In the Gulf of Maine, the advancement of offshore aquaculture is currently being driven by aquaculture researchers associated with local universities and colleges who are working with commercial fishermen. The species, technologies, and (small) scale of operations that are the focus of attention are seen as compatible with the equipment, skill sets, and lifestyles of commercial fishermen. In Southern California, proposals for offshore aquaculture operations have been submitted by a private entrepreneur and a non-profit research institute working in partnership with an aquaculture investment firm. Proposals are for the eventual establishment of large scale operations. In Hawaii, interest in the expansion of commercial scale aquaculture operations in federal waters is from member of aquaculture industry with extensive experience in hatchery technology and finfish net-pen aquaculture. Operations sited for federal waters utilize advanced submersible cage and single mooring technology. Appendix A provides in table form of comparative assessment of our three case study areas.

Of note, currently aquaculture firms in our study regions are focusing on species that do not require a federal permit from NMFS. These species include: white seabass, California yellowtail, blue mussels, Olympia oysters, Pacific oysters, Mediterranean mussels, and mahi-mahi.[19]

[19] Although mahi-mahi is a federally managed species, harvesting does not reportedly require a permit.

7.0 Non-government Organizations and the Development of Marine Aquaculture

NGOs have been avid interlocutors in debates regarding the development of aquaculture in state and federal waters. They have been influential in the creation and implementation of domestic aquaculture policies and regulations and in the permitting of aquaculture operations. Many have engaged in educational outreach and targeted messaging regarding the safety of farmed fish and the environmental impacts of farming operations.

The industry is characterized, as one respondent put it, by "a great deal of angst" in regards to the power of environmental groups. In open-ended discussions, 56% of our respondents in the aquaculture industries, research, and regulatory agencies reported the influence of environmental movement as a significant constraint to the development of open ocean aquaculture industry within United States. 60% of respondents within the industry mentioned opposition from conservation NGOs to their current or proposed operations. 66% of researchers active in aquaculture and 46% of regulatory agency staff expressed similar concerns regarding the influence of conservation NGOs[20].

In this chapter we consider NGO concerns regarding marine aquaculture and the strategies NGOs utilize to influence the development of the open ocean aquaculture industry. One goal of this investigation is to identify potential collaborative opportunities between the industry and conservation groups.

The following discussion and analysis is based on research conducted on 20 NGOs with past or current involvement in aquaculture issues[21]. The twenty organizations represent the most influential NGO voices involved in aquaculture issues within our case study regions. Of the twenty NGOs, the majority (twelve) define the primary mission of their organization as (marine, terrestrial, or wildlife) conservation or environmental protection, two as sustainable economic development, one as consumer protection, one as native rights, and one as improvement of civic life and public policy. Three organizations were established as aquariums. Two organizations are major funders of other non-profit organizations and provide research grants for ocean and fisheries related causes.

7.1 Environmental concerns and preferred marine aquaculture technologies and species

[20] In our three case study regions, respondents from the industry sector and in state regulatory agencies noted the influence of Food and Water Watch. The Ocean Conservancy, Environmental Defense Fund, Surf Rider, and David Suzuki Foundation were also mentioned as having been powerful adversaries of open ocean aquaculture development in both state and federal water jurisdictions. A 2010 survey of state aquaculture coordinators, respondents specifically named the Environmental Defense Fund and Food and Water Watch as advocacy groups opposed to aquaculture (cf. Siddiki and Weible 2010, 2011).

[21] Interviews were conducted with individuals associated with ten organizations: Sea Web, Ocean Conservancy, The Nature Conservancy, Gulf of Maine Research Institute, Aquarium of the Pacific, The Ocean Foundation, New England Aquarium, The Environmental Law Institute, Oceana, and Food and Water Watch. Information on the following ten organizations was gathered through a literature review: Environmental Defense Fund, Pew Charitable Trust, World Wildlife Fund, Conservation Law Foundation, Conservation International, Greenpeace, National Resources Defense Council, KAHEA Hawaiian-Environmental Alliance, Monterey Bay Aquarium, and Sierra Club.

The often repeated and primary environmental concerns expressed/reported by NGOs, or as one respondent observed "the laundry list" regarding marine aquaculture generally has centered on impacts to water quality and benthic communities, wild fish stock, marine mammals and/or birds (cf. Ocean Conservancy 2011; Monterey Bay Aquarium 2011). Nutrient pollution from fish feces, unconsumed meal, and mortalities and chemical pollution from the use of therapeutants and anti-foulants can threaten native species, alter natural environment, impact biodiversity, change eco-system functions, and harm human health. The use of wild forage species, such as anchovies, sardines, and mackerel, to feed carnivorous fish[22] potentially threatens the food source of marine mammals, seabirds, and other predatory fish species with possible long-term and far-reaching consequences throughout the ecosystem. Escapes of non-native species can compete for food, mates, and other resources, and through interbreeding can impact the resilience and fitness of wild stock and compromise genetic integrity of native populations. Additionally, and irrelevant of rates of escape, farms can serve as reservoirs of concentrated disease and parasites that represent vectors of transmission for wild populations.

Concerns regarding impact to marine mammals, turtles and birds have centered on how aquaculture operations can affect natural feeding and breeding behavior by either impeding access to natural resources or attracting predators to sites and result in entanglement in aquaculture gear. Within our study regions, concerns about the aggregating of sharks (Hawaii); habituating of dolphins (Hawaii); and entanglement of whales and other wildlife (New England, California) have been the most often cited. Other concerns include the impact on wild stock from the collection of spat or larvae (in the case of shellfish); broodstock (for hatcheries); and wild juvenile fish (for ranching).

Many of these environmental concerns are shared by NGOs with state and federal agencies that have regulatory authority over different aspects of aquaculture. Of note, in Chapter Eight we detail current technological solutions and management measures available to mitigate the common concerns regarding environmental impacts.

Of the twenty organizations considered as part of this study, eight showed a distinct preference for self-contained re-circulating aquaculture system (RAS) technology that treat and/or re-use waste. Closed systems are promoted for the aquaculture of marine finfish as a way to: minimize pollution from fish waste and chemical therapeutants and control adverse impacts on wild fish due to disease transference, or escape of farmed fish. Closed land-based systems also preclude the possibilities of marine mammal or bird attraction to farms which can lead to entanglement and increased predation of wild species. Due to the high energy demands associated with the operation of closed systems, some NGOs also note that closed systems should be powered by solar, wind, or geothermal energy and could even be designed to generate methane from waste produced during operations (cf. White et al. 2004; The Ocean Foundation 2011). In response to high energy and construction costs and high real estate values associated with land based closed containment systems, a recent floating tank system was created and tested by a Canadian company, AgriMarine. The completely contained hydroelectric generating floating system was highlighted in a 2012 Seafood Summit, attracting the attention of a number of NGOs (cf.

[22] The majority of marine fish species that are currently farmed or are candidate species for farming in United States are carnivorous: salmon, threadfin, amberjack, red drum, cobia, cod, haddock, sablefish, red snapper, striped and white seabass, California halibut, and yellowtail.

Buchanan 2012). The current costs of operating land-based systems suggest that seafood produced will be of high cost and for a limited market (Goldman 2012).

Ten organizations acknowledged the need for and acceptability of some form of open ocean aquaculture. Nine of these organizations showed preferences for IMTA or polyculture systems. These systems are proposed as a possible means to mitigate nutrient loading associated with finfish farming and to remediate ocean acidification (Ish 2009; Ocean Conservancy 2011; Monterey Bay Aquarium 2011; Spalding et al. 2013). IMTA will require that site locations be able to meet the expanded space requirements and the different oceanographic needs of culturing a variety of species.

Four organizations promote traditional land based aquaponic and coastal fish ponds as the future of aquaculture. Hawaii had a tradition of fish pond aquaculture (*loko i'a)* with an estimated 340-360 operating prior to the arrival of Captain James Cook in 1778. Currently there is a movement to restore traditional fish ponds as a way to support native Hawaiian cultural tradition. To this end, the state of Hawaii is conducting an environmental assessment of traditional fish ponds practices and technology. Annual production rates for fish ponds are low in comparison to other modern aquaculture techniques (cf. Keala et al. 2007).

Seven organizations expressed preferences for shellfish and or kelp because they do not require the addition of feed but rather extract nutrients from the environment and thus are perceived as having a lower environmental impact (White et al. 2004; Spalding et al. 2013; Ocean Conservancy 2011). For example, Conservation Law Foundation has testified in lease hearing in support of kelp farming and has worked with the Maine Aquaculture Association regarding mussel farms (cf. Maine Department of Marine Resources 2012b). Environmental Defense Council is generally supportive of California's shellfish industry including reportedly the open ocean operations conducted in state waters off Santa Barbara (cf. Conservation Working Group 2007). And The Nature Conservancy is currently collaborating with the Pacific Shellfish Growers on a California Shellfish Initiative.

Six organizations reported preferences for the farming of herbivore or omnivore species to reduced reliance and impact on wild fish food sources. Carnivorous species raised with conversion yield rates at one to one and fed with fish meal from sustainably produced fisheries are also generally deemed acceptable.[23] One organization favors the use of only sustainably grown plant based food sources or use of trimmings from seafood processing. One organization opposes the use of any soy based feeds, due to concerns with potential food safety issues related to GMO soy.

7.2 NGO strategies and effect on influencing the development of offshore aquaculture

NGOs utilize a number of different strategies to seek redress for environmental problems associated with marine aquaculture generally and influence the development of the offshore aquaculture industry more specifically. These strategies include: litigation directed at regulatory agencies or individual companies; lobbying for or against legislation; grass root activism directed at proposed aquaculture operations; and a market-based approach.

[23] Disagreement, however, remains between NGOs on how conversion rates should be calculated for fish oils and which sustainable certification systems are acceptable.

Litigation. Five of the organizations we researched have been involved in lawsuits against federal agencies in relation to the permitting or regulating of aquaculture operations. Conservation Law Foundation filed suit against the Army Corp of Engineers for permitting a large scale fish farm in federal waters of the Gulf of Maine in 1992 (*Group file suits 1992).*In 2010, the Ocean Conservancy, Gulf Restoration Network, and Food and Water Watch filed a lawsuit against NOAA for the Gulf of Mexico Fishery Management Plan for Offshore Aquaculture. The claimants assert that the plan "violates the Maguson-Stevens Act, the National Policy Act (NEPA), the Administrative Procedure Act." (cf. Etheridge 2011). In 2011, the court found that because the plan had not been implemented, the claimants did not (yet) have standing to sue. In 2011, Food and Water Watch and KAHEA Hawaiian Environmental Alliance filed suit against the National Marine Fisheries Service regarding the issuance a Special Coral Reef Ecosystem Fishing Permit for an offshore aquaculture operation. Food and Water Watch and KAHEA sought that the one-year permit be invalidated. The claimants asserted that the NOAA did not have authority under the Magnuson Stevens Act (MSA) to permit the operation and the failure to require an Environmental Impact Statement was a violation of the National Environment Policy Act (NEPA). The first claim was decided in favor of the agency, i.e. that the use of MSA by NMFS to regulated aquaculture was reasonable (United States District Court for the District of Hawaii 2012: 22). The second claim was determined to be moot in so far as the aquaculture operation had ceased activities and the permit had expired.

Non-government organizations have also been involved in litigation against federal agencies and the industry by citizens groups for marine aquaculture more generally. In 1991, the National Resource Defense Council won a suit against the EPA requiring that the agency regulate aquaculture under the Clean Water Act. This lawsuit resulted in the EPA establishing effluent guideline limits for the industry (Tucker and Hargreaves 2008). In 1999, the National Environmental Law Center was pivotal in a suit filed by a citizens group again finfish farmers in Maine for violations of the Clean Water Act (cf. Maine Department of Environmental Protection 2014). This lawsuit reportedly resulted in the bankruptcy of a number of companies and the creation of a pollutant discharge elimination system permit for aquaculture operations by the state of Maine. In 2002, a nonprofit organization, The Association to Protect Hammersley, Eld, and Totten Inlets (APHETI), filed suit against Taylor Seafood for a violation of the Clean Water Act. The lawsuit was decided in favor of the operators of the mussel farm; the Ninth Circuit judged that the shellfish farm did not required a NPDES permit based on the definition that natural mussel elimination was not a form of pollution (cf. National Sea Grant Law Center 2012).

Lobbying and Legislative Efforts. At both national and state levels, NGOs have been active in lobbying for and against legislative initiatives regarding offshore aquaculture. Of particular note are the influence and involvement of The Environmental Defense Fund, National Resource Defense Council, Sierra Club, The Nature Conservancy, Food and Water Watch, Ocean Conservancy, and Oceana. Between 2005 and 2009, NGOs actively collaborated to ensure any national aquaculture legislation that was passed reflected their broadly shared environmental concerns.

In 2005, a proposed National Aquaculture Act (S.1195) sought the creation of a streamlined regulatory process, overseen by NOAA, to regulate aquaculture in federal waters. Thirty-eight non-governmental organizations expressed their opposition; they were joined by 14 commercial

or recreational fishing associations (cf. United States Government Printing Office. 2006).[24] The Act was not passed. Also in 2005, The Ocean Conservancy sponsored a state bill regarding open ocean aquaculture of finfish in California state waters. Supported by thirty non-governmental organizations[25], SB201 was subsequently enacted as California's Sustainable Oceans Act. National legislation similar to the standards found in California's Sustainable Oceans Act was proposed in 2009 for federal waters but as mentioned in Chapter Two, was not passed.

In Hawaii, Food and Water Watch, KAHEA, and thirty other organizations that constitute the Pono Aquaculture Alliance have opposed state bills to lengthen the period of leases for open ocean aquaculture in state waters (HB 2409 and 568) and supported bills calling for a moratorium on granting further leases (HR 245 and HCR 326) (cf. The Hawaii Independent Staff 2010).

In support of national legislative efforts, The Pew Foundation and the Ocean Conservancy have formulated extensive of policy recommendations for the development of the offshore aquaculture industry (cf. Marine Aquaculture Task Force 2007; Ocean Conservancy 2011). Ocean Conservancy proposed four principles for the regulation and development of offshore aquaculture. They are as follows:

1) The establishment of comprehensive national framework that would include the passage of federal legislation; an integrated regional ocean management and marine spatial plans; development of regional programmatic environmental impacts statements; allowance for states to opt out of all coastal fishing farming; and prohibition of aquaculture in marine reserves, protected areas, and sanctuaries and on offshore oil and gas platforms;

2) The utilization of a precautionary standard in the assessment of all aquaculture operations and preference for close containments in water technologies and IMTA;

3) The application of environmental standards that would ensure water quality standards, protect wildlife and wild fish stocks, prevent (the impact of) fish escapes, mitigate disease transfer, and minimize use of chemical therapuetents. In particular, Ocean Conservancy calls for water quality standards that contain numerical limits and consider cumulative impacts; the prohibition of all non-native/non-local fish species beyond

[24] Center for Food Safety, Greenpeace USA, Food and Water Watch, National Environmental Trust, National Resource Defense Council, The Ocean Conservancy, Environmental Defense,; Pacific Marine Conservation Council, Oceana, Environment Matters, Alaska Marine Conservation Council, Prince William Soundkeeper, Transboundary Watershed Alliance, Hurricane Creekkeeper, Inc., Clean Water Action, Environment California, Friends of the Eel River, Savannah Riverkeeper, KAHEA: The Hawaiian-Environmental Alliance, Gulf Restoration Network, Louisiana Bayou keeper, Institute for Agriculture and Trade Policy, Raritan River keeper, National Coalition for Marine Conservation, Go Wild Campaign, Hawaii Audubon Society, Rhode Island Sierra Club, Environment Maine, Cook Inlet Keeper, PCC Natural Markets/Sound Consumer, National Environmental Trust, Casco Bay keeper, Friends of Casco Bay, Mangrove Action Project, GRACE Public Fund, Maryland Conservation Council, Reef Relief, and Whale Center of New England (cf. US Government Printing Office. 2006)

[25] Other supporters of SB201 were: Bluewater Network, California Coastkeeper Alliance, California Coastal Protection Network, California League of Conservation Voters, CalTrout, Coastside Fishing Club, Center for Food Safety, Defenders of Wildlife, Environment California, Environmental Center of San Luis Obispo, Environmental Defense, Environmental Defense Center, Environmental Entrepreneurs, Institute of Marine Sciences--US Santa Cruz, Monterey Bay Aquarium--Center for the Future of the Oceans, Natural Resources Defense Council, Oceana, O'Neil Sea Odyssey, Orange County Coastkeeper, Pacific Coast Federation of Fishermen's Associations, Planning and Conservation League, Santa Barbara Channelkeeper, San Diego Baykeeper, San Luis Obispo Coastkeeper, Santa Monica Baykeeper, Save Our Shores, Seaflow, Sierra Club California, The Nature Conservancy, University of California Marine Council. (cf. US Government Printing Office. 2006)

second generation, genetically modified fish stock, and ranching; the prohibition of prophylactic use of therapeutents; and a requirement that wild fish based feeds are sourced from abundant and well managed wild fish stock;

4) The protection of ocean as a public trust resource that would require the permitting and regulating of operations be conducted through a public participatory process and operators compensate the public through appropriate permit fee structures and be responsible for any environmental damages. Of particular note, the Ocean Conservancy also calls for a national provision that would allow citizens to file suit against operators in the case of violations (cf. Ocean Conservancy 2011).

Local Campaigns and Grassroot Activism. NGOs have weighed in on the local level as aquaculture operations have been proposed for federal water jurisdictions. Representatives of Sierra Club and Save the Bay have spoken at public hearings in Hawaii and California, respectively.[26] In California, environmental groups have been joined by recreational and commercial fishing organizations in expressing opposition to offshore aquaculture operations based on concerns regarding loss of fishing grounds and potential impact to essential fish habit.

In Hawaii, Food and Water Watch has been active working with local organizations and involved in "online activism" in relation to proposed projects. Food and Water Watch identified Hawaii as the location where open ocean aquaculture, in state and federal water jurisdictions, would likely develop (Food and Water Watch 2010). In addition to expressing their organizational concerns in written and oral form, Food and Water Watch has provided internet based form letters for concerned stakeholders to communicate with staff at regulatory agencies. Food and Water Watch campaigns resulted in 84 identical letters in opposition to Hukilau Farms; over 220 form letters in opposition to Hawaiian Ocean Technology; and "several thousand" duplicated letters in opposition to Kampachi Farm's Velella Beta (Aquaculture Planning and Advocacy LCC. 2009; Tetra Tech 2009; Tosatto 2011). Additionally, Food and Water Watch expressed opposition to Monterey Bay Aquarium for the listing of Kona Kampachi as a "good alternative." (cf. *Hawaiian Seek Removal* 2009).

Respondents within the regulatory agencies in Hawaii and Maine report that the effectiveness of NGO and grass roots opposition to proposed operations within state waters has depended on the legal standing of the commenter and the informational quality of objections. Opponents must convincingly argue some kind of negative environmental or economic impact from the proposed operations. Generally form letters or electronically generated oppositional emails do not carry the weight of individually crafted correspondence especially if they are generated through a non-local non-government organization. According to state agency staff, the influence of opposition letters "is not based on their number but the informational quality." Social opposition can increase the amount of time staff at regulatory agencies and industry applicants need to address public concerns. NGO concerns regarding proposed operations may result in the imposition of additional monitoring requirements as part of permit approval, as was the case in recently the federal permit of shellfish operation in California, KZO Sea Farms.

[26] Heal the Bay, Los Angelese Waterkeeper, Ocean Defenders Alliance, and Orange County Coastkeeper provided letters of opposition to the California Coastal Commission's federal consistency review of KZO proposed project for an offshore mussel longline operation. Sierra Club filed letters of concern and/or oppostion to Hawaiian Ocean Technologies and Kona Blue's proposed projects off the coast of the Big Island and Cates proposed project off Ewa Beach.

Consumer Seafood Guides and Farm Certification Systems. Currently the most widespread strategy utilized by NGOs focuses on harnessing the power of the market to influence the development of aquaculture industry practices. Market based approaches have developed as part of a sustainable seafood movement and in response to concerns on the part of the environmental community regarding the management of wild catch fisheries; they have since expanded to include aquaculture products. Seventeen of the 20 organizations within our study utilized some kind of a market based approach including: consumer guides to seafood, distributors, and restaurants; certification systems for farms or industries; and partnerships with retailers.

Market-based approaches are premised on the notion that consumers, once educated, will prefer sustainably produced seafood, and thus increase the demand and price of sustainable products (cf. Roheim 2013). Certification systems are also seen as a way to encourage governments to develop effective and enforceable laws that ensure protection of the environment. NGOs variously target three links within the seafood chain –end consumers; distributors; and producers. For example, Monterey Bay Aquarium's provides a consumer guide to seafood through their Seafood Watch program, established in the late 1990s. In 2008, Greenpeace initiated a ranking and reporting system to provide consumers with information about seafood retailers (cf. Mitchell 2014). Established in 2008, the Conservation Alliance for Seafood partners conservation NGOs with major retailers to improve retailers' understanding of environmental issues and sourcing of sustainable seafood.[27] And in 2004, the World Wildlife Fund began focusing their efforts on creating environmental aquaculture standards for the marine aquaculture industry. Other environmental NGOs have followed suit establishing their own seafood guidelines; standards for farms practices; and (eco-) labels and marketing campaigns.

Public Outreach and Education. NGOs commonly include some kind of public education or messaging as a part of their litigation, lobbying, or market strategies. Public messaging surrounding grass roots activism has in some cases been polemic in character presenting the potential impacts of marine aquaculture as a fait accompli. To convey their understanding of the potential threats of open ocean aquaculture, Food and Water Watch and Environmental Defense Fund publications have expressed environmental concerns in an impressive array of similes that have likened: farming salmon to "farming tigers" (Goldburg 1997); open ocean farming as "aquatic feedlots" (Goldburg 1997); currently operational farms in the US as "factory farming" (Food and Water Watch 2011); and fish and feed waste associated with marine cage culture operations to untreated human sewage (Food and Water Watch 2010). The imagery has found its way into the public conscience and is reflected in some consumer attitudes towards farmed seafood; residents' opposition to proposed aquaculture operations; and (commercial and recreational) fishermen's resistance to the marine aquaculture industry, generally.

Three NGOs within our study have comprehensive educational lectures, videos series, and webinars specifically focusing aquaculture issues germane to the development of open ocean aquaculture in state and federal waters. Sea State lectures, sponsored by the Gulf of Maine

[27] In addition to making a commitment to buying environmentally responsible/sustainable seafood, companies agree to educate their employees, customers, and suppliers on seafood sustainability and participate in and support policy reform. Currently 17 conservation NGOs belong to the alliance and 21 major retailers in United States and Canada have signed on to the alliance's environmentally sustainable seafood vision (cf. Conservation Alliance for Seafood Solutions n.d.)

Research Institute, are largely targeted for highly engaged and concerned public who already have an interest and familiarity with aquaculture issues. The lectures cover such technical topics as: ecosystem carrying capacity, welfare challenges in aquaculture, effectiveness of eco-certification, alternative feed development, and disease interactions between farmed and wild salmon, current status of IMTA, and antibiotic usage. Sea Web created their webinar series specifically for scientists, the industry, agency staff and NGOs to provide a venue to debate issues. Through the webinar series, Sea Web hopes to move "the conversation forward" from that which focuses on threats. They have covered such topics as: sustainable aquaculture's role in meeting global food supply; NOAA and Department of Commerce Aquaculture Policies; innovations in aquaculture feed; and Aquaculture Steward Council's certification standards.

In total, the aforementioned strategies have influenced the development of marine aquaculture in the United States by focusing on different players within the system and on current and future practices of regulators, aquaculture operators, businesses within the seafood distribution sectors, consumers/citizens. Lobbying primarily targets the development of regulations for marine aquaculture at state and federal levels. Grass root activism has focused on marshalling local forces in relation to the permitting of potential projects. Litigation has been pursued to: restrict the authority of federal agencies to permit operations or to require federal agencies to exercise a regulatory authority and to restrict business practices. Seafood guides and ecolabels have targeted the marketing of farmed seafood.

7.3 Current NGO efforts to further the development of environmentally sustainable offshore aquaculture

Between 2005 and 2009, when national aquaculture legislation for aquaculture was being debated, NGOs were active in raising funds, conducting research, lobbying, and educating the public regarding their environmental concerns. The resulting impasse in passing national legislation and the appearance of other environmental issues has reportedly resulted in decreased amounts of funding available for focusing on domestic offshore aquaculture. The Environmental Defense Fund and Ocean Conservancy have dropped their aquaculture programs.[28] The Pew Charitable Trust's Salmon Aquaculture Reform Campaign is also no longer active. Many NGOs have subsequently turned the focus of their ocean conservation programs to the impacts of ocean acidification, climate change, illegal fishing, coral health, marine debris, and/or coastal restoration.

Changing understandings: of seafood supply and demand; energy requirements of various food production systems; food security issues related to climate change and increasing water shortage; and national health crisis are encouraging a re-evaluation of the need and potential benefit of developing offshore aquaculture industry. Additionally, technological and management improvements developed by the industry and researchers are encouraging some NGOs to re-consider early/previous positions on aquaculture and envision the possibility of environmental

[28] Chief scientist and past director of the Ocean Conservancy's Aquaculture Program recognizes that the industry is now required to proceed without the national framework and that the environmental sustainability of offshore aquaculture operations will demand proactive engagement of applicants and regulators on a case by case basis (cf. Leschin-Hoar 2014; Yehle 2014).

sustainable forms of marine aquaculture. As one respondent reported "[we] are in a different position in the arc of understanding aquaculture [now]." In particular, key NGOs are recognizing the comparative eco-friendliness of aquaculture relative to terrestrial forms of protein production, for example, the efficient feed conversion rates of fish (versus terrestrial animals), efficient use of water and fossil fuels of aquaculture versus terrestrial agriculture, reduced greenhouse gas emissions of aquaculture production versus that of beef and pork, and stringent regulation of drug use for aquaculture in comparison to the livestock industry (cf. Hall et al. 2011; Monterey Bay Aquarium 2011; Ocean Conservancy 2011). In the context of growing concerns about illegal fishing, aquaculture is also being considered as a possible method of preventing seafood fraud. Additionally, growing concerns regarding the impact of coastal eutrophication, ocean acidification, and coastal erosion are creating an opportunity for collaboration between NGOs and sectors of the aquaculture industry that have previously been at odds. NGOs are considering the potential positive eco-system impact of aquaculture for creating habitat in open ocean environments and improving water quality in coastal waters (cf. Ocean Conservancy 2011). In comparison to other aquaculture producing nations, particularly in Asia, the US is being recognized for its stringent safety regulations and the best place to provide an exemplar of environmentally sustainable aquaculture.

Two conservations organizations are focusing particularly on offshore aquaculture. The Nature Conservancy is currently focusing on the potential of offshore aquaculture to address food security issues and considering the development an offshore aquaculture initiative that will include United States and other countries (Meliana and Deutz 2012). The Nature Conservancy has begun to identify collaborative partners within the government, academia, and industry (cf. Udelhoven 2014). A key determinant will be if the organization can acquire necessary funding and if it will be in their interests and ability to extend their activities beyond the near-shore where their strengths and experience lie.

In 2012, The Environmental Law Institute with funding from the Ocean Foundation began reviewing how current laws can be refined to ensure that the environment is protected should offshore aquaculture develop. In contrast to those NGOs that continue to oppose the development of offshore aquaculture without the passage of national aquaculture legislation, the institute is working with existing regulations, considering their strengths and limitations, and making recommendations. The Institute has held webinar discussions between aquaculture industry members, regulators, researchers, and NGOs regarding the utility of and challenges for regulating offshore aquaculture under existing regulations. To date, the Institute has reviewed Magnuson-Stevens Fishery Conservation and Management Act and the Clean Water Act and provided a White paper of regulatory recommendations (cf. Emmett Environmental Law and Policy Clinic et al. 2012, 2013). The Institute is currently reviewing Army Corp of Engineer regulations and reportedly is considering extending their review efforts to improve the Marine Mammal Protection, Endangered Species, National Environmental Protection, and Coastal Zone Management Acts.

The Institute has recommended that EPA regulations safeguarding the environment could be strengthened by creating numerical discharge and fish escape standards and developing monitoring and reporting requirements for offshore aquaculture facilities as part of the Clean Water Act (cf. Emmett Environmental Law and Policy Clinic et al. 2012). In regards to the Magnuson-Stevens Act, the Institute recommends that NOAA and the regional Fishery

Management Councils establish numerical guidelines for optimal yields and allowable "catch" limits in line with fishery management plans (cf. Emmett Environmental Law and Policy Clinic et al. 2013). As detailed in Chapter Three, the Institute also devised a series of recommendations for the Gulf of Mexico Fishery Management Plan in light of NOAA's desire to have it serve as a national model for other regions.

Other NGOs that are working toward the advancement of sustainable marine aquaculture include the: the World Wildlife Federation, Sea Web, New England Aquarium, and Aquarium of the Pacific. The World Wildlife Federation, Aquarium of the Pacific, New England Aquarium, The Nature Conservancy, and the Environmental Law Institute. The World Wildlife Fund has applied their stewardship mission and strategy of working with big businesses to create the aquaculture dialogues (cf. Clay 2010; Tercek 2013). The dialogues have brought together stakeholder groups from the production and distribution sector, researchers, government representatives, and NGOs. The goal of the dialogues has been to build consensus regarding the environmental and social impacts, means of and measures for improving aquaculture practices. As a result, the World Wildlife Fund has created aquaculture standards for the five marine species groups: salmon, shrimp, abalone, bivalves and seriola/cobia.[29] Industry respondents noted the Federation's early recognition of marine aquaculture "as the only means to keep pace with aquatic food production" and emphasis on resolving problems and conflicts.

In California, the Aquarium of the Pacific has created workshops on the development of offshore finfish aquaculture in the region and accurate aquaculture messaging (Schubel et al. 2007; Schubel and Monroe 2008; Aquarium of the Pacific 2013). In regards to the latter, the Aquarium of the Pacific notes that the aquarium community has an opportunity to effectively communicate to the public the role of "responsible aquaculture" in meeting society's demand for seafood, especially as the public may involve themselves in legislative actions (Aquarium of the Pacific 2010). According to Aquarium staff, the purpose of the messaging workshop was to "generate a more strategic alignment and messaging consistency" regarding aquaculture amongst aquariums and to "counter anti-aquaculture rhetoric…by presenting the public with a more balanced view." In conveying educational message, the workshop stressed the importance of framing the discussion of aquaculture in ways that would resonate with the public and providing clear and succinct statements that accurately and neutrally convey key information about aquaculture. Workshop members arrived at four consensus framing messages regarding seafood as a healthy food source; the limited supply of capture fisheries; and the current ways responsible aquaculture can fulfill seafood demand and 13 consensus statements regarding the environmental impacts; safety and health; market demand and socio-economics of farming and farmed seafood (Aquarium of the Pacific 2013). Additionally, the Aquarium of the Pacific has created a visually compelling and easily understandable video outlining the need to and potential benefits of advancing marine aquaculture in United States. The six minute video addresses technological developments and regulatory measures that can ensure the environmental sustainability of marine aquaculture and safety of farmed seafood (cf. Aquarium of the Pacific 2014b).[30]

In the Gulf of Maine Region, the New England Aquarium has taken the lead in creating a multi-stakeholder workshops to discuss the management of the potential environmental impacts of

[29] Seriola/cobia has been identified by industry respondents as particularly suitable species for offshore aquaculture in California, Hawaii, and Gulf of Mexico.
[30] No research has been conducted on the number of persons reached by or the impact of these educational efforts.

aquaculture (cf. Tlusty et al. 2001). Additionally, the Aquarium has taken undertaken a GIS assessment of potential offshore aquaculture sites (cf. The Marine GIS Group at the New England Aquarium n.d.)

In light of the technological developments associated with open ocean aquaculture and narrative changes surrounding seafood demand, respondents within the industry sector and research wonder how more NGOs can be brought into champion aquaculture offshore aquaculture. Industry respondents fear that it may be difficult for NGOs "to back down" from long standing public opposition to marine aquaculture. Some respondents have noted although personal attitudes of some key figures within NGOs have changed, the organization itself has not necessarily changed official proclamations. Industry respondents, however, also express optimism regarding the increased attention given to the issue of seafood supply and demand and positive coverage aquaculture was receiving in the National Geographic, New York Times, and National Public Radio, among others (cf. Greenburg 2014; Stone 2014). In particular, respondents noted recent recognition by seafood guides -– such as Monterey Bay Aquarium's Seafood Watch- for seafood farmed in net pens operations (cf. FIS United States 2014 a,b,c). Respondents also expressed hopes regarding the potential positive influences of USDA's forthcoming organic standards to positively change public perceptions of marine aquaculture.

In the current fragmentation of what was once a fairly cohesive movement, NGOs are not unaffected by the opinions of other NGOs or their reception by the industry. One respondent noted "being pillored" by another organization for collaborating with the aquaculture industry. Another respondent noted feeling "nervous" about the positive response a recent white paper received from government agencies and the industry. The ability of an NGO to change its stance regarding aquaculture may be affected by the organization's mission and structure and the willingness of donors to change their focus or stance. Proactive collaboration will depend on the ability to construct a new organizational identity vis-à-vis offshore aquaculture; the presence of other pressing issues; and the ability to raise/access funds. Respondents with the Nature Conservancy report that the organization develops their policies in response to local level conservation dilemmas and through collaborative efforts with communities and local industries. This bottom up approach has allowed the Nature Conservancy to move away from an early oppositional stance regarding aquaculture based on concerns regarding marine invasive species to a collaborative stance based on coastal restoration. And as reported the findings of a 2013 workshop conducted by the Aquarium of the Pacific and New England Aquarium, some participating institutions reported that health and/or socio-economic issues pertinent to the messaging of responsible aquaculture were not part of their institutions mission or expertise and as such although they agreed with the statements, they would not necessarily promote them (cf. Aquarium of the Pacific 2013).

8.0 The Siting of Aquaculture Operations and Coastal Marine Spatial Planning (CMSP)

Appropriate siting of aquaculture operations is well recognized as an important mitigation strategy for addressing potential environmental impacts as well as social conflicts. As noted in by the Marine Aquaculture Task Force "The location of a marine aquaculture facility can make the difference between an operation that is opposed by the local community, fails economically, and/or causes severe environmental impacts and one that is sustainable – economically, environmentally, and socially. Although good siting is not a substitute for good management and appropriate regulation, it is clearly a key component of environmentally sound marine aquaculture (Marine Aquaculture Task Force 2007: 27).

Recognition of the importance of siting has led to increasing emphasis being placed, by industry and regulators, on the collection of marine spatial data; development of geographic information system (GIS); and creation of software models to assess cost and benefit analysis of various siting scenario. The purpose of this chapter is four-fold: 1) describe the kinds of criteria and the goals and rationale of siting; 2) explain the purpose of coastal marine spatial planning (CMSP) and current status of efforts in our case study regions; 3) provide an overview of the availability and utility of GIS data and analytic models; and 4) analyze current debates regarding the utility of CMSP to advance offshore aquaculture.

8.1 Siting Criteria

Criteria important to the siting of aquaculture operations can be divided into a number of different rubrics: physical-oceanographic factors, marine and coastal infrastructure, human use patterns, and protected habitats and species. **Table 8.1** includes criteria important to the siting of offshore aquaculture operations.

Table 8-1: Select Siting Criteria for Offshore Aquaculture Operations

Physical Oceanographic Criteria	
Wave Height	Storm tracks
Wind Speed	Ocean Depth
Current Speed	Seafloor Substrate
Temperature (minimum, maximum)	Dissolved Oxygen Concentration
Turbidity	Nutrient Levels/Red Tide and Hypoxic areas
Salinity	Pollution (bacterial)/PSP closures
Clorophyll A Concentration	Pollution (chemical)
Marine and Coastal Criteria	
Offshore energy installations	Shoreline access/launch sites
Offshore communication cables	Land-based Industrial Zoning
Dumping and Mining Areas	Hatcheries
Human Use	
Military use zones	Commercial fishing areas
Marine transport routes/lanes	Recreational fishing areas
Protected Habitats and Species	
Marine reserves/protected areas	Fishery management areas/closures
Sanctuaries	Essential fish habitat

Sources: Macleod 2007; Kapetsky et al. 2013; Puniwai et al. 2014

Finfish and shellfish species have bio-ecological requirements related to temperature, currents, dissolved oxygen content and salinity. Ocean temperature effects growth and metabolism of finfish and shellfish and varies by species.[31] Finfish and shellfish are also susceptible to impaired water quality: reduced levels of depleted oxygen, harmful algal blooms, and turbidity. Excessive wind and wave action and currents can also impact fish growth and cause fish mortality (cf. Kapetsky and Aguilar-Manjarrez 2007; Kapetsky et al. 2013; Macleod 2007). Additionally, shellfish require certain levels of food nutrients measured as chlorophyll A concentration.

Bottom substrate, wind and wave action, ocean depth and slope, and current are important criteria from an engineering perspective. Soft bottom substrates are preferred for engineering and economic reasons as well as conservation purposes. Excessive wind and wave action and height can impede access to aquaculture installations and cause wear and tear on equipment and vessels (cf. Kapetsky and Aguilar-Manjarrez 2007; Kapetsky et al. 2013). Although the impact of waves can be mitigated by increasing the depth of and/or submersing installations, this has its installation and maintenance costs as well as biological constraints specific to species. Similarly, excessive currents can increase engineering and maintenance costs for installations. Alternatively, lack of current can impede the dispersion of nutrients and negatively impact the surrounding substrate. The selected aquaculture technology being utilized and species being cultivated influences the range of current[32] and ocean depth[33] that is acceptable.

The presence of other human activities and marine and coastal infrastructure are also important to the siting of aquaculture structures. In the offshore region, such activities as commercial and recreational fishing, transportation, and military activities and (infra)structures as energy installations, communication cables, and dumping and mining areas etc. can represent significant spatial conflicts.

The proximity of coastal infrastructure necessary to support offshore aquaculture operations is also an important, if not primary, criteria in siting projects (cf. Benetti et al. 2010; Kapetsky et al. 2013). Offshore aquaculture operations depend on coastal access points and onshore infrastructure to carry out a variety of service activities. With the exception of hatchery infrastructure, the needs of offshore aquaculture in terms of stocking, harvesting, processing, market transfer and sales distribution overlap with those required of the commercial fishing and seafood processing industries. General coastal infrastructure requirements include: vessel landing areas for launching, mooring, docking, and (un)loading fish; space for storage, dry-docking, and parking; onshore facilities for (live or cold) storage, processing and buying/selling; general vessel and fishery support services ranging from fuel and equipment supply, boat and equipment repair; and transportation system of trucks, container vessels, and airplanes that can ensure

[31] Kapetsky et al. (2013) used the following temperature ranges for their GIS suitability assessment: Cobia 22-32°C; Atlantic Salmon 1.5-16°C; and Blue mussels 2.5-19°C. Macleod used a temperature range of -2 - 20°C for suitability assessment for cod and mussels in New England region.

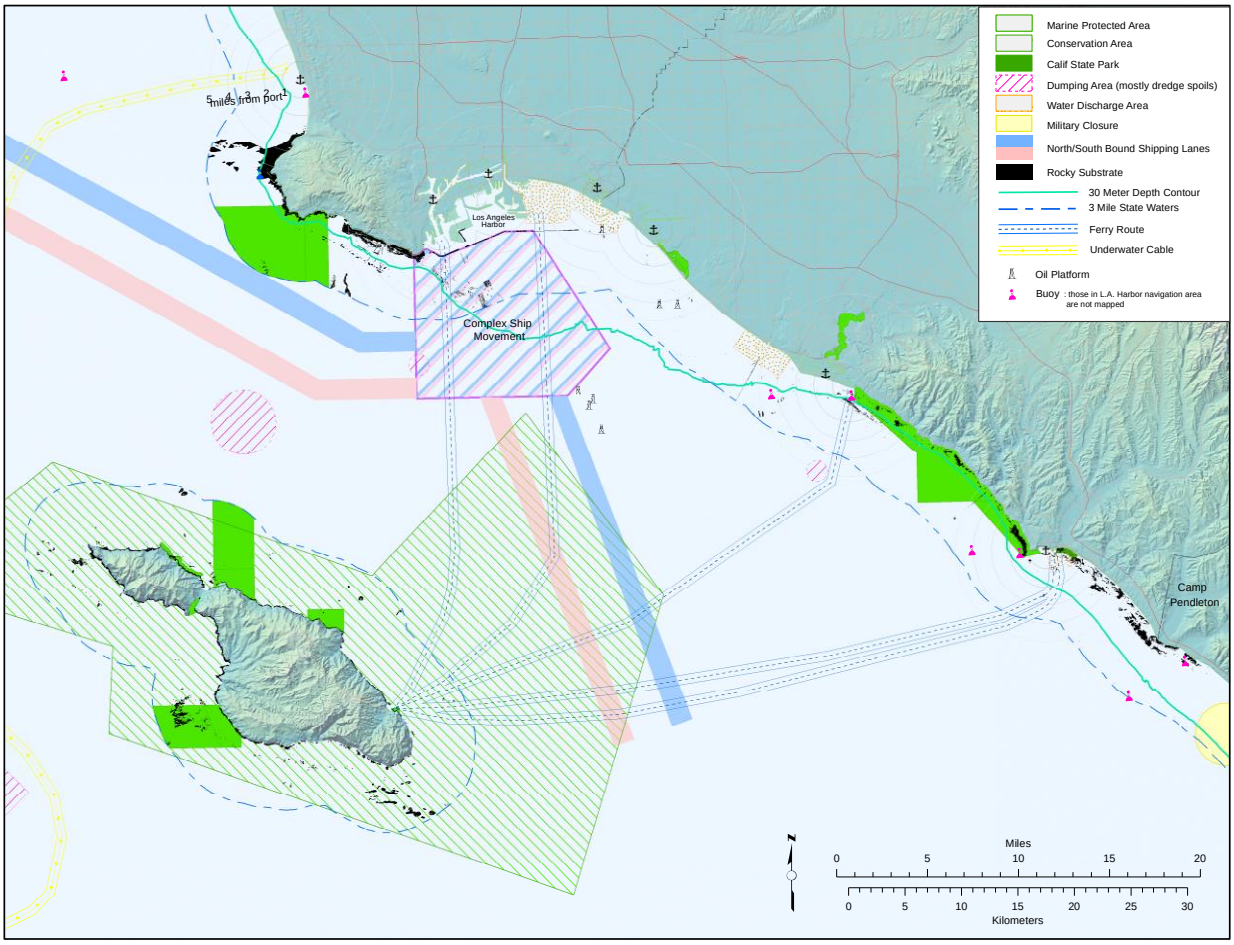
[32] Macleod (2007) utilized a current range of 10 to 110 cm/s, measured at depth of 25 m, based on biological constraints for mussels and cod. Kapetsky et al. (2013) utilized a current range of 10 to 100 cm/s, based necessary nutrient dispersive capabilities of current and engineering and maintenance costs.

[33] Researchers have run suitability analysis using different depth ranges for mooring. For example, Macleod (2007) used a range of 30 to 100 meters and 27 to 60 meters when conducting her suitability analysis for the aquaculture of longline mussel and cod, respectively in New England. Puniwai et al. (2014) used a range of 20 to 200 meters for their analysis of cage finfish and longline aquaculture. Kapetsky et al. (2013) used a range of 25 to 100 meters for cage and longline systems.

delivery of a perishable resource. Reliability of coastal access to offshore facilities affects the performance of routine operations and response to emergencies. Because distance from shore infrastructures increases fuel, labor, and vessel maintenance costs; marine zones that are closer to onshore infrastructure are generally favored by aquaculture operators.

From a conservation perspective, various habitats and areas of high concentration of protected species are important criteria to be factored in site selection. These include: marine protected areas, sanctuaries, and marine mammal migration routes.

Of note, aquaculture technology advances will undoubtedly change the importance of certain criteria. For example, the Cupod utilized in the Velella Gamma project in Hawaii utilizes a single mooring system and automated aquaculture system, the Oceansphere,^{TM} permitted for open ocean environment in Hawaii state waters, is untethered. These kinds of developing technology will change the siting criteria regarding depth. Additionally, in contrast to the multiple point mooring required of conventional net pen systems, both the single moored Cupod and untethered Oceansphere^{TM} will likely present less of a risk for large marine mammal entanglement. **Map 8.1** below depicts select factors conditioning open ocean aquaculture off Los Angeles, California.



Map 8-1: Select factors conditioning open ocean aquaculture in Southern California Bight.

Due to the myriad of criteria that must be considered when siting an aquaculture operation, the following must be determined and their locations identified: activities that represent absolute spatial conflicts; habitats or species that can receive no impacts; and biological or engineering requirements that represent absolute constraints. The requirements, conflicting activities, and protected habitat and species form the basis for creating exclusion zones and for determining the geographic boundaries for where any trade-off analysis must occur.

The activities that represent absolute spatial conflicts vary regionally and by aquaculture system and the constraints vary by species and aquaculture system. Generally speaking, shipping and transportation lanes, dumping and mining areas, and military closures are considered absolute spatial conflicts. In contrast, the acceptability of locating aquaculture on energy installations varies by particular installations and regionally. For example, the potential benefits to co-locating aquaculture on unused oil or gas platforms and wind-farm supporting structures are currently being debated by the industry in the Gulf of Maine and Gulf of Mexico. Additionally, the necessity of excluding aquaculture from marine protected areas, and/or sanctuaries varies by region and remains a topic of debate. In ocean regions of New England, aquaculture is permitted in four sanctuaries but prohibited in the Stellwagen National Marine Sanctuary. In Hawaii, the Hawaiian Islands Humpback Whale National Marine Sanctuary has not expressly prohibited aquaculture; one farm currently operates within the boundaries.

Once all biological and engineering constraints and conflicting uses are defined, ideal locations can be determined in the remaining area. This generally involves weighing factors that are not absolute constraints but, for example, can influence economic costs such as water depth, optimal current, and proximity to harbor. Additionally the determination of suitable areas can include modeling environmental impact to determine areas of least impact and calculating trade-offs between potential impact to environment and marine users and potential economic benefit to local community. Site modeling can also be used to generate suitable operational characteristics (stocking densities, discharge limits, chemical treatments) based on modeling the assimilative capacities of different types of sites (cf. Macleod 2007). Kapestky et al. (2013) describe the a recently created interactive decision support system, AkvaVis, that assesses site suitability, calculates carrying capacity, and generates management and monitoring programs. As was noted in Chapter One, site modeling can also be used to estimate national mariculture potential.

Of note, although the importance of various criteria for siting aquaculture operations is well understood, the necessary information is not always available. Accurate information regarding marine resources and human use patterns is not always available and proxies are frequently utilized. For example, essential fish habitat can be used as a proxy for wild populations and marina density may be used for recreational fishing intensity. Additionally, data regarding oceanographic conditions is often extrapolated from limited number of sampling stations and thus may not be accurate. Moreover, although the weighing of siting factors is an important part of developing siting models, there is no universal approach for weighing factors. Industry members, marine users, and conservations groups often have different perspectives on what factors are the most important.

The evaluation of criteria and siting of aquaculture operations can be conducted on individual specific project or as part of a larger regional approach to marine spatial planning. Below we provide an introduction to coastal marine spatial planning (CMSP) and overview of regional planning efforts.

8.2 Coastal and Marine Spatial Planning

Intensifying human use of ocean space, increasing variety of marine based industries, growing interest in ocean conservation, and greater understanding of marine ecosystems have led to the recognition of the need for marine spatial planning. The purpose of marine spatial planning is to make decisions about how a variety of human activities are to be temporally and spatially allocated in marine areas while balancing economic, conservation, and social objectives. The goal of spatial planning is to minimize user conflicts; reduce political and social opposition to new ocean uses; ensure ecosystem health; increase predictability and access of industries to marine resources; maximize efficient resource use; and improve regulatory efficiency.

A significant and initial component of CMSP involves the creation of mapped data to identify ocean uses/users, natural resources, and ecological habitats. Data mapping efforts can be divided into separate stages and outcomes including: the identification and compilation of existing datasets; the standardization of geospatial data; the creation of a portal for data access; the identification of data gaps; and the augmentation of data sets through stakeholder participation. Challenges include: collecting and rendering data at an appropriate scale; collect and integrating new stakeholder information; protecting sensitive or confidential information; and providing guidelines for the appropriate interpretation of spatial data. In regards to the foremost, end users generally want and need fine temporal and spatial scales. In particular, updating, formatting and processing of data layers take considerable manpower. Important to the spatial planning process is also the development of decision support systems to analyze or illustrate costs, benefits, and trade-offs of management decisions.

Advances in software, affordable computing, and user-accessibility are allowing consideration of greater amounts of information, more sophisticated analysis of tradeoffs of ocean uses, more visually compelling ways to present analytic findings, and greater public participation in management decisions. Technological advances and the recognition of the potential benefits of CMSP are propelling federal and regional level planning efforts.

An examination of CMSP efforts to date suggests that a long term commitment on the part of agencies is necessary for CMSP to be effective. CMSP also should be supported by high level government mandates to ensure funding and manpower. Additionally, planning process demands the establishment of clear objectives; a coordinated system of policies and regulations; and a review process. Well-defined planning objective(s) ensures that purpose and needs of the process are clearly communicated. Additionally, it must be clear to agencies and key decisions makers that CMSP can improve regulatory efficiencies or the incentive to undertake long-term collaboration is likely to wane (cf. Beck et al. 2009).

Effective CMSP also is a public process that involves diverse and robust local stakeholder engagement. Local stakeholder participation is necessary to gain community support of management decisions; it ensures that decisions are being made in accordance with the community values and priorities and allows for the input of local knowledge. Additionally, when considering management alternatives, the CMSP process must include: rigorous and transparent analysis of trade-offs that recognizes diverse objectives and means to resolve conflicts between and identify a common ground amongst stakeholders (cf. Beck et al. 2009).

Federal Ocean Policy and CMSP Efforts. In June 2009, the Obama Administration established the Interagency Ocean Policy Task Force to develop recommendations for creating a national policy for US Oceans and Great Lakes. In December of that year the Task Force released recommendations and a framework for coastal marine spatial planning that included the principles and goals of the planning process and timelines to reach the goals. In July 2010, the President adopted the Task Force's recommendations regarding the creation of a new federal framework. Key elements in CMSP process include: 1) collection and utilization of relevant information for decision-making; 2) establishing a framework for agency cooperation and coordination; 3) developing plan for siting multiple uses; and 4) engaging public and stakeholders in deciding on priorities for ocean use and evaluating trade-offs (cf. Blue Earth Consultants and Gabriela Goldfarb Consulting 2011). In 2013, the National Ocean Council released the final implementation plan for a National Ocean Policy and Marine Planning Handbook, to support regional CMSP efforts (cf. National Ocean Council 2013a and b).

The plan's goals include improving agency coordination to expedite federal permitting decisions and improve management of marine ocean resources; developing, improving access, and integrating scientific information needed by local communities, industries, and decision-makers; and encouraging and supporting state agency efforts to focus on ocean policy development. A national data portal - ocean.data,gov - has been created to support planning efforts. The portal provides over 300 sets of unrestricted federal data to the public.

An important aspect of the national ocean policy rests on the recognition of different regional priorities for economic development and conservation objectives. The federal CSMP framework is implemented through nine regional planning bodies that represent nine regional marine ecosystems. The state of California is included in the West Coast Regional Planning Body, Hawaii is a member of the Pacific Island Regional Planning Body, and the Gulf of Maine belongs to the Northeastern Regional Planning Body.

The regional planning bodies do not have any independent regulatory authority but rather serve to integrate data management across existing regulatory authorities. In addressing their own priorities and needs, regional planning bodies define the scope, scale, content, and objectives of MSP efforts. Marine spatial planning efforts currently vary by region and state in terms of: extent of regional collaboration; pre-existing agency and stakeholder data collection efforts; purpose of data collection and kinds of data collected; and public availability of data and ease of use, amongst others.

The West Coast Regional Planning Body and California. Marine spatial planning efforts of the West Coast Regional Planning Body build on the West Coast Governors Alliance on Ocean Health which was established in 2006. The West Coast Ocean Data Portal launched in January of 2014 houses over 550 GIS datasets. The data portal provides interactive maps: users can select different data layers; zoom and click on map features; and share and print maps. The West Coast Regional Planning Body has identified three priority threats for which analytic tools are currently be developed – marine debris, sea-level rise, and ocean acidification.

The establishment of a statewide network of marine protected areas, and proposals for desalination facilities, renewable ocean energy projects, and offshore aquaculture proposals, have led to an interest in and awareness of the need for CMSP in California. The establishment of a statewide network of marine protected areas is of particular note because of the

extensiveness of stakeholder participation and the development of OpenOcean Map software that facilitated the survey collection of marine use patterns and internet-based mapping and decision support tool, MarineMap, for the siting of marine protected areas (cf. Cairns et al. 2009; Blue Earth Consultants and Gabriela Goldfarb Consulting 2011).

The state's collaborative ocean planning efforts were initiated in 2009. In Southern California, the Aquarium of the Pacific in collaboration with the Marine Conservation Research Institute, University of Southern California Wrigley Institute, and USC Sea Grant held a forum to introduce the concept of CMSP, explore the potential benefits of its use in the Southern California bight, and provide recommendations on how to launch the planning process.

In regards to aquaculture within the Southern California Bight, two geospatial assessment efforts are of particular note. In 2009, a multi-dimensional site assessment was conducted at the request of the KZO Sea Farms to inform the siting of their offshore shellfish farm. The Southern California Aquaculture Site Assessment Model (SCASAM) project considered environmental parameters necessary for biological viability of mussel and logistical parameters necessary for ensuring economic viability/potential (cf. Raines 2013). The Geodata base that were considered in the site assessment included: MPAs, shipping and navigation channels, submerged cables, oil platforms, security zones, port and fish processing facilities, and water sampling data from two sites. The economic analysis resulted in the identification of five different zones: restricted[34]; preferred exclusion[35]; acceptable; desirable; most desirable[36].

Additionally, researchers at the University of California- Santa Barbara are currently creating a software model to evaluate tradeoffs between economic benefits of aquaculture and environmental impacts (cf. Lester et al. 2010). Researchers are focusing on three species and gear type combinations: white seabass in net pen cages; Mediterranean mussels on longlines; Laminaria kelp on longlines. The model will examine the potential impacts of these three aquaculture scenarios on: 1) the California halibut fishery[37], 2) water quality and the bottom environment, and 3) visual impact from shore line. The assessment will be conducted for the Southern California Bight. Siting criteria include open ocean areas with waters from depths of 20 to 80 meters for shellfish and kelp and 30 to 100 meters for finfish. The following are considered unacceptable for the siting of operations: shipping lanes, military use zones, MPAs (that do not lot allow any altering of sea floors); oil/gas /energy platforms; hard bottom habitat; and sewage outlets will be assessed.

The model aims to allow stakeholders – the public and key decisions makers - to see how impacts across categories can change depending on siting and priorities and what kind of sites

[34] Marine protected areas, marine transportation and navigation channels, security areas comprised restricted zones.
[35] Submerged cables, oil platforms, restricted zones, and various buffers were merged to comprise the preferred exclusion zone.
[36] Desirable and most desirable zones were defined by suitable depth range and proximity to necessary coastal infrastructure.
[37] The model considers impact to the California halibut fishery because halibut reside in soft bottom substrates that are also preferred, from an engineering and conservation perspective, for the siting of aquaculture operations. Economic valuation will reportedly be conducted by considering the decline in value of wild catch fishery, due to exclusion of commercial fishing vessels and assessed by state landing data, and value of aquaculture production.

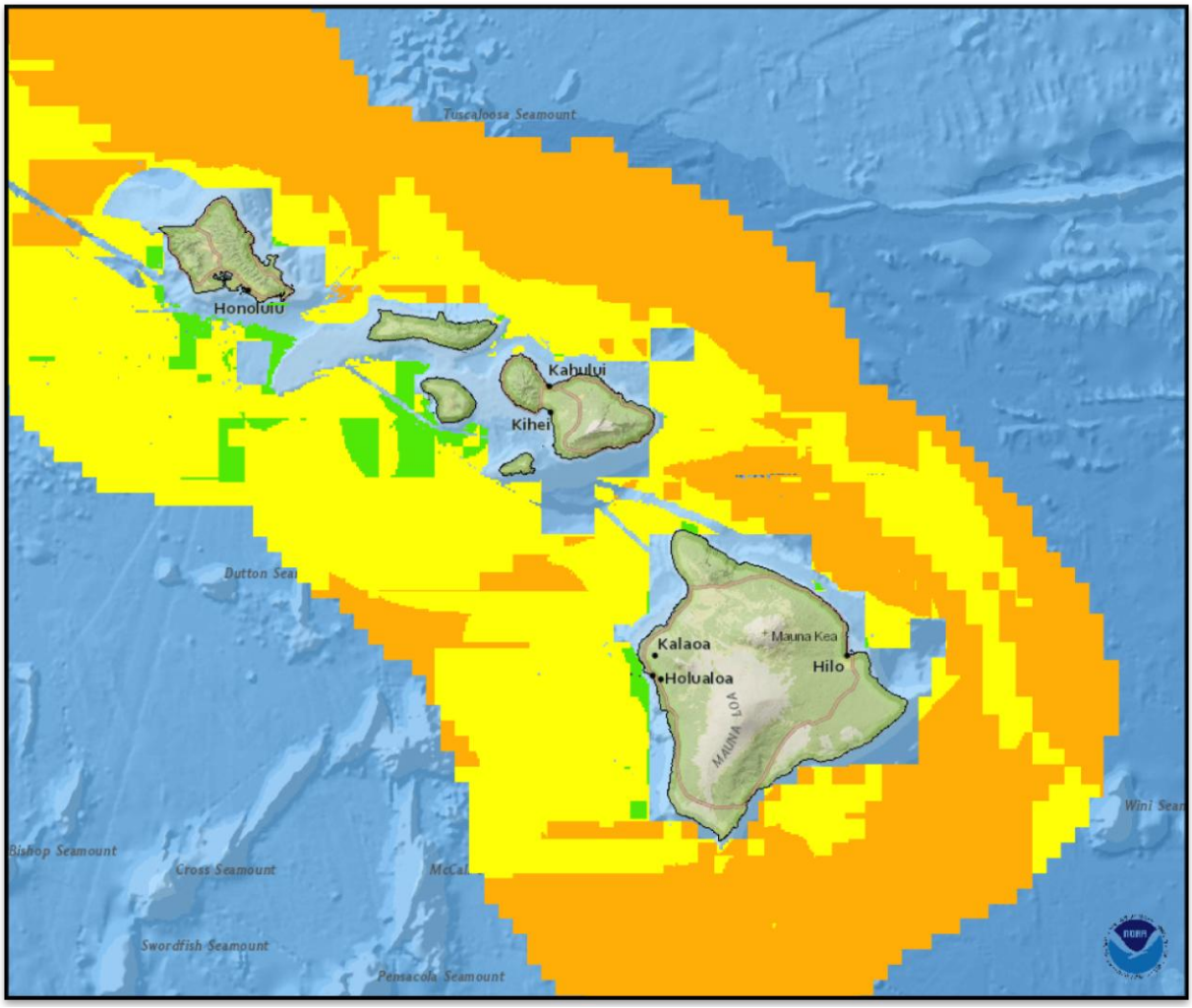
and scenarios result in the least amount of tradeoffs. The program is modular - other modeling programs can be incorporated and the program can be transferred to different locations.

The Pacific Island Regional Planning Body and Hawaii. The Pacific Island Regional Planning Body was formally established in 2013. In 2012, a workshop was conducted in advance of its creation. The objectives of the workshop included: increasing participants understanding of CMSP usage; assessing current GIS data availability; identifying informational and technological needs; and building partnerships for CMSP implementation (cf. Pacific Islands Regional Planning Board 2012).

The Pacific Island regional planning body will build on mapping efforts, and stakeholder engagement already achieved by the State of Hawaii Office of Planning and in the 2013 updated Hawaii's Ocean Resources Management Plan. Additionally, the Western Pacific Fishery Management Council conducted workshops and forums in 2010 and 2011 on CMSP for fishery management and NOAA and the Bureau of Ocean and Energy Management (BOEM) conducted workshops in 2012 and 2013 to assess the availability of GIS data on habitat and human uses for future planning. A regional data portal has not yet been developed. Offshore aquaculture was identified as an issue of particular interest (cf. Pacific Islands Regional Planning Board 2012).

In regards to aquaculture siting specifically, one online GIS tool is of particular note. In 2013, NOAA's Pacific Islands Fisheries Science Center completed the creation of their Marine Aquaculture GIS Mapper and Decision Support Tool for Hawaii (http://www.pifsc.noaa.gov/marinemapper/MHI/). It is intended for use by state and federal regulators and managers, NGOs, citizens, and aquaculture entrepreneurs. The GIS Mapper includes spatial data layers for: conservation areas and distribution of select protected resources; land use and coastal infrastructure; fishery management zones and recreational use patterns; marine infrastructure and hazards; and oceanographic conditions and physical characteristics, such as water, wave, and seafloor characteristics.

A site selection suitability model allows users to select and weight a variety of variables and select exclusion areas. Site selection criteria reflect factors of importance to industry, regulators, and community stakeholders and include: water depth and height, distance from harbor, wind speed, chlorophyll, salinity, water temperature, and current velocity (eastward and westward). Exclusion areas include: restricted military areas, reefs, class AA waters (which are to be maintained in a pristine state), dumping areas, federal waters, Hawaii state waters, major shipping routes, and conservation areas. The tool provides a visual representation of sites that fulfill user's criteria: sites are ranked on a scale of 1 to 5 for suitability based on the users selected variables. Staff at PIFSC report that the tool is not intended to provide an empirical analysis due to the lack of uniform data of appropriate scale. Staff report that the software program could be improved to better serve the needs of managers and the industry by the inclusion of recently developed nutrient flow model. **Map 8.2** below depicts the suitability analysis for the following (equally weighted) variables: water depth, distance from harbor, wind speed, significant wave height, and current velocity and exclusion zones: restricted areas dumping areas, Class AA waters, major shipping routes, and reefs. Green corresponds with a favorable rating of 4 out of a five point scale; yellow and orange correspond with ratings of 3 and 2, respectively.



Map 8-2: Marine Mapper Suitability Analysis

One other geospatial assessment efforts for Hawaii Island is of particular note. Puniwai et al. (2014) analyzed the suitability of state waters of Hawaii (Big) Island for three aquaculture systems of line culture for algae and bivalves, intertidal bottom culture, and cage for finfish. The suitability analysis identified approximately 5180 hectare (12,800 acres or 20 square miles) suitable for line and cage culture and 1750 hectares (4,324 acres or 6.75 square miles) suitable for inter and sub/tidal bottom culture.[38]

Northeast Regional Planning Board and Gulf of Maine. The Gulf of Maine is a member of the Northeast Regional Planning Body. The regional planning body was established in 2012 and

[38] The nearshore aquaculture model contains 82 GIS data layers; 26 of which were used for a suitability analysis. Analysis was conducted using depth, wind speed, substrate, salinity, chlorophyll A, and distance to shore infrastructure[38]. Areas with marine obstructions/hazards such as buoys, cables, and sewer line; within lava zones, and marine life conservation districts were excluded. Terrestrial parks, fishery managed areas, recreational sites, dolphin restings areas, and marine sanctuaries were considered cautionary but were included in the suitability assessment. GIS data sources, modeling, and spatial query functions are reportedly available at University of Hawaii-Hilo geoportal (http://geodata.sdal.hilo.hawaii.edu/aquaculture/). At the time of this writing, however, the site was not accessible.

builds on efforts of the Northeast Regional Ocean Council (NROC), which was established in 2005 by the governors of the New England states.

Northeast Regional Ocean Council has conducted extensive outreach with stakeholders to discuss ocean planning, develop maps of human activity, identify important ecological areas, and prioritize future mapping and analytic products. Data and decision support system is housed at the Northeast Ocean Data portal (northeastoceanviewer.org), which was launched in 2011. [39] In 2012, Northeast Regional Ocean Council held working sessions with stakeholders in the aquaculture community to: gather information on existing and potential future aquaculture activities and geographies; learn about permitting and leasing process and challenges; and discuss how regional ocean planning might address aquaculture siting challenges (cf. Northeast Regional Ocean Council 2012).

Two GIS analysis of note has been conducted regarding aquaculture offshore waters in the Gulf of Maine. Macleod (2007) assessed potential sites for Cod (*Gadhus morhua*) and Mussels (*Mytilus edulis*) in the Cape Cod Region. The assessment considered bio-ecological factors of temperature and current; economic factors of distance from major ports, depth, current velocity, and benthic sediment type; and user conflict with commercial fisheries of lobster trapping and finfish gillnet and recreational fisheries. GIS spatial analysis indicated that absolute constraints, such as depths, currents, and existing marine uses encompassed approximately 20% of the available area for the cultivation of finfish and shellfish; these constraints, however, were largely associated with inshore areas and "rendered locations that were further offshore generally more viable" (Macleod 2007: 76). Other important findings of the study suggest areas that were generally favored for environmental factors, were less favored for economic factors. The overlay of maps revealed that areas off Cape Cod were favored for environment and social factors and areas off Cape Ann were favored for economic factors.

The New England Aquarium has also taken a GIS assessment of potential offshore aquaculture sites. The Aquarium's efforts involved: integrating spatial and temporal datasets for shipping, (commercial and charter) fishing, marine mammals and sea turtles; conducting an economic analysis of the value of fishing effort and cost of displacing shipping lanes; and assessing the suitability of low use areas for aquaculture operations. The study revealed potentially suitable areas in federal waters of Nantucket Shoals. (cf. The Marine GIS Group at the New England Aquarium n.d.)

8.3 Debate regarding marine spatial planning

The CMSP planning process can result in a range of management outcomes from the establishment of useful and voluntary guidelines for siting to statutorily authorized rules

[39] Northeast Ocean Data is a collaborative venture of the Northeast Regional Ocean Council, Gulf of Maine Research Institute, The Nature Conservancy, NOAA and other working groups. The portal provides spatial information related to maritime commerce; commercial fishing; recreational activities (consumptive and non-consumptive); marine mammals, sea turtles and other marine life; fish and shell fish; energy; aquaculture; and water quality. Each dataset is accompanied by information regarding source and a status of data updates; guidelines for appropriate interpretation of spatial data; box for feedback; and link to how the data is being used by Northeast Regional Planning Body. The site also provides a "Data Explorer:" users can select different data layers and zoom and click on map features. The interactive maps require neither special software programs nor expertise and allows for easy sharing and printing. The site supports users with guided video tour.

regarding (exclusionary) use, for example, military exclusion zones, shipping lanes, or conservation areas. In regards to aquaculture, various possible outcomes have been linked to or recommended in relation to CMSP efforts such as, per-permitted areas; marine aquaculture parks; designated sites for pilot projects; and state or federal water sector zoning (cf. United States Government Printing Office 2011; Corbin 2010). Zoning as one outcome for marine spatial planning has also been discussed as a way to ameliorate the conflict between individual operators who are often set against all other coastal and ocean users as well as reduce the opportunity for poaching and vandalism; the need for and liability attending individual site marking; and the costs for permitting (cf. Fletcher and Neyrey 2003).

Although, CMSP has received attention from regional planners and NGOs for its potential benefits, members of the aquaculture industry and research, contacted as part of our study, have been less sanguine. Members of the open ocean aquaculture industry in California and Maine who have had experience with regional mapping efforts report that the industry cannot successfully represent itself. Because aquaculture technology is evolving, the needs, likely locations, and potential conflicts are not easily knowable. Respondents within the industry and aquaculture research in California reported that stakeholder workshops devoted to initiating mapping efforts have had the effect of marginalizing aquaculture interests, whether intentionally by those who opposed aquaculture, or unintentionally through lack of adequate representation of individuals knowledgeable about aquaculture.

Key industry experts in Maine and Hawaii expressed the fear that aquaculture would be "left with the leftovers" as the ocean areas is delegated to other uses. The aquaculture industry would then reportedly be "locked into unsuitable areas" that would be technically less feasible, economically more costly, and environmentally more impactful. A challenge facing CMSP lies in ensuring that planning efforts provide some certainty regarding management decisions while also enabling long term flexibility especially as technological advancements and research findings create opportunities for the co-siting of activities that may have been understood as incompatible (cf. Beck et al. 2009).

Of note, the Gulf of Mexico Fishery Management Plan for Offshore Aquaculture opts for case-by-case site selection over marine zoning. The Fishery management Council considered the establishment of 13 aquaculture zones within the Gulf.[40] Marine zoning was rejected for both economic and environmental reasons: zoning could "require the use of inferior sites with higher start-up and operational costs" and "result in density problems" (cf. Gulf of Mexico Fishery Management Council and National Oceanic and Atmospheric Administration 2009 :405). Discussions within the Gulf of Mexico Fishery Management Council favored GIS planning to identify areas that aquaculture should avoid –such as areas that are environmentally sensitive or where other competitive use is high - but that entrepreneurs should be allowed to identify sites outside of the excluded areas. As participant in the council process explained, there are too

[40] Measuring 10, 392 square nautical miles, the 13 zones encompassed approximately 5% of the Gulf EEZ and 36% of the total area considered suitable for offshore marine aquaculture. The zones did not include: "navigational fairways, lightering zones, platform safety zones, permitted artificial reef areas, HAPCs, coral areas, marine reserves, MPAs, areas of high shrimp fishing effort based on electronic logbooks, hypoxic areas (< 2 mg/l), areas with current speeds of 0.1 m/s or less, depths less than 25 m (82 feet), and depths greater than 100 m (328 feet)." (Gulf of Mexico Fishery Management Council and National Oceanic and Atmospheric Administration 2009:67)

many variables depending on species, aquaculture technology, and operational scale for a one size fits all approach (cf. Environmental Law Institute 2013).

Staff at regulatory agencies and participants in the aquaculture industry in Hawaii and Gulf of Maine also reported concerns regarding the appropriate scale; kinds; and accuracy of data used for CSMP. Respondents within the industry and aquaculture research in California report that the push towards marine spatially planning is waning due to the paucity of accurate information. Additionally, industry respondents and staff at regulatory agencies report that the site requirements for species and technologies differ such that regional efforts at mapping and/or zoning are not likely to serve the informational needs of the industry. Participants expressed strong concerns about the limited resources available to keep maps updated and the possibility that data could become outdated yet still be used in permitting to inform leasing or related decisions. Participants discussed the need for data to be credible and updated regularly.

In Hawaii and California, staff within NOAA report that maps and site selection models should be viewed as "tools for communication purposes" and "a mechanism to bring stakeholders together to discuss possibilities of co-siting activities" not the end result. In Hawaii, an aquaculture researcher observed that an overemphasis on mapping can alienate stakeholders in so far as they may have a different language for speaking about marine space and may perceive CMSP as "divvying up space." The researcher reports that greater emphasis should be placed on allowing stakeholders to draw their own maps and creating an environment in which stakeholders connect on an emotional basis regarding their understandings and hopes for future use of ocean spaces. Additionally, staff in Hawaii reported that advance modeling for siting criteria must be transparent to ensure stakeholder buy in.

At best, respondents suggest that mapping of the distribution and abundance of species, benthic types and human uses may provide some information on areas where there are certain to be conflicts. In particular, industry respondents reported a need for oceanographic data and fishing effort at a finer scale for siting individual operations. In regards to offshore aquaculture in particular, participants in the Northeast Regional Ocean Council marine mapping workshops reported a need for a regional protocol for tracking red tide and water quality to ensure food/safety standards are met.[41] Additionally, industry respondents expressed interest in GIS information that would evaluate the potential of co-locating aquaculture operations on offshore energy installations. Staff in NOAA's protected resources reported the need for more information on marine mammal presence.

[41] Various research efforts are underway to model and monitor harmful algal blooms in the Gulf of Maine (cf. NOAA Ocean Science Blog 2012).

9.0 Challenges and Solutions for the Development of Offshore Aquaculture

A wide range of human factors and processes have thus far acted to constrain development of the offshore aquaculture industry, including: policy limitations or lack of a sufficient policy framework for enabling and guiding an offshore industry; economic and technical challenges inherent in developing such an industry and effectively marketing its products; differing cultural perspectives on marine aquaculture generally among persons in public trust governance positions, non-governmental organizations (NGOs), capture fisheries, and the general public; competition for, or conflicts regarding, use of finite ocean space; and potentially manageable environmental challenges that can present obstacles to the satisfaction of human needs and interests related to the production, marketing, and consumption of seafood grown in the EEZ.

Analysis of interview data and literature suggest that there are considerable similarities in understanding of the primary constraints and challenges to the development of offshore aquaculture across all kinds of respondents and all three regions of study. Those constraints include: unclear or cumbersome permitting policies; lack of adequate financing for research and business start-up; and negative public perceptions of marine aquaculture generally.[42, 43] The perceived need or desirability to expand into federal waters, however, differs by region and relates in part to regulatory hurdles associated with the establishment of operations in state waters.

The purpose of this chapter is to provide a summary discussion of the human/social dimensions that have constrained the development of offshore aquaculture in United States and of the efforts to resolve these challenges. We consider the following issues: policy and regulatory challenges, economic constraints, and socio-cultural perspectives. In so far as social opposition and regulatory and policy impasses are in part due to concerns about environmental impacts, we also review recent technological advancements and current management measures that may not be familiar to the public and key decision makers.

9.1 Policy and regulatory challenges and solutions

As aquaculture firms in the study regions apply to carry out commercial operations in federal waters, operators report facing: uncertainty regarding permit requirements and permit lengths; difficulty negotiating the permit process; potentially contradictory conditions established by agencies; and/or unclear timeline for permitting.

[42] Our interview data agree with a 2010 survey of participants in ten marine aquaculture partnerships (cf. Weible et al. 2011; Calanni et al. 2012). The surveyed partnerships dealt with aquaculture in Florida, Maine, Maryland, New Jersey, Rhode Island, California, and Washington, and the Pacific Coast region and focused in part or solely with marine aquaculture issues. Participants identified a wide range of expertise including: oceanography, biology or ecology, engineering, business or economics, policy, law or planning, and finfish and shellfish aquaculture. Survey data collected from members of the United States' National Association of State Aquaculture Coordinators, which includes members of states with primarily land-based aquaculture, similarly revealed major barriers related to start-up investment costs; minor to moderate barriers related to complicated regulatory processes and environmental protection safeguards; and public opposition occurring more frequently in urban areas (Siddiki and Weible 2010, 2011).

[43] Respondents identified the least serious challenges as those related to water pollution from aquaculture facilities and threats of disease outbreaks or genetic impurity of wild stocks.

It should be noted many of the challenges raised are characteristic of establishing any new large multi-agency administrative process. Challenges are largely informational in nature and include the need to understand the mechanics and potential impacts of marine aquaculture operations as well as other agency mandates, processes, and expertise. Institutional barriers between and within agencies are not infrequently interpreted a "turf battles." Solutions demand appropriate funding, require time, and most importantly necessitate project applications through which agencies can gain experience.

NOAA's challenges and efforts. NOAA's Office of Aquaculture faces a variety of challenges facilitating the development and regulation of offshore aquaculture. These including: gaining acceptance of agency authority from the industry and public stakeholders; educating other divisions within NOAA on the Office of Aquaculture's mission; and providing information about marine aquaculture systems and impacts to agency staff and key decision makers.

As noted in Chapter Two, the National Marine Fisheries Services has been identified in major policy studies as the most suitable federal agency to create and oversee an offshore aquaculture permitting process (cf. Cicin-Sain et al. 2005; United States Commission on Ocean Policy 2004). Interview data reveals, however, that many respondents within the aquaculture industry and some in regulatory agencies consider NOAA as an unsuitable agency for overseeing the permitting of aquaculture due the perceived conflicts between an agency mission of conservation and aquaculture development (cf. United States Government Printing Office 2011; Rieser and Bunsick 1999). The National Aquaculture Association (NAA) has opposed NOAA's efforts to define marine aquaculture as a form of fishing. NAA has maintained that aquaculture is a form of agriculture and as such that the USDA should be assigned the role of lead agency overseeing the management of open ocean aquaculture (Rheault et al. 2002).[44]

According to Corbin (2007), evidence at the state level suggests that agencies involved in natural resource management, economic development, or agricultural development can successfully serve as leads in aquaculture development. For example, in Hawaii, the Department of Land and Natural Resources oversees leases and permitting and in Maine, the Department of Marine Resources is defacto lead agency. Of greater importance is that aquaculture development programs: include personnel with expertise in business management and economic development, and have aquaculture experience in the private sector; have the political stature to ensure that staff have access decision makers and can effectively coordinate efforts within and between government agencies; and are adequately funded.

Currently NOAA's Office of Aquaculture fulfills criteria regarding expertise. Staff, both in Maryland and at the regional level, come from a variety of backgrounds in conservation, fishery management, aquaculture development, policy development, and private sector (with experience both domestically and internationally). Staff in the Office of Aquaculture, however, are reportedly outnumbered and underfunded in comparison to the Offices of Protected Resources, Habitat Conservation, and Sustainable Fisheries.

[44] The defining of aquaculture as fishing or agriculture not only effects the regulatory authority of agencies but the eligibility of offshore aquaculture operations for disaster relief and other funding (cf. National Sea Grant Law Center 2010).

Staff report that their efforts are largely focused on: educating staff members in other divisions regarding the NOAA's aquaculture mission and "getting aquaculture on NOAA's agenda" to procure funding to support research. Additionally, the Office is tasked with conducting outreach with other agencies and divisions within NOAA to understand and assist in addressing their informational needs regarding marine aquaculture. As one staff respondent reported, NOAA's goal is to educate regulatory agencies about offshore aquaculture and establish a permit reviewing process that "does not require the applicant to hire (or be) a biologist or engineer." The Office reportedly has focused to a lesser degree on changing public perceptions of marine aquaculture. NOAA's efforts reportedly have occurred primarily behind the scenes, and from the perspective of many in the industry painfully slow and have resulted in few tangible benefits.

Staff members at NOAA regional Offices of Aquaculture report challenges in convincing industry members to seek consultation with agencies and "not fight the process." Staff report that applicants do not always understand the purpose, potential benefit to the applicant, and necessity of the consultative process and may believe that agency reviews can be avoided. Staff recommend that applicants notify and seek consultation with all relevant agencies early in the process to facilitate concurrent review of proposals by federal and state agencies and the incorporation of agency concerns in proposal design. Concurrent review can allow for better sharing of expert knowledge between agencies and better communication between agencies regarding project concerns and possible mitigation strategies. Concurrent reviews can shorten the duration of the review process; decrease the number of informational requests; address contradictory conditions established by different agencies, and result in the establishment of "workable" permit conditions. Staff also note that proper permitting and review, for example in relation to National Pollution Discharge Elimination System Permit and marine mammal entanglements, can "act as a shield to litigation."

Current educational efforts on the part of NOAA include conduct of legal reviews, development of white papers, and the creation of model tools to assist in the siting and evaluation of operation. At the regional level, staff have facilitated intra-and interagency consultation processes for permit applicants. Under requests by NOAA staff, the National Sea Grant Law Center, has provided legal reviews of various legal requirements for shellfish and finfish aquaculture in offshore waters (cf. National Sea Grant Law Center 2014, 2012, 2010a and b). A report on the development of alternative feeds and their potential implications for the environment and human health was published in 2011 (cf. Rust et al. 2011). White paper review of up-to-date science on the environmental impacts of marine cage aquaculture was completed in 2013 (cf. Price and Morris 2013); this white paper has been welcomed by the industry. A similar effort has recently commenced regarding potential impacts of long line aquaculture operations on marine mammals. Additionally, staff member report that modeling tools are currently being developed and tested to assess: water column and benthic impacts of farms; genetic risks associated with escaped fish; and risk of disease transmission to wild fish.[45,46] These tools will assist in the siting of operations

[45] The AquaModel models environmental impacts, through oceanographic and operational parameters such as currents, depth, fish species, farm capacity, and feed (cf. O'Brien et al. 2011). The OMEGA (Offshore Mariculture Escapes Genetics/Ecological Assessment) model assesses impacts on wild species in terms fitness and abundance and includes parameters on broodstock source, cultured fish size and growth, and escape magnitude and frequency (cf. Volk et al. 2014)

[46] The USDA's Animal and Plant Health Inspection Services (APHIS) leads the collaborative efforts on the lattermost research.

and in meeting scientific needs of regulators. Additionally, one NOAA staff respondent noted plans to create regulatory guidebooks to help the industry understand that consultations "are not the end of the world."

Of note, industry consultants have noted that to be effective, white papers and new analytic tools will need to be accompanied by a concerted and ongoing effort to identify agency staff and key decision makers that need the information, especially in light of high staff turn-over rates and/or changes in political appointees. In addition, researchers have also noted the need to be included in ongoing discussion with key decision makers in light of the rate of technological advancement in aquaculture technology, species, and gear.

Staff within NOAA Office of Aquaculture report the need for greater coordination between staff within the Division of Protected Resources, which is housed in National Marine Fisheries Service, and between staff within the Sanctuary program, which is housed within the National Ocean Services. Staff also report that more consistent meetings of headquarters and regional offices could allow staff to take greater advantage of each other's fields of expertise and lessons learned at the regional level as permit applications undergo review.

State level experience and efforts: Although a regulatory framework for development of aquaculture in federal waters is being worked out separate from that in the state waters, the knowledge of state agency staff; the status of interagency relationships; and existence of cooperative processes, or lack thereof, has the potential to influence the development of regulatory framework for federal water operations. In particular, scientific expertise and knowledge of open ocean aquaculture operations among local staff of federal agencies of the EPA, United States Fish and Wildlife Service, and the Army Corps of Engineers is reportedly important for facilitating the development of appropriate regulatory process.

Agencies in our case study regions have different level of expertise in permitting and regulating marine aquaculture in state waters and face their own institutional challenges. California, Hawaii, and Maine stand at different points in a continuum regarding experience permitting and regulating open ocean aquaculture in state jurisdiction waters. Currently agencies are gaining experience and developing procedural solutions as they review permit applications for federal waters.

In California, staff at agencies that regulate and promote aquaculture reported a lack of familiarity with missions of other agencies and expertise or role of specific individuals involved in making permitting or regulatory decisions. During the course of this two and half year study and as a consequence of reviewing an application for an offshore shellfish farm, respondents report a better understanding of the missions of other regulatory agencies and the establishment of important personal connections with staff at other federal and state agencies. Respondents report that the next step is to arrive at a "collective bottom line" regarding permitting requirements and establish one application form that fills the informational needs of all agencies. To achieve these ends, aquaculture development coordinators at the state in CDFW and federal level in NOAA's regional Office of Aquaculture are seeking to establish an offshore aquaculture working group that includes the various federal and state agencies and regional entities that have regulatory authority over aquaculture.

Respondents within the industry, research, and regulatory sectors have also suggested the importance of demonstration projects through which to create a shared vision of permitting and monitoring requirements for federal waters. The recent filing of a permit application by Hubbs SeaWorld Research Institute and Cuna del Mar, the Rose Canyon Fisheries Sustainable Aquaculture Project, reportedly represents just such an opportunity.

In Hawaii, agency staff noted challenges arising from ineffective or inappropriate placement of staff and programs within state agencies to promote aquaculture development; personality rather than organizationally driven permit processes; and turnover or inexperienced staff. Agency staff and aquaculture operators report the need for a revision of benthic monitoring requirements for operations sited in deep waters and strong current ocean environment and a programmatic environmental assessment to standardize permit and monitoring requirements and reduce permit costs.

During the course of this research, an Offshore Aquaculture Monitoring Working Group was established to create a set of water quality and benthic monitoring requirements suited for Hawaii's deepwater and strong current ocean environment. Challenges reported by EPA agency staff included determining sampling locations so as to establish most accurate and efficient monitoring requirements. Current and plume modeling programs are currently being developed to facilitate the determination of sampling locations. This working group effort has reportedly been transferred to the federal level to create a standardized monitoring protocol for aquaculture for the nation.

Agency staff also noted the goal of creating a programmatic environmental impact statement for offshore aquaculture that would clarify permitting requirements and streamlining review process and thereby reduce the time and costs of preparing an application and undertaking proposal review. Included in this effort would be programmatic agreements with other relevant federal agencies such as the EPA and Army Corps of Engineers. A programmatic environmental impact study would preclude the necessity of an extensive NEPA review for each project. The streamlined review process would require that applicants prepare an environmental assessment and NEPA review would be conducted in regards to site specific concerns related to for example, impacts to protected resources and/or essential fish habitats.

Maine's permit and management framework for marine aquaculture conducted in state waters has been refined over approximately 35 years. Staff at regulatory agencies report having knowledge of each other's role and functions. Additionally, the decision making criteria and processes for operations sited in state waters have reportedly reached a status of institutionalization. Of particular note, Maine's Pollution Discharge Elimination System permits (DPES) have been refined a number of times since initial establishment in 2003. The most recent modification, approved in 2014, recognizes the effectiveness of standard industry based mitigation strategies and reduces the amount of monitoring data that operators collect and the department must manage. Although the lessons have been learned regarding environmental monitoring at the state level, staff members at Region One of the EPA report that Maine's standards would not necessarily be adopted for federal waters. The staff express concerns about the revisions, particularly the elimination of video monitoring and the use of a control site. There are no proposed projects for federal jurisdiction waters of Maine and thus no regulatory challenges or progress specific to federal waters was reported by respondents.

In New Hampshire, agencies developed a process for permitting open ocean finfish and shellfish aquaculture in state jurisdiction waters as a result of the University of New Hampshire's Open Ocean Project. In 2014, a permit application was submitted and approved for a longline mussel farm located in thus ensuring that agency staff continue to have experience in reviewing applications; there is, however, a concern about staff turnover rates and the need to ensure "institutional memory" for permitting aquaculture operations. There are no proposed projects for federal jurisdiction waters of New Hampshire and thus no regulatory challenges or progress specific to federal waters was reported by respondents.

In Massachusetts, agencies have experience permitting long line mussels farms in state and federal jurisdiction waters. The potential for marine mammal entanglements are of particular concern for longline mussel farms. Staff at the Office of Aquaculture within the Greater Atlantic Regional Office of NOAA are currently conducting interagency workshops regarding the issues associated with mooring technology and marine mammal protection. Staff within NOAA's Office of Protected Resources are currently creating internal guidelines for assessing the potential risk of aquaculture gear to protected marine mammals, and to provide technical assistance to applicants regarding suitable site locations and gear configurations to mitigate the potential of entanglement. Staff report the need for more detailed information on marine mammal presence and the impact of aquaculture operations on marine mammals. A white paper regarding aquaculture and marine mammal entanglements focusing on long-line mussel technology is in preparation. Reportedly, information gained from this regional effort may assist other regions in assessing the risks of marine mammal entanglement and formulating appropriate mitigation strategies. NOAA staff also report the need for greater coordination between staff within the Division of Protected Resources, which is housed in National Marine Fisheries Service, and between staff within the Sanctuary program, which is housed within the National Ocean Services.

Political challenges and industry efforts. Currently industry respondents in all the case study regions note the noted a lack of political allies with the necessary clout to influence state or national policies and politics in favor of marine aquaculture development. Respondents in New Hampshire, Maine, and Hawaii noted the loss of previously powerful senators and/or state legislators and current representation by junior congressman with less political clout. In California, a senior legislator has promoted legislation at the state and national level that many in the industry viewed as distinctly anti-aquaculture, at least for finfish aquaculture.

Industry respondents recognize that the industry itself must do more active lobbying. According to survey results conducted with state aquaculture coordinators, the industry rarely (less than yearly) or occasionally (yearly) works with allies to seek support of decision makers. Less than 8% of state aquaculture coordinators report the industry seeks legislative support on a monthly or daily basis and only 11% of the respondents reported the industry working on monthly basis coordinating activities with allies and influencing the composition of advisory committees for aquaculture issues (Siddiki and Weible 2011).

Coalition for U.S. Seafood Production (CUSP) was formed in early 2014 to represent the aquaculture industry in discussions with agencies and legislators at the federal level and to the public. The coalition includes members from the feed industry, aquaculture system makers, seafood processors and distributors, aquaculture research, and aquaculture associations. Currently the coalition is focusing their lobbying efforts on: (1) the finalization of the Gulf of

Mexico Fishery Management Plan for Offshore Aquaculture to allow for the permitting of aquaculture in the federal jurisdiction waters of the Gulf of Mexico; (2) the re-authorization of the Magnuson-Stevens Fisheries Conservation and Management Act to codify NOAA's authority to permit aquaculture; and (3) the inclusion of aquaculture as a "specialty crop" in a proposed farm bills to allow aquaculture activities to be included in plans and programs developed by the USDA(cf. Seafood Source Staff 2014). CUSP is also involved in the development and promotion of open ocean demonstration projects designed to test commercial viability and environmentally sustainability. The coalition has garnered support from NOAA's Office of Aquaculture, the Department of Agriculture, and important conservation organizations, such as the New England Aquarium (cf. Robinson 2014). The trade organization Ocean Stewards Institute, established in 2008, is also an active voice and advocate for the nascent open ocean aquaculture industry.

9.2 Economic constraints and recommendations

Respondents at state and federal agencies, from the industry, and within the research sector all report economic challenges associated with the development of the marine aquaculture industry generally. Aquaculture programs that have supported the development of open ocean aquaculture in state waters have experienced defunding and restructuring in Hawaii and Maine. Staff at state agencies report lack of staff to conduct permit processes in a timely manner and engage in aquaculture development activities. Staff at federal agencies report the lack of funding to conduct the research necessary to develop the industry in federal jurisdiction waters. In Hawaii, NOAA staff noted inadequate funding for the development of GIS and utilization of impact modeling software. Tools such as these could fulfill scientific needs of regulators and communication needs of stakeholders. In addition, staff note the lack of funding and human resources needed to conduct interagency workshops to create new or streamline regulatory processes. As one agency respondent in California observed, many agencies function in a "triage" mode working on a project by project and do not have the staff time to participate in working groups or creatively to arrive at solutions that can facilitate the development of the aquaculture industry.

Industry respondents report high costs of preparing information required for the permitting open ocean net pen operations in Hawaii and California. Additionally, industry respondents report difficulty obtaining capital and access to investment funding. Most types of offshore operations will require considerable capital investment. As is a case for any emerging industry, the offshore aquaculture industry lacks successful examples to entice investors from alternative options. There is also a greater need for economic modeling depicting the potential of specific operations. Industry respondents note that the accessibility of investment funds and/or loans demand the assurance that permits and leases be long term and renewable. Standard leases for state water aquaculture operations are only ten years in Maine and the Gulf of Mexico FMP for aquaculture is proposing permits of ten years (with renewal of five years). Currently, there is no leasing arrangement for aquaculture in federal waters unless the operation is associated with an energy structure (such as gas/oil platform or wind energy installation).[47] Some industry respondents note that lack of a lease arrangement is perceived by investors as indicative of an unstable business

[47] As of 2005, and the passage of the Energy Policy Act, the Bureau of Ocean and Energy Management (BOEM) has been given the authority to allow existing energy platforms to be used for offshore aquaculture activities, conditioned on permitting by the agencies that have authority over marine aquaculture in federal water (cf. Bureau of Ocean Energy Management Nd).

climate. The establishment of general lease arrangement would require an Act of Congress and the appointment of an overseeing agency. Additionally, the industry could benefit from the establishment of some form of risk management, such as an insurance pool, to indemnify producers for stock losses due to natural diasters or disease outbreaks (cf. Rieser and Bunsick 1999; Bridger 2004).

Respondents within the research sector report that government funding for research supporting open ocean aquaculture has been inconsistent and to date has largely been conducted as federal earmark funding.[48] Research on open ocean aquaculture was initiated in the early 1990s and focused on the development of aquaculture equipment and systems. In the 1990's several workshops were held throughout the United States. Additionally, research was funded on policy and regulatory challenges, environmental issues, GIS development, and development of new species. Funding, however, was reduced in 2002, 2003, and 2005 (cf. McVey 2007). And, most recently, pioneer marine aquaculture research institutes/projects in both Hawaii and New Hampshire lost funding in 2008.

Industry respondents who are familiar with the marine aquaculture industry in Canada, Norway, Japan, and Scotland point to substantial government funding and government policies that view aquaculture as a focus of economic or rural development rather than as primarily an environment problem demanding management. The kind and scale of support needed to develop open-ocean aquaculture, in either state or federal jurisdiction waters, has been variously compared by industry respondents in Maine and Hawaii to a "blue water space program" and a "homestead act for the ocean."

Respondents from research and industry sectors identified the following funding needs:

(1) Expansion of hatchery infrastructure (as a federal effort; through partnering with states; or incentivizing private for profit companies or non-profit organizations) to identify suitable marine species and develop culture techniques;

(2) Research to test grow-out rates and assess the economic viability of open ocean operations;

(3) Research on disease/parasite levels and genetic make-up of wild stock;

(4) Development of automation systems suitable for high energy and cold temperature offshore locations to undertake basic operations such as feeding and cleaning;

(5) Development of environmental impact and site modeling programs for open ocean environments;

(6) Development of technology that can continuously monitor environmental variables, in offshore region, that effect farm productivity and gauge environmental impact;

[48] According to a 2014 Interagency Working Group of Aquaculture publication titled *National Strategic Plan for Federal Aquaculture Research* (2014-2019), recent federal expenditures for aquaculture research by federal and non-federal entities have averaged $94 million annually (National Science and Technology Council, Committee on Science, and Interagency Working Group of Aquaculture 2014:8).

(7) Enhancement of scientific and technological transfer akin to that undertaken by USDA in support of terrestrial farming.

(8) Establishment of investment incentives, such as tax credits, loan funds, and development grants (cf. United States Government Printing Office 2011; Corbin 2007);

(9) Research on ecosystem and community benefits of marine aquaculture operations.

In 2014, the Interagency Working Group on Aquaculture (IWG-A), which establishes high priority strategic goals for federally funded research and development efforts, released a five year plan (2014-9) identifying nine high priority goals:[49] The research priorities variously respond to needs expressed by industry and concerns expressed by NGOs.

"1. Advance Understanding of the Interactions of Aquaculture and the Environment
2. Employ Genetics to Increase Productivity and Protect Natural Populations
3. Counter Disease in Aquatic Organisms and Improving Biosecurity
4. Improve Production Efficiency and Well-being
5. Improve Nutrition and Develop Novel Feeds
6. Increase Supply of Nutritious, Safe, High-quality Seafood and Aquatic Products
7. Improve Performance of Production Systems
8. Create a Skilled Workforce and Enhance Technology Transfer
9. Develop and Use Socioeconomic and Business Research to Advance Domestic Aquaculture" (National Science and Technology Council, Committee on Science, and Interagency Working Group on Aquaculture 2014: 2)

Although the need for extensive funding support is a common theme expressed by our respondents and reported in the literature, there are divergent perspectives on the roles of the private sector and government in providing funds for research and development. For example, an industry respondent in Hawaii noted that existing companies have and will likely continue to invest in feed improvement and cage development and as such these should not be a priority for government funding. In contrast, due to the high cost and time required to establish a hatchery, industry respondents and aquaculture researchers in Gulf of Maine and California have reported the need for government funded hatchery support. The recently established aquaculture group, Coalition of US Seafood Production (CUSP), has recommended that commercial scale demonstration operations be funded by private-sector investors but supported by the efforts of federally funded investigators researching technological engineering, business planning, and management approaches (cf. CUSP 2013). A respondent involved in aquaculture research in California noted that government funding should support regional demonstration projects that could produce benchmark studies to attract investors, assess ecological impacts, and provide the public with evidence that "farms are not the end of the world." Additionally, the successful permitting of a project in the federal waters could provide a template for the process. Another California respondent involved in aquaculture research noted that public-private venture could ensure that those making the regulations would be better apprised of the costs of those regulations and promote the creation of permitting (and monitoring) requirements that are economically workable for the applicant and manageable for agency staff. To provide adequate

[49] The aquaculture research plan does not directly address needs in regards to policy and regulatory plans; financing and disaster assistance; and zoning development that also effect development of aquaculture industry.

evidence regarding commercial viability and ecological sustainability of farming, respondents note that demonstration farms need to operate 10-20 years and should be operated by "real farmers" in consultation with experts in disease management and engineering technology.

Additionally, to address the costs associated with fulfilling the permit process, respondents have recommended that some kind of government entity (local government, state agency) undertake the cost of environmental impact studies. This entity would then be in charge of sub-leasing or sub-permitting individual projects. This approach is currently being taken for shellfish aquaculture in northern California's Humboldt Bay and in state waters of Cape Cod Bay and Nantucket Sound.

Regional and state efforts to conduct programmatic reviews, such as the Gulf of Mexico fishery management plans and the current programmatic environmental impact assessment of marine aquaculture in state waters of California, will potentially reduce costs and time of applicants to undergo permit review. Programmatic reviews reduce burden on applicants to provide scientific information and create a more efficient and focused environmental review process.

9.3 Socio-cultural Perspectives.

The offshore aquaculture industry has faced challenges related to public perceptions of marine aquaculture generally and opposition from fishing community more specifically. Below we divide our discussion into two parts: 1) public perceptions and educational needs and 2) fishing community opposition and strategies to mitigate space and resource conflicts.

Public perceptions and outreach and educational needs. Respondents within the industry and conducting aquaculture research argue social opposition to marine aquaculture generally reflects a lack of understanding on the part of the general public and decision-makers regarding: the potential severity of future seafood shortages; advancements within the aquaculture industry; the state of scientific knowledge regarding aquaculture impacts; and regulatory and monitoring requirements placed on existing farms. Additionally, respondents express concerns that the overriding negative view presented of aquaculture by conservation organization over the past two decades has led to a great deal of skepticism regarding the current body of knowledge.

Industry respondents reported a need for NOAA to take a stronger role in countering misinformation by providing official statements regarding the science of what is known regarding aquaculture impacts and benefits. The hope is that such official statements would define what kinds of concerns have validity and serve to keep irrelevant issues and politics out of the permit process. Respondents in educationally orientated NGOs reported the need for, and challenges of translating complicated scientific and technical information of an evolving industry to the general public, especially in light of a history of polemic messaging. Although research efforts have produced good quality information regarding risk and mitigation of aquaculture, this information has not for the most part been adequately communicated. According to NOAA agency staff what is needed is more effort to translate scientists' focus on "being methodical, meticulous, and documenting their evidence" to the public's preference for information to be conveyed in short time spans and in compelling visual representations.

Additionally, respondents note that the acceptance of offshore aquaculture may demand a fundamental cultural change in attitudes regarding the ocean from viewing that as a pristine

environment to that of a useable resource. To realize this shift, agency staff in Maine suggest that the public needs to be educated regarding the current interpretation and application of the public trust doctrine to other ocean-based enterprises.

Respondents within the open ocean aquaculture industry report their efforts to respond to public misinformation by conducting their own outreach and educational efforts.[50] Industry respondents in Hawaii have collaborated with renowned chefs to act as ambassadors for farmed products, and two industry respondents in California and Hawaii use social media to inform the public of their individual business practices as well advancements in the industry as a whole. Industry respondents also reported potential opportunities for conducting public education and ecotourism at hatcheries and farms and outreaching to journalists to tell their stories. Aquariums also play an important role in educating the public in our study regions.

Fishing community opposition and mitigation strategies. Opposition from the commercial and recreational fishing sectors has centered on space conflicts; the potential impact of marine aquaculture to essential fish habitat; and the impact of ranching of tuna species on stock abundance. Additionally, the commercial fishing sector has expressed concerns regarding the impact on the pricing of wild caught seafood.

Siting to avoid major fishing grounds and spacing and/or submerging of farm structures to enable the continuation of fishing activities have been the primary strategies used to mitigate space-use conflicts. Respondents within the industry sector and aquaculture research reported efforts to mitigate market impact by choosing farm species that are undesirable targets as wild species for sales and consumption (Almaco jack/*kahala* in Hawaii or mussels in New England) or that will replace an imported seafood (California yellowtail in California). Other candidate species in our study regions - Atlantic cod, Atlantic halibut, and white bass are a commercially important species. Proponents of aquaculture have suggested that market conflict can be addressed through product differentiation and market segmentation, much as has happened in the case of salmon (cf. United States Government Printing Office 2011).

In the Gulf of Maine, aquaculture training programs have been established that target commercial fishermen. Candidate farms species are chosen that are operationally and seasonally compatible with current commercial fishing operations (seaweed in Maine and mussels in New England). In California and Hawaii, open ocean aquaculture companies have instituted programs in stock enhancement that have been received favorably by recreational fishermen.

In Hawaii, opposition to operations sited in state jurisdiction waters has been expressed from parts of the native Hawaiian community. As noted in Chapter Six, concerns have focused on how aquaculture operations may impact traditional fishing ground (*ko'a*) and culturally valued shark species.[51] Some members of the native Hawaiian community also have long standing grievances

[50] According to a 2011 survey, efforts on part of the aquaculture industry as a whole to counter misinformation vary in frequency and effectiveness. Less than 8% of state aquaculture coordinators report that the aquaculture industry engages in publicity or marketing campaigns regarding aquaculture on a monthly or daily basis (cf. Siddiki and Weible 2011). Additionally, according to survey results, the industry never or rarely (less than yearly) utilizes experts to countering inaccurate information regarding marine aquaculture. That said, however, in a study of the effectiveness of (marine) aquaculture partnerships, survey respondents reported that partnerships had some positive impact countering misinformation (cf. Calanni 2012).

[51] Sharks are considered "guardians" and serve important ecosystem role in protecting fishing grounds.

regarding the state and federal government making decision about what they perceive as native Hawaiian's resources. Many within the Hawaiian community support the re-establishment of a native aquaculture system of fish ponds rather than developing open ocean aquaculture. A respondent in the native Hawaiian community reported the importance of honoring native Hawaiian cultural traditions of sharing resources and "giving back to nature" and suggested offering farmed product the local community at discount rates or giving seafood to school cafeterias. To date operations sited in open ocean environments of state waters have attempted to address these concerns by: proper siting of operations to avoid traditional harvest areas and cultural resources; establishment of predator management practices; provisioning local stores with farmed seafood; and supporting stock replenishment efforts (cf. Tetra Tech, Inc. 2009).

Recreational and commercial fishermen in Hawaii have reported the affect aquaculture operations have on attracting fish. The Vellela Gamma offshore farm reportedly attract a variety of commercially important fish species including yellowfin and bigeye tuna, wahoo or 'ono, mahi mahi. Respondents from the fishing community report that fishermens' response to the FAD (fish aggregating device) effect of the offshore operation has generally been favorable due do a recent dearth in state funded FADs. Respondents have, however, also noted concerns about the FAD effect of farms drawing fish away from traditional grounds and/or increase predation by sharks of target wild catch species. Respondents involved in tourism reported the potential attractiveness of farms for (consumptive and non-consumptive) diving and eco-tourism.

Of note, currently permitted state water operations in our study regions allow access to the aquaculture lease area but exclude public from entry into the farm and mooring structures. To maximize the benefit of the FAD effect, fishing community respondents report the need for "clear cut guidelines for operating around structures" and diagram of operation configurations for avoiding entanglement. Industry respondents report the need to ensure the safety of workers and to protect equipment and fish stock from possible dangers when fishermen enter farm sites.

It should be noted that the aquaculture industry is currently being asked to address potentially contradictory concerns, for example, community desires to increase the supply of affordable seafood versus commercial fishermen's desire to protect the market prices of locally caught seafood. The industry and regulators are also being asked to weigh trade-offs of mitigation strategies. For example, although submersible structures can increase transit accessibility for marine users, offer greater security of stock, and address aesthetic concerns, submersible structures have some disadvantages vis-à-vis conventional surface net pens. The cost of operating and maintaining net pens is less than submersible cages (cf. Kona Blue Water Farms 2009). Surface cages are generally safer for workers. They do not require specialized diving skills and thus allow for the more ready transition of skills for fishermen displaced from wild catch fisheries.

9.4 Environmental concerns, technological solutions, and management measures.

Social opposition and regulatory and policy impasses are in part due to concerns about environmental impacts. Advances in technologies and best management practices are providing the means to resolve many environmental concerns. Recognizing that key decision makers and the public may not be familiar with these advances, we review them below.

As noted in Chapter Six, environmental concerns expressed/reported by NGOs regarding marine aquaculture generally have centered on impacts to: (1) water quality and benthic communities due nutrient pollution and chemical use; (2) wild fish stock due to disease transmission from farmed stock, competition from escapes, use of wild forage species in aquaculture feed; and use of broodstock; (3) marine mammals due to entanglement or siting of operations in important feeding or breeding areas, amongst others. Additionally, concerns regarding the environmental impact to humans have centered on the safety of consuming farmed fish.

Conservation NGOs have created various standards and certification programs to address public concerns regarding the food safety, environmental sustainability and social ethics of aquaculture practices (cf. Goldman 2012; Villalon 2012). Currently the USDA is creating an organic standard for aquaculture (based on such criteria as: use of chemical therapeutants, stocking density, fish meal use etc) that may also serve to assuage public concerns regarding the safety of farmed seafood.

Impacts to water quality, benthos, and micro and macro fauna communities can be mitigated through proper site selection for current flow and water depth; use of improved feed formulations; and best management practices for feeding, stocking density, net cleaning, and fallowing (cf. Corbin 2010, Price and Morris 2013). Research conducted on marine cage aquaculture operations sited in open ocean environments reveals negligible impact. Additionally, IMTA is being promoted as a mitigation strategy for nutrient impacts.

Common disease management practices include use of brood stock that have been raised in land-based sites and have undergone quarantine procedures. In addition, aquaculture operators commonly mitigate the potential of disease transmission from wild to culture species by maintaining low stocking densities and separation zones between sites (cf. Bridger 2004).

Concerns regarding potential impact of farm escapees on the genetic make-up of wild fish populations have arisen in relation to salmon species and relate to the distinct genetic make-up of salmon populations located in river systems. These concerns are commonly addressed by prohibiting the use of non-native and GMO species, choosing regional species that are considered one genetic stock (such as cobia, red drum and red snapper in the Gulf of Mexico), and stocking only reproductively sterile species. Significant declines in the number of escapements have also been realized by advancement in cage materials to withstand extreme weather and improvement in cage technology to deter predators (cf. Corbin 2010).

Concerns regarding increased demand for wild stock sources to be used for feeding farmed species are being mitigated by advances in food formulation, and in particular, the inclusion of soy as a protein source for carnivorous fish. Trimming from seafood processing are also being used in fish meal (cf. Stickney and McVey 2002; Rheault et al. 2002). Additionally, automated

feeding system that incorporate monitoring capabilities have also been developed (cf. Price and Morris 2013).

Concerns regarding impact to marine mammals, turtles and birds have centered on how aquaculture operations may impede access to natural resources; cause habituation to different food sources; and result in entanglement in aquaculture gear. Currently efforts to mitigate the potential for marine mammal entanglement include: (1) siting to avoid emplacement of aquaculture operations in areas of high marine mammal presence including important movement/migration routes; ensuring mooring lines are taut; and utilizing rigid netting (cf. Price and Morris 2013). Inspection of mooring lines is routinely required and conducted as part of industry management practices. Additional mitigation strategies were incorporated into a recently approved longline shell fish farm sited in federal waters of Nantucket Sound; they include: limiting the number of vertical lines; minimizing diagonal mooring configurations; utilizing high visibility materials and fine mesh netting; and using break away linkages. An aquaculture operator in Hawaii has also suggested that aquaculture staff be trained by NOAA in first response measures for animal entanglement events. Of note, although acoustic devices have been employed to deter predators in other parts of the world, they currently are not accepted in the United States.

In Hawaii, concerns have been expressed regarding how aquaculture operations may attract sharks and result in increased predation of dolphins and monk seals. The primary mitigation strategies utilized for decreasing the attractiveness of aquaculture operations to sharks and other species center on feeding practices – the use of fish feed pellets rather than fresh fish and the monitoring of feed to avoid excess feed waste – and the routine removal of dead fish. Shark resistant netting, double netting, and shark avoidance colors are also commonly utilized (cf. Price and Morris 2013).

The use of antibiotics and other chemicals to treat disease have given rise to concerns regarding: the food safety of farmed fish and the development of antibacterial resistant strains of disease in wild fish. The use of chemical therapuetents have also resulted in mortality of wild crustaceans during their molting phase. The development of vaccination protocols in conjunction with establishment of best management practices for stocking density reduce stress and have resulted in declines in use of antibiotics and other chemical therapeutants. In addition, screening for chemical residues is widely accepted as an industry practice (cf. Stickney and McVey 2002).

Of note, the economic feasibility and practical trade-offs of various mitigation strategies (will) vary by location and operational configuration. For example, although weak break away linkages are currently being considered as an appropriate mitigation strategy for whale entanglement, their use must be considered in regards to equally pressing environmental and economic ramifications of losing pens, cages, or lines. Additionally, although the Gulf of Mexico Fishery Management Plan for Offshore Aquaculture, current aquaculture operations in Hawaii, and a proposed aquaculture operation in California, limit the stocking of fish to second generation, ostensibly to mitigate potential impacts to wild fisheries from escapes, there is no clear consensus that this practice is best for the environment, companies, or the nation's seafood supply. Respondents within the industry and aquaculture research assert that selective breeding is essential to improving growth efficiencies, feed conversation rates, and disease resistance and thus can lead to a decrease in environmental pollution and an increase commercial viability of operations and product affordability.

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11.0 Appendix A: Identification of Select Factors Important to the Development of Offshore Aquaculture

Factor	California	Hawaii	Gulf of Maine
Offshore Environmental Conditions	(+) suitable bathymetric conditions for current conventional open ocean cage technology (+) warm water temperatures conducive to high growth rate (+) mild weather conditions.	(+) warm water temperatures conducive to high growth rate (+) mild weather conditions (-) steep bathymetry in offshore waters necessitate advanced cage technology	(-) strong and complex wind and current patterns (-) icy winter conditions
Market Demand	(+) proximate to urban population (+) availability of transport infrastructure	**(+)** high tourist demand (+) high per capita seafood consumption (+) proximate to Asian markets (-) distant from US mainland markets	(+) proximate to urban population (+) availability of transport infrastructure (+) strong local food movement
Coastal Support Infrastructure (see Interim Report for detailed infrastructure assessments by harbor and fishing community)	(+) availability of commercial fishing and seafood processing infrastructure (-)competition for harbor space and limited facilities in some ports	(-) lack of suitably zoned land (Oahu) (-) limited port facilities (all other islands)	(+) extensive throughout region (+) availability of commercial fishing and seafood processing (-) increasing competition for access to waterfront facilities
State Financial Support/Investment Incentives	-	+	+ (Maine)
Research Support	private	private and public	private and public
Existing State Regulatory Framework for Open Ocean	established for shellfish	good regulatory structure for finfish	good regulatory structure for finfish, shellfish and seaweed

Factor	California	Hawaii	Gulf of Maine
Number of open ocean sites, proposed, reviewed, permitted and currently active (state/federal waters)*	● one operation permitted and active (shellfish – state waters) ● one operation permitted (shellfish – federal waters) ● two operation proposed (finfish – federal waters) ● one operation under review (finfish – federal waters)	● eight projects proposed (finfish – state waters) ● three projects permitted (finfish – state waters) ● one project currently active (finfish –state waters) ● one project under review (finfish – state waters) ● two projects permitted for one year (finfish – federal waters) ● one project under review (finfish – federal waters)	● three permitted projects (shellfish – state waters) ● one permitted and active project (shellfish – state waters) ● one project pending approval (shellfish – federal waters)
History of Community Acceptance	Shellfish	Finfish	Finfish and Shellfish
Candidate Species	• Mediterranean mussel *(Mytilus galloprovincialia)* • Pacific oyster *(Crassostrea gigas)* • White seabass (*Atractoscion nobilis)* • California yellowtail (*Seriola lalandi)* • Striped bass (*Morone saxatilis*) • California halibut (*Paralichthys californicus*)	• Pacific Threadfin (*Polydactylus sexfilis)* • Almaco jack (*Seriola rivoliana)* • Yellowfin tuna (*Thunnus albacares)* • Bigeye ahi tuna *(Thunnus obesus*) • Mahimahi (*Coryphaena hippurus*)	• Atlantic salmon (*Salmo salar*) • Atlantic Cod (*gadus morhua*) • Atlantic Halibut (*Hippoglossus hippoglossus)* • Steelhead Trout (*Oncorhynchus mykiss)* • Blue mussels (*Mytilus edulis)* • Seaweed –various species
Other	(+) Offshore oil platforms for possible co-siting with aquaculture operations (-) marine mammal presence	(-) marine mammal presence	(+) presence of fishing cooperatives for technology transfer and cooperative management of farms (-) marine mammal presence

*Projects/operations in Massachusetts south of the Gulf of Maine are not included.