

Sectoral Insights on the Future of Aquaculture in the US

June 2021



ABOUT THIS REPORT

This brief was prepared by Meridian Institute and Ocean Strategies in June 2021 based on insights from nearly 100 interviews across industries, nonprofits, universities, financial institutions, advocacy groups, and other organizations. It provides an overview of general perspectives, key concerns, and promising opportunities regarding the development of nearshore and offshore aquaculture in the US.

Cover Photos (from left): Oyster in Alabama by U.S. Department of Agriculture on Flickr. Kelp at Low Tide photo in California by Shane Stagner on Unsplash. Salmon Fisherman in Alaska by Georgie Heaverley. Atlantic Salmon Aquaculture Net Pens photo in Maine by Leo W. Kowal on Shutterstock. Seafood Counter in Florida by Joni Hanebutt on Shutterstock. Recreational Fishing Boat in Florida by Chase Barker on Unsplash.

Table of Contents

SECTORAL INSIGHTS ON THE FUTURE OF AQUACULTURE IN THE US	0
ABOUT THIS REPORT	1
INTRODUCTION	3
AQUACULTURE INDUSTRY	5
SUMMARY OF FINDINGS	5
OPPORTUNITIES AND RECOMMENDATIONS	9
AQUACULTURE INVESTMENT	10
SUMMARY OF FINDINGS	10
OPPORTUNITIES AND RECOMMENDATIONS	12
COMMERCIAL FISHING	13
SUMMARY OF FINDINGS	13
OPPORTUNITIES AND RECOMMENDATIONS	15
SEAFOOD SUPPLY CHAIN	17
SUMMARY OF FINDINGS	17
OPPORTUNITIES AND RECOMMENDATIONS	19
RECREATIONAL FISHING	20
SUMMARY OF FINDINGS	20
OPPORTUNITIES AND RECOMMENDATIONS	21
ENVIRONMENTAL NON-GOVERNMENTAL ORGANIZATIONS	22
SUMMARY OF FINDINGS	22
OUTSTANDING QUESTIONS	24

Introduction

Meridian Institute and Ocean Strategies have been working collaboratively since the fall of 2020, with support from Builders Initiative, to gain an understanding of the broad range of perspectives on the future of aquaculture in the US. As a neutral third party, Meridian has undertaken an approach to learn about different sectors values and needs, as well as concerns and opportunities regarding the future of aquaculture in the US. We have partnered with Ocean Strategies on their detailed expertise with the commercial fishing industry as well as the seafood supply chain including processors, distributors, and retailers.

One of the goals of this project is to inform the policy process, with an emphasis on federal policies. These interviews were in anticipation of future aquaculture policy as well as in response to policies in the executive and legislative branches, such as President Trump's executive order seeking to expand aquaculture, NOAA's pursuit of Aquaculture Opportunity Areas, US Army Corps of Engineers' permitting activity, and the AQUAA Act. Considering this activity, we sought to understand how six sectors think about the future of aquaculture in the US. Together we have interviewed close to 100 individuals, to listen and learn. This includes a broad set of actors from the environmental NGO community, commercial fishing industry, aquaculture industry, recreational fishing community, the aquaculture finance community, and the seafood supply chain. We have brought together our learnings from these discussions in this compendium of information to foster cross-sectoral learning and understanding. We are sharing this high-level, non-attributional synthesis with interviewees and beyond to inform the future of work on US aquaculture.

For each sector, this document outlines primary perspectives and values. It also highlights challenges and opportunities that were identified. It should be noted that this document is not intended to be a comprehensive accounting of perspectives. We have not spoken to everyone from each sector who could have shared their perspectives. We are committed to continuing to learn from new voices. If there is a critical perspective you feel is missing in this document, we would encourage you to reach out to Meghan Massaua (mmassaua@merid.org) and Brett Veerhusen (brett@oceanstrat.com).

Overview of Engagement

Aquaculture Industry: Twenty-two interviews with companies across the value chain working on production, technology innovation, feed, processing, and more.

Aquaculture Investment: Twelve interviews with firms who are investing or are considering investing in aquaculture in the US.

Commercial Fishing: Twenty-seven interviews with eighteen leading commercial fishing organizations, each representing a different fishing region of the United States.

Seafood Supply Chain: Eleven interviews with industry organizations, processors, distributors, and grocers.

Recreational Fishing: Eleven interviews with anglers, charter captains, gear manufacturers, and regional and national fishing associations.

Environmental Non-Governmental Organizations: Nine interviews with environmental non-governmental organizations (ENGOS) that are working or historically worked on aquaculture domestically and/or internationally. Several convenings with the ENGO community were held to explore challenges, developments, and opportunities associated with offshore aquaculture, and five “Deep Dive” sessions to explore in detail the community’s environmental concerns, possible benefits of aquaculture, and current research.

Aquaculture Industry

Meridian interviewed 20+ aquaculture companies working across the value chain on production, technology innovation, feed, processing, and more. Key points from our research and interviews are highlighted below.

SUMMARY OF FINDINGS

ELEMENTS OF THE AQUACULTURE VALUE CHAIN

- **Research:** Aquaculture research and development are critical needs for the industry, particularly for offshore finfish aquaculture development. Critical research questions in the industry include sustainable feed development, fish genetics, and fish health and management.
- **Aquaculture Technology Companies:** Aquaculture technology companies provide a wide range of technologies and services including infrastructure for fish containment, feeding systems, and instrumentation and software for monitoring environmental conditions and fish health management. Technology companies are developing innovative systems and technologies to develop more resilient and effective farm infrastructure, reduce labor needed for fish farm monitoring and to increase the availability and accuracy of data to inform farm management decisions and increase farm efficiency.
- **Feed Production:** Feed is the highest capital expenditure for aquaculture farms by far, consisting of 50 – 70% of aquaculture production costs. The primary objective of companies that formulate feeds is to produce fish feed at the least cost possible that will grow fish quickly and at optimal health. The composition of aquaculture feed has become a major focus for improving the environmental footprint of aquaculture, leading to the development of novel ingredients to replace fish meal and fish oil. However, there is no widely agreed-upon standard for what constitutes “sustainable” aquaculture feed, which is a major challenge in improving feed sustainability across the industry.
- **Aquaculture Production:** Aquaculture production in the U.S. covers a range of modalities and species, from cultivation in freshwater rivers and ponds, indoor Recirculating Aquaculture Systems (RAS), nearshore marine operations, to further offshore (although offshore projects are generally at the pilot scale in the US). To increase aquaculture production in the United States, there is a movement of aquaculture companies and industry experts interested in developing farms in the offshore marine environment. The offshore marine environment is thought to be less crowded, have higher water quality, and is less spatially constrained than potential nearshore farm locations, which often face challenges to development from coastal stakeholders.
 - **Offshore Farm Site Selection:** In selecting a target site for farm development, companies consider the local ocean conditions required for growing their target species (such as water temperature), the proximity of the location to target markets and other infrastructure, cost of labor, and both the ease and certainty in navigating required permitting and regulatory processes.
 - **Species Selection:** When selecting a species to farm, companies look for species that are highly valued, native, or naturalized to the area, are well researched, grow well in the selected environment, and preferably do not compete with commercial fishermen.

Finfish farms typically select only one species to cultivate, while shellfish companies may farm multiple species.

- **Seafood Processing:** Seafood processing infrastructure was identified by both finfish, shellfish, and seaweed producers as a bottleneck in the supply chain. Current seafood processing infrastructure does not currently have the capacity to deal with potential increases in product through growth in domestic aquaculture production. Processing is a high-volume and low profit margin segment of the seafood value chain. As a result, tourism development and increasing property values along coastlines makes it difficult to build new processing plants and infrastructure.
- **Seafood Distribution:** The aquaculture industry is increasingly challenging existing systems of seafood distribution, which are designed to support many small, independent fishermen in the wild-caught seafood industry. The existing system has many intermediaries that aggregate seafood products, are very price-sensitive, and sell and promote multiple products to customers. This has posed a challenge for aquaculture companies that want to produce premium seafood products associated with a brand focused on sustainable production.
- **Marketing and Sales:** In general, finfish and shellfish farms report high market demand for their products. The target customer of many seafood companies is a higher-income, more highly educated, health-conscious person, and often women or older individuals. Aquaculture companies are tapping into current market trends where these consumers are looking for increasingly local, healthy, and sustainably produced products, as well as substitutes to land-based meat proteins. Despite the success of aquaculture companies interviewed for this report, seafood remains far behind other protein sources in terms of demand and consumer consumption. Barriers to increasing consumption of seafood in the United States include price point, since seafood is the most expensive protein in the marketplace, consumer education about how to cook seafood, negative perception of farm-raised fish, and, in some areas, quality control.
- **Finance:** Financing aquaculture farm development is considered a key bottleneck to growth of the industry. Although aquaculture farms can be extremely profitable, they are both financially risky investments, require significant capital investments to build infrastructure and navigate permitting processes, and often take several years from initial investments to begin producing a profit. The expansion of aquaculture in other countries has often been facilitated through government-backed financing efforts. For example, government-backed debt offerings in Canada were instrumental in the growth of the aquaculture industry there. There is concern that the difficulty of securing financing will prevent small operators from starting aquaculture farms, with implications for equity in the industry.
- **Pre-Competitive Efforts:** There are some pre-competitive efforts driven by universities, NGOs, philanthropy, or mission-driven businesses interested in building the aquaculture industry for both environmental and social benefit. Individuals leading these efforts feel that a lack of collaboration in the aquaculture industry will ultimately undermine industry development. As a result, they see themselves as uniquely positioned to address industry needs, bottlenecks, and challenges in a way that benefits the entire industry.

At a Glance: The Aquaculture Industry Value Chain

The aquaculture industry in the US and globally is broad and really consists of several distinct industries that create a robust value chain, which varies by type of aquaculture (finfish, shellfish, and RAS) as well as by geography and maturity of a company.

Hatcheries (often vertically integrated)	Feed	Other Inputs and Pharmaceuticals	Technology and Equipment	Professional Services	Production (often vertically integrated)	Processing (often vertically integrated)	Distribution or Storage	Sales (often vertically integrated)
Broodstock and seed production, sales, and genomics	Sourced from plant-based, terrestrial-animal byproducts, seafood processing waste, microbial ingredients, fishery resources, and insects	Probiotics, antibiotics in some cases (but many are not using these), bacteriophages, etc.	Monitoring (often via sophisticated AI & tech), feed dispersal, nets, lines, pens, boats, barges, and much more	Farm design, environmental surveys & permitting assistance, attorneys, accountants, etc.	Finfish, shellfish, seaweed; offshore, nearshore, land-based RAS	May be integrated with existing infrastructure or new infrastructure; includes value added products where relevant	May be integrated with existing infrastructure or new infrastructure	Seafood markets, grocery retailers, restaurants, direct to consumer

SUSTAINABILITY

- Environmental sustainability is a key component of the core business strategy for every aquaculture operation interviewed for this report. This is both because environmental sustainability is demanded by rigorous permitting processes, but also because there is a high consumer demand for sustainably produced, domestic seafood. However, definitions of sustainability vary.
- There is no widely agreed-upon standard for what constitutes sustainable aquaculture feed, whether that is net carbon footprint, sustainable sourcing of all materials, or the reduction in use of fish oil and fish meal. This is a major challenge in improving feed sustainability across the industry.
- The shellfish industry faces sustainability challenges related to habitat use and interactions with protected species, both nearshore and offshore.
- More research is needed to understand seaweed's carbon lifecycle and how much carbon is permanently sequestered through seaweed cultivation. Seaweed aquaculture has been suggested as a strategy for ocean "greening" that can build the carbon sequestration potential in the ocean.
- Many aquaculture companies pursue sustainability certifications for their facilities to help build a positive public perception, build confidence with customers and retailers, ensure they are competitive against other products with sustainability certifications, and, for new aquaculture farms, help design and check internal operations to ensure they are building sustainable processes.

PERMITTING

- State and federal permitting processes for aquaculture were identified as *the primary obstacle* to development in the US across every segment of the industry.
- Navigating the numerous regulations governing the marine environment is a complicated, costly, and time-intensive process, which is exacerbated in many areas due to a backlog of permit applications, commonplace understaffing and underfunding of government agencies, and further permitting delays due to the COVID-19 pandemic. In several states, this confluence of factors has effectively created a permitting moratorium.
- Ultimately, companies that cannot get permits to expand in the US or who fear the complexity of the US regulatory process move to other countries nearby, such as Panama and Mexico, with established permitting processes.
- Companies who choose to operate in the U.S. are working to address permitting challenges through a variety of strategies. These include conducting preemptive outreach to regulators to share draft project descriptions, hear concerns, and address questions; participating in government siting processes; conducting voluntary environmental reviews and assessments; building relationships with local and national environmental NGOs; and, conducting community outreach to build social license for aquaculture development. This additional research, community outreach, and the legal services required to navigate permit appeals increases regulatory costs.
- The high cost of permitting means that companies may propose larger-scale farms and operations to offset the initial development costs. This indirectly preferences the development of larger farms.

OPPORTUNITIES AND RECOMMENDATIONS

SUPPORT INNOVATION

- Develop a national economic development plan that reframes aquaculture as an economic development strategy, instead of a resource management discussion.
- Advocate for increased government grant funding and incentives for research and development to answer key industry questions, including infrastructure development and aquaculture feed formulation.

MITIGATE RISKS AND ADDRESSING BARRIERS

- Advocate for policy changes to reduce regulatory burdens.
- Mobilize capital that is already assured via the creation of low interest loan programs from government sources or revolving loan funds to support new aquaculture businesses, particularly small farmers.
- Identify agriculture risk mitigation and stabilization tools that may be applicable for aquaculture markets in the US and ensure these tools are available equitably.
- Invest in coastal seafood infrastructure, particularly for seafood processing.

INCREASE EDUCATION AND CONNECTIVITY

- Build workforce development programs in collaboration with universities, community colleges, and technical schools to build a knowledgeable and robust aquaculture work force.
- Educate consumers on the economic, health, and environmental benefits of locally caught seafood.
- Advocate for federal policy that collectively addresses finfish, shellfish, and seaweed production.
- Provide more consistent avenues for international information exchange.

STREAMLINE PERMITTING

- Have NOAA identify areas suitable for aquaculture in advance and clearly define criteria for farm development.
- Specify in aquaculture regulations what species are best raised in specific geographies.
- Create permitting processes that recognize offshore aquaculture's long-term investment timeline.
- Create efficient data reporting requirements.
- Create policies that recognize that monitoring protocols and farm technology will shift and develop over time.
- Nationwide permits could be a good solution for permitting offshore aquaculture if done correctly and with the right cumulative impact analysis.
- Avoid no-deforestation clauses for aquaculture feed due to the lack of a widely accepted methodology for measuring deforestation.
- Create regulations for monitoring and enforcement that include third-party certifiers and external audits.

Aquaculture Investment

Meridian conducted interviews with 12 firms who are investing or are considering investing in aquaculture in the US. Key points from our research and interviews are highlighted below.

SUMMARY OF FINDINGS

THE INVESTMENT LANDSCAPE

- Financing methods include grants, program related investments, angel investing, venture capital, and debt financing. The interviewed firms primarily relied on equity-based investments, with debt utilized in certain specific cases.
- Investors make their own assessments of financial risk and have independent investment philosophies. Based on their investors and degree of “patient capital” available, different firms can take on varying levels of risk.
- Exit strategies for investors are carefully considered and are still developing. Options include being bought out by larger firms or integration into pension funds and going public.

WHY INVESTORS ARE LOOKING AT AQUACULTURE

- Investors are motivated to do both “well and good” with their capital. They focus on sustainability, the ability to feed a growing population, and the opportunity for substantial returns. While investors are aligned on their interest in sustainability, they do not have standard metrics to assess sustainability in aquaculture investments.
- While most aquaculture investment is happening outside of the US, investors are putting more capital into the US market. Some firms focus on technology innovation up the value chain from production, some focus primarily on farms, and others invest across the value chain. Multiple firms emphasized the importance of creating partnerships in the investment community, across various sources of capital, to increase impact and address the entire value chain.

BARRIERS TO INVESTMENT

- Permitting is seen as the largest barrier to successful aquaculture in the US. Without consistency in the policy environment or coordination among agencies, only those with high amounts of capital and risk tolerance can invest in aquaculture production in the US.
- Financial institutions in the US lack the knowledge and experience that has been developed by investors and banks in other countries. They are hesitant when it comes to debt lending.
- Investors are very interested in the quality of the teams they invest in. However, the US lacks talent, skill, knowledge, and experience; there is a concerted need for workforce development. This is especially true because there is a lack of comparables in the market.



Figure 1. One firm's motivations for investing in aquaculture.

At a Glance: Types of Aquaculture Investment

There are several types of aquaculture financing summarized in the table below, with the most risk tolerant and lowest expectations of return on the left and increasing expectations of profitability on the right.

Grants	Program Related Investments	Angel Investors & Seed Capital	Venture Capital	Debt Financing	Public Markets & Private Equity
Philanthropic and government capital invested without any expectation of return (e.g., research, pilots etc.)	Philanthropic and government capital invested as debt with minimal expectations of return and favorable terms (e.g., foundation investments that tolerate very low rates of return, revolving loan funds). These investments may not require payment until an enterprise earns revenue and rates may be as low as 1-3%.	Angel investors are usually friends and family who invest in a relationship, with very patient capital and less guarantee of returns. Seed capital is the first source of funding, critical to startups, and often less than Venture Capital.	Capital invested in larger businesses, sourced from venture capitalists who raise the funds from their own internal pools of investors. Risk tolerance may be high, but expectations of rates and time to return may be fixed within an overarching investment strategy.	National, Regional, and Community bank lending. Require bankable assets and a favorable/informed banking community environment for aquaculture.	Once the business is established as consistently profitable investors may exit through several strategies like going public or acquisition by larger companies or private equity firms.

OPPORTUNITIES AND RECOMMENDATIONS

MITIGATE RISKS AND ADDRESS BARRIERS

- Assure private capital to reduce risk and create a more favorable environment for investment.
- Identify agriculture risk mitigation and stabilization tools that may be applicable for aquaculture markets in the US.
- Mobilize capital that is already assured via the creation of low interest loan programs from government sources or revolving loan funds.
- Advocate for policy changes to reduce regulatory burdens.
- Mobilize philanthropic capital to fill gaps.

INCREASE EDUCATION AND CONNECTIVITY

- Educate regional and national banks to create assurance around types of investment in aquaculture to increase debt lending and unlock working capital at low rates.
- Invest in building knowledge in the US.
- Support emerging thought leaders at the intersection of aquaculture and finance to drive engagement and understanding.
- Create a network of investors to address a broad portfolio of issues.
- Develop a set of principles to guide/ensure investments in aquaculture are sustainable.
- Educate consumers on the economic, health, and environmental benefits of locally caught seafood.

PILOT AND INNOVATE

- Use farms as testing platforms to drive technology innovation.
- Pilot aquaculture and marine energy co-location.
- Pioneer small-scale aquaculture in food insecure communities.

Commercial Fishing

Ocean Strategies (with support from Meridian) led 27 interviews with eighteen leading commercial fishing organizations, each representing a different fishing region of the United States. Key points from their research and interviews are highlighted below.

SUMMARY OF FINDINGS

BIG PICTURE VIEW OF THE COMMERCIAL FISHING SECTOR

- The commercial fishing industry is a regionally diverse and established economic and cultural sector of the United States. Fishing operations are typically categorized into seven regions of the country, with management and oversight from federal fishery councils -- the Western Pacific, North Pacific, Pacific, Gulf of Mexico, South Atlantic, Mid-Atlantic, and New England regions. Due to the historical, cultural, and economic influence the commercial fishing community has in the US, their voices are not only an essential element of the aquaculture conversation, but one of the first sectors that must be consulted when furthering federal aquaculture development.
- Commercial fishermen have a long history of defending fishing access from offshore development and regulatory restrictions. In the past few decades, threats to commercial fishing access have compounded. These issues include grounds closures and gear restrictions due to endangered species protections, loss of working waterfront access, rising costs of fishing operations, lack of younger generations entering and investing in the industry, effects of climate change on the ocean and harvested stocks, offshore wind development and conservation initiatives such as marine monuments. The addition of federal aquaculture development is one more issue that commercial fishermen must engage to ensure their ability to harvest effectively remains intact and whose livelihoods are not jeopardized. It is worth noting that many fishing groups in the US are not informed or fully engaged in federal aquaculture development due to the growing list of time critical concerns the commercial fishing industry must deal with. By nature, commercial fishermen are out on the water. Engaging with more and more policy discussions is difficult, and it can be expensive to hire professional representation.

OPINIONS ON FED VS. UNFED AQUACULTURE

- Commercial fishermen expressed general opposition to the development of offshore finfish (fed) aquaculture as many communicated the need for additional regulatory structures and scientific assessments before offshore finfish aquaculture expands. Some of the industry's deep-seated opposition to offshore finfish farming stems from direct experience with past events, such as the devastating economic impacts the farmed salmon industry had on the wild-capture sector in the 1990's, facility failures in Puget Sound, and the lack of accountability thereafter. In regions with extreme weather patterns, facility failures were also a common concern. Some commercial fishermen expressed concerns about ecosystems impacts from waste and feed. About half expressed neutrality towards offshore finfish expansion (if, and when, regulatory and scientific answers can be provided) as well as an agreed framework for fishermen to engage in the policy and permitting process. No one expressed full support of offshore aquaculture, but a few interviewees did express potential for mutually beneficial opportunities between wild capture and farm raised products. Many interviewees offered that aquaculture expansion in the United States is inevitable

and commercial fishermen “being at the table” is necessary. A few were doubtful that offshore aquaculture could expand due to financial, regulatory, infrastructure and other hurdles.

- Most of the industry is supportive of nearshore unfed aquaculture (mariculture). General support for the unfed aquaculture sector is due to the industry’s recognition of the environmental benefits of mariculture (unfed) practices, and many embrace the opportunity for commercial fishermen in declining fisheries to supplement their income by entering the industry. There is little concern about unfed aquaculture from fishermen who operate offshore because within these federal fisheries there exists no competition for grounds. Therefore, if offshore unfed aquaculture is pursued, this will open the door to opposition from this commercial fishing sector because of issues like ground conflicts, siting, and marine mammal interactions. Additional concern about whale entanglements or burdensome regulations were expressed (a common issue for commercial fishermen in California and New England) should offshore mariculture be developed and more lines in the water are present.

CLIMATE CHANGE AND OTHER ENVIRONMENTAL CONCERNS

- There is concern about climate change effects and the uncertainty of what future marine conditions will look like in areas open to aquaculture operations. As wild fish stocks are expanding and shifting it is hard to predict how fishing grounds will change. If aquaculture infrastructure is put in place and these waters prove to be prime fishing grounds in the future, this will cause problems for commercial fishermen who will need to rely on these new areas. Also, commercially harvested forage fish are used in aquaculture feed (among many uses) and these fishermen have strong economic ties to the aquaculture industry. As ocean conditions change and increased activity to protect domestic forage fish increase, fishermen expressed concern that the aquaculture industry may need to rely on larger quantities of other feed to grow the same amount of product.
- Many environmental concerns from the commercial fishing industry are shared by other groups. These concerns include disease and escape of farmed stocks due to aquaculture facility infrastructure failures, particularly net pens. Fishermen in regions that are prone to extreme weather conditions and natural disasters are especially concerned about the inevitability of facility failures. Also, fishermen illuminated that if a natural disaster occurred it could cause a ripple-effect of failures that would be catastrophic to their fisheries. Examples used were if an aquaculture facility failure occurred at the same time as the Exxon Valdez or BP oil spills. A full understanding how these effects could compound each other and impact wild-capture fisheries is not fully understood.

OUTREACH AND COMMUNICATION TO THE COMMERCIAL FISHING COMMUNITY

- Some fishermen expressed frustration on receiving biased information about aquaculture expansion efforts. Fishermen in New England spoke to wealthy landowners feeding misinformation or biased information to them, with the intent to “prop up” fishermen to speak out against aquaculture development. However, the reason behind opposition from coastal landowners is due primarily to the “not in my backyard” mentality, and frustration of infrastructure impacting vistas and views of coastal real estate rather than aquaculture operations infringing on traditional fishing grounds.
- Commercial fishermen recognize that federal offshore aquaculture development may be an inevitability, and therefore many accept the need and willingness to work toward a sufficient regulatory framework. However, one of the first steps in establishing these regulations is ensuring

commercial fishermen have a seat at the table. An issue of great concern is that fishermen are not being given the opportunity to provide input regarding aquaculture development to the extent that is needed. Prior to entering the formal state permitting process, a major aquaculture company on the East Coast conducts direct outreach to fishermen in the form of off-record meetings and personal phone calls. This outreach strategy could serve as a model for initial stakeholder engagement with aquaculture development moving forward. Additional concerns about fishermen's capacity to engage while fishing and the expense to hire professional assistance were expressed. It is imperative that aquaculture developers not only provide for this opportunity, but they learn how to effectively communicate with the commercial fishing industry and consider the historical knowledge that fishermen hold.

OPPORTUNITIES AND RECOMMENDATIONS

CONSIDER COMMERCIAL FISHING ACCESS CONCERNS

- Take commercial fishing grounds into consideration when siting aquaculture operations and developing Aquaculture Opportunity Areas. NOAA aquaculture siting plans must incorporate on-the-water observations, historical knowledge, and electronic monitoring data from fishermen.

FORM A ROBUST REGULATORY FRAMEWORK WITH FISHERY STAKEHOLDER PARTICIPATION

- Address regulatory uncertainties and establish NOAA as the lead agency in federal aquaculture development, with regional fishery management councils providing oversight. Fishermen are familiar with their regional council processes and so concerns and input should be taken at this level.
- Form an advisory panel at the council level, consisting of fishermen stakeholders that provide input on aquaculture regulation. This will not only better inform aquaculture decisions but will lead to greater engagement from the fishing community. The fishing leaders that serve on this panel can relay the issues and information to their respective fishing representative groups.
- Include a state opt-out provision for offshore aquaculture development. The state opt-out provision was included in the first draft of the AQUAA Act but taken out of the most recent legislation — an enormous concern for North Pacific fishermen especially. One North Pacific fisherman did not want a special carve-out only for Alaska, but that any state could opt-out should they wish.

ENSURE THOROUGH PREVENTION AND INDEMNIFICATION PLANS FOR AQUACULTURE DEVELOPMENT

- Increase focus on the prevention of negative impacts of aquaculture facilities and more consideration for remediation and mitigation. The indemnification models being used for offshore wind development or for oil and gas exploration could be used for aquaculture development as well.
- Consider liability insurance policies, taken out by aquaculture operators, in the amount of median revenue generated by local fisheries these facilities will affect. This would be in lieu of negotiation

compensatory mitigation after negative impacts have occurred and provide certainties for all parties.

IDENTIFY MUTUAL BENEFITS FOR THE COMMERCIAL FISHING AND AQUACULTURE COMMUNITIES

- Create a national seafood marketing campaign to improve consumer education and awareness of both wild-capture and farmed seafood and increase domestic seafood consumption overall. This campaign must include information about wild species sustainability and ensure more robust seafood labeling. Increasing awareness of seafood generally will help consumers exercise their own choice between farmed and wild seafood.
- Finance working waterfronts and coastal infrastructure improvements with aquaculture development. In some fishing regions working waterfronts do not have sufficient resources to support fishing operations. Aquaculture infrastructure may be used to supplement and help these waterfronts, which are vital to functioning food systems and supply chains.
- Invest in advancing nearshore unfed aquaculture with incentives, such as experimental lease programs, for commercial fishermen to enter the industry to supplement and diversify fishing income. In fishing areas with a rapidly growing unfed aquaculture sector, like Alaska, some interviewees requested an AOA expansion in state waters. This would bring in federal financial assistance to contribute to industry growth and to provide further research opportunities for unfed aquaculture. Areas in New England and the Gulf of Mexico are seeing a surge in mariculture development and these industries can complement wild capture fisheries and supplement fishermen's incomes while improving ecosystem health.
- Conduct a thorough market analysis to determine how farmed seafood will affect the wild harvest seafood market. This will allow commercial fishermen to better plan for these impacts. Use analysis from farmed salmon as an introduction, and expand to other nationally and internationally farmed products to fully understand the complex threats and opportunities to markets.

Seafood Supply Chain

Ocean Strategies (with support from Meridian) led 11 interviews with seafood supply chain industry organizations, seafood processors, distributors, and grocers to understand what actors of different types think about aquaculture, how they make decisions about aquaculture products, and how aquaculture products affect their business. Key points from their interviews are highlighted below.

SUMMARY OF FINDINGS

PERSPECTIVES ON AQUACULTURE

- The seafood supply chain's impression of aquaculture was influenced by three main factors: regional influences on seafood sourcing, trends in consumer seafood demands, and opportunities to diversify risk in the seafood supply chain with aquaculture. These dynamics drive how they shape and consider aquaculture products in their businesses and for the customers they serve.
- Overall, seafood supply chain companies expressed that wild-caught and aquaculture products complement one another in the market. There are some consumers who are willing to pay a premium price for domestic, wild-caught seafood, and others who are looking for the lowest cost and best value, which aquaculture can provide (although this is often an imported product). Seafood retailers are not interested in "choosing sides" between wild-caught and aquaculture seafood products, so as not to alienate their suppliers or customers.
- Aquaculture can help create a stable supply of seafood products. There is a limit to the amount of wild product that can be produced due to fishing quotas, and aquaculture can help reduce seasonality of supply, increase the overall amount of seafood available to consumers, create more stability in seafood prices, and increase the diversity of seafood products available to consumers. These factors help distributors reduce their supply chain risks.
- Some seafood companies expressed concern that aquaculture products could over-saturate markets for some seafood products (e.g., salmon), especially once farms refine their farming techniques and further scale production.
- Aquaculture companies have different advantages than wild-caught fisheries in marketing seafood products. Aquaculture farms have significant control over product quality as compared to wild-caught counterparts and can therefore market their product's unique attributes (e.g., taste, consistency). Aquaculture products are also more easily traceable to the source. Some aquaculture companies are also creating unique narratives around recirculating aquaculture systems and the advantages such systems offer (e.g., potential for beneficial reuse of abandoned buildings, fresh products close to market).

TRENDS IN SEAFOOD PURCHASING DECISIONS

- Seafood retailers have limited staff, meaning that staff time is allocated to purchasing critical seafood items (e.g., tuna, mahi mahi), and generally buy direct, frozen, high-volume seafood products (e.g., sockeye and coho salmon, cod). Retailers often prefer large volume opportunities for fresh fish, as opposed to smaller farms that ship infrequently. Retailers also often prioritize seasonal seafood products to offer greater diversity and avoid food fatigue among consumers. Shelf space is a primary determinant of how many seafood products a retailer can offer.

- There is consistent, increased consumer demand for both wild and farmed seafood products. Seafood is one of the fastest-growing departments in a retail grocery store. Increases in seafood consumption during the COVID-19 pandemic have been attributed to meal fatigue (i.e., consumers looking to try new foods and cooking experiences).
- There are significant regional differences in how seafood distributors and retailers make seafood purchasing decisions. In some areas, where wild-caught seafood is part of the local culture (e.g., Pacific Northwest & Alaska), there is strong regional opposition to aquaculture, which influences purchasing decisions. In other regions (e.g., the Midwest), price is a much greater factor in seafood sourcing.
- Ultimately, consumer demand drives the seafood supply chain. Taste, price, and health are the major consumer motivations for purchasing seafood products. Consumer purchasing of wild and farmed seafood products is primarily based on availability, and there was no discernable shift seen, recently, in consumer demand between wild and farmed seafood products.
- The target customer of many seafood companies is a higher-income, more highly educated, health-conscious person, who are often women or older individuals. These customers are often willing to pay more for fresh, artisanal, and/or local products, and are not looking for the cheapest products at the grocery store. Aquaculture companies are tapping into current market trends where these consumers are looking for increasingly local, healthy, and sustainably produced products, as well as substitutes to land-based meat proteins. Specialty seafood companies buy seafood sourced from both regional wild fisheries and regional aquaculture operations to provide the “local seafood” experience to consumers. That said, price-conscious shoppers are also a core contingent of seafood consumers, as farmed (and often imported) products are some of the highest selling seafood items in the U.S.
- While not the most highly ranked consumer motivator, seafood sustainability is also important to consumers and a major concern for retailers. Most retailers have visible communications about seafood policies, and many require the products they purchase to have sustainability certifications or benchmarks. In many cases, aquaculture products are easier to track and certify as sustainable, since their point of origin is clearer. There is less scrutiny of sourcing details for domestic, wild-caught seafood, and heavy reliance on certifications for imported, wild-caught products.
- Sustainability certifications for aquaculture farms only exist at the farm-level, rather than the ecosystem-level, raising concerns that certification schemes do not measure the cumulative impacts of aquaculture farms.

ELEVATING OVERALL SEAFOOD CONSUMPTION

- The seafood supply chain is interested in increasing overall seafood consumption and sees two major opportunities to do so: attracting new consumers to eat seafood and expanding the palate of existing seafood consumers to incorporate new seafood products.
- Point-of-sale interactions (i.e., at seafood counters) and digital engagement tools are essential education points for consumers. Consumers ultimately decide to eat when at the store and learn the most through direct conversation. Digital engagement (e.g., recipes on social media, video tutorials) complements in-person education by meeting consumers where they are at and acknowledging that people are on their phones while shopping and engaging with food.

OPPORTUNITIES AND RECOMMENDATIONS

BRING THE RIGHT STAKEHOLDERS TOGETHER

- Develop more liaisons between the aquaculture and commercial fisheries industries to identify win-win opportunities for expanding both sectors in tandem.
- Convene seafood supply chain roundtables to bring together processors, distributors, retailers, and restaurants to discuss the dynamics around the current and future status of aquaculture and other seafood policies and initiatives in the U.S.

FIND COMMON GROUND

- Develop a consolidated seafood marketing campaign—inclusive of both wild-caught and farmed species—to provide uplift for the overall seafood industry, rather than focusing on the differences between wild-caught and farmed products.
- Leverage one's position in the supply chain to break down areas where regionality may be hurting rather than helping the seafood industry.

MARKET AQUACULTURE PRODUCTS STRATEGICALLY

- Continue taking advantage of trends that have contributed to the growth in seafood sales. This includes considerations of product presentation and packaging (e.g., skin packing), along with certifications and labels that increase consumer trust in products.
- Address consumer concerns and hesitations surrounding farmed seafood, particularly considering growing consumer interaction with aquaculture products. Considerations include safety in product consumption, point-of-purchase education, perceptions of price, and sustainability.
- Grow the aquaculture industry by prioritizing product diversification to avoid oversaturating markets. Entities at the “end” of the supply chain (e.g., retailers, restaurants) can help assess and communicate demand to aquaculture suppliers to avoid market disruptions.

CONTINUE AND EXPAND THE CONVERSATION

- Enhance conversations both within the seafood supply chain and between the aquaculture industry and the supply chain, particularly in light of aquaculture companies starting to vertically integrate operations (and thus work outside of the traditional supply chain).



Recreational Fishing

Meridian led 11 interviews with anglers, charter captains, gear manufacturers, and regional and national recreational fishing associations. Key points from our research and interviews are highlighted below.

SUMMARY OF FINDINGS

BIG PICTURE VIEW OF THE RECREATIONAL FISHING SECTOR

- Recreational fishing is composed of multiple types of groups including gear manufacturers, fishing charters, private anglers, and associations that represent each of these subsets. Due to the recreational fishing community's economic value and presence on the water, their voices are an essential element of the aquaculture conversation.

VARYING PERSPECTIVES ON AQUACULTURE

- Recreational fishers fall into three primary categories on offshore fed aquaculture: openly supportive of aquaculture, cautiously open to aquaculture because they view it as inevitable, and adamantly opposed to aquaculture. They are generally supportive of nearshore unfed aquaculture and proponents of its environmental benefits. Most private anglers and some associations have not spent considerable time forming an opinion on aquaculture and the community is far more concerned about other conflicts that they perceive as more immediate, including offshore wind, than they are about aquaculture.
- Recreational fishers who are either in favor of aquaculture or cautiously optimistic about it consider some positive benefits of fed aquaculture including the potential for augmentation of depleted stocks and decrease of conflict with commercial fishermen. Even those who expressed opposition to fed aquaculture were largely in favor of well-managed unfed aquaculture.
- Recreational fishers expressed concerns, including that aquaculture might infringe on the access to and opportunity within fishing grounds, that net pen infrastructure could decrease safety of recreational fishing routes, and that infrastructure would not be durable enough to withstand superstorms. Those who were in favor of offshore fed aquaculture shared these concerns but believed they were mitigable, while those against offshore fed aquaculture did not see ways to overcome these concerns.
- Recreational fishers echoed many concerns that other sectors shared about aquaculture, including invasive species, genetic modification, escapement, disease, impacts on forage fish populations, and habitat impacts. Some believed these concerns could be mitigated or avoided while others saw them as insurmountable barriers.

COMMUNICATION AND ENGAGEMENT WITH RECREATIONAL FISHERS

- Recreational fishers depend on state and local agencies, their associations, and word-of-mouth to get information. Broadly speaking, there is not a lot of interest in the community for learning more about the aquaculture industry and the impacts of aquaculture, until and unless it is likely to affect access to fishing. This is especially true for those who engage in recreational fishing as a pastime and not an occupation.

- Potential avenues to drive effective engagement include engaging through social media and websites, information-sharing at docks, through fishing talk shows, and fishing forums, and spreading the word through fishing groups, state agencies, and ports. Federal processes, such as public forums, may be less effective than more bottom-up processes.

OTHER CONSIDERATIONS

- Anglers, charters, and associations alike considered offshore wind to be a far more pressing concern than aquaculture. A couple fishers felt that offshore aquaculture development could learn from offshore wind by incorporating stakeholders into earlier conversations.
- Pilots could be a promising way to prove aquaculture on a small scale and alleviate concerns of the recreational community. Transparency of funding is paramount. Collaboration with academic institutions and community education programs can build trust and engagement.

OPPORTUNITIES AND RECOMMENDATIONS

ADDRESS ACCESS, SAFETY, AND ENVIRONMENTAL CONCERNS

- Take recreational fishing grounds and navigational pathways into consideration when siting nearshore unfed and offshore fed aquaculture and developing Aquaculture Opportunity Areas.
- Target recreational fishermen for up front consultation in specific areas where aquaculture development is being considered.
- Ensure navigation and safety concerns are allayed through working with the Coast Guard.
- Allow recreational fishing close to aquaculture pens where possible and safe.
- Require disaster preparedness plans and minimum standards for pen durability.
- Address public statements made by fishing groups to avoid detrimental environmental impacts.
- Emphasize the ecosystem services, coastal resiliency, and environmental co-benefits of unfed aquaculture and working with recreational fishermen to develop unfed aquaculture where possible.
- Invest in development of alternative fish feeds to preserve forage fish species and clearly communicate intention for how finfish will be fed.

MAXIMIZE BENEFITS FOR THE RECREATIONAL COMMUNITY

- Explore the feasibility of pairing offshore fed aquaculture for protein with restocking programs.
- Pair aquaculture development with other benefits for recreational fishermen, including dredging and access to channels (particularly in smaller ports and emerging harbors) and shoreside infrastructure and access points.

IMPROVE COMMUNICATION AND INCLUSION OF RECREATIONAL FISHERS

- Utilize state agencies to communicate with anglers and charter operators.
- Collaborate with national groups to ensure recreational fishers feels as though they are being brought along in the process rather than being left out.
- Prove aquaculture can be done safely in a pilot or small area before scaling. If successful, utilize recreational fisher networks to spread information about proper aquaculture execution.
- Address regulatory uncertainty.

Environmental Non-Governmental Organizations

Meridian engaged nine environmental non-governmental organizations (ENGOS) that are working (or have historically worked on) aquaculture domestically and/or internationally to understand their perspectives on the future of aquaculture in the U.S. and approaches to engaging in domestic policy discussions. Meridian then convened several meetings of the ENGO community to explore challenges, developments, and opportunities associated with offshore aquaculture, and five subsequent “Deep Dive” sessions to explore in detail the group’s environmental concerns, potential benefits of aquaculture, and current research. High-level takeaways from this engagement of the environmental ENGO community are highlighted below.

SUMMARY OF FINDINGS

ENGAGEMENT ON AQUACULTURE ISSUES

- **Focus on international aquaculture:** ENGOS we interviewed working on offshore aquaculture have initiatives that are, currently, mainly, or entirely focused on aquaculture outside the United States. This is due in part to the fact that aquaculture development in some locations outside the US poses more immediate environmental threats than the less developed domestic aquaculture space, and therefore receives more attention from the ENGO community. Since the complex offshore aquaculture regulatory structure in the US has essentially closed federal waters to aquaculture development, many ENGOS are not engaging actively on domestic aquaculture, since there is no perceived, active environmental threat.
- **Aquaculture programs:** ENGOS working on aquaculture have varying scopes of work and focus areas. Areas of focus for different ENGOS include improving management of aquaculture operations; mitigating risk through financial tools; siting of aquaculture operations to provide ecological benefits; developing governance indicators to assess the industry; sustainability certification and traceability; and understanding consumer perceptions and trends in aquaculture product consumption.
- **Public opinion:** Low levels of public support for aquaculture and low overall consumption of seafood in American diets are barriers for some ENGOS to engage on domestic aquaculture. The widely publicized, accidental release of thousands of farmed salmon in Washington in August 2017 engendered public concern regarding the risk farmed salmon pose to native salmon. In addition, some NGOs noted that not enough Americans eat large enough quantities of seafood to justify the development of a domestic, offshore aquaculture industry. It was suggested that a shift in American diets replacing some land-based animal protein consumption with increased seafood consumption, would be required to garner the political will for offshore aquaculture development to move forward.
- **Opportunities for U.S. leadership:** ENGOS already interested in the opportunity for engaging domestically on aquaculture pointed out that, should the United States decide to proceed with legislative approaches to regulating aquaculture comprehensively, there is an opportunity to assume international leadership and set thoughtful, science-based standards that could be exported to other countries. There is a need, however, to avoid a scenario in which the US sets such stringent regulations that all operations move abroad, and America continues to export the environmental costs of its resource consumption.

PERSPECTIVES ON AQUACULTURE: CONCERNS AND OPPORTUNITIES

- **Fed and unfed aquaculture:** In discussions with ENGOs, a prominent dichotomy emerged between unfed aquaculture (shellfish and seaweed) and fed aquaculture (finfish). Some ENGOs feel that policy should address these segments of the industry differently because of the different impacts of fed and unfed aquaculture. Shellfish and seaweed farms have a relatively low environmental impact because growth requires few-to-no inputs, and may even provide environmental quality benefits, such as improving water quality, sequestering carbon, providing fish habitat, and contributing to species diversity. Finfish have higher inputs and feed requirements, therefore potentially posing a greater threat to water quality and ecosystem sustainability. Finfish escapements may also pose a greater threat to wild fish stocks, since only native shellfish are utilized in aquaculture. However, other ENGOs point out that finfish are the preferred fish of American diners and US markets for shellfish are limited. Excluding all finfish aquaculture from federal waters would cede a large market to foreign businesses, over which the United States has no regulatory control.
- **Environmental concerns:** ENGOs have many concerns about the environmental impacts of aquaculture development. Primary areas of concern include the environmental impacts of fish feed, aquaculture's impacts on marine life, including potential entanglement with marine mammals, aquaculture's potential water quality impacts, and aquaculture siting and interaction with other ocean uses. At the same time, it was noted that some scientists would consider the current state of information adequate to address aquaculture's environmental risks by instituting best management practices.
- **Opportunities for climate adaptation and human health:** While mitigating risks of aquaculture development is important to achieving sustainable outcomes, many ENGOs also recognize the potential for positive impacts. The potential for creating positive economic impact, revitalizing working waterfronts, and supplying protein that is much less carbon intensive than traditional agricultural sources are among the most cited potential benefits of aquaculture.
- **Economics and scale:** There is tension inherent in the need to address global sustainability challenges with development that has local impacts. A fundamental question raised by several interviewees was the tradeoff inherent in the scope and scale of aquaculture development. As the scale of aquaculture development increases, its environmental footprint and the environmental risks expand. However, large scale aquaculture is exactly what some governments and organizations have called for to address pervasive food security needs in a manner consistent with global emissions reductions goals. The point at which aquaculture development becomes too large and risky is up for debate and weighs heavily on how the United States will choose to promote or continue to restrict aquaculture in its federal waters.
- **Disagreement on the state of the science:** ENGOs expressed varied opinions regarding whether there is currently enough technical expertise and scientific evidence to successfully conduct and regulate an offshore aquaculture industry in a sustainable manner. Some believe we can move forward in a stepwise but prudent fashion and others favor a more cautious approach that prioritizes filling perceived data gaps (e.g., marine mammal entanglement).

OUTSTANDING QUESTIONS

NGOs have many outstanding questions related to the future for aquaculture in the United States, including the questions highlighted below.

ENVIRONMENT

- How far has science come in addressing the environmental risks and impacts of aquaculture? What are the leading best management practices?
- How could aquaculture standards and best practices be actualized through the development of regulatory structure for aquaculture?
- What is the carrying capacity for ocean ecosystems to support aquaculture, especially in fed, open-ocean operations?
- How large of an impact on biodiversity is acceptable?
- How will climate change and increasing ocean temperatures affect aquaculture development? What potential is there to think proactively about this (e.g., are there risks to not developing aquaculture as a food/economic development source in the face of changes to wild fisheries)?

SOCIOPOLITICAL DYNAMICS

- What is the true potential for the sociopolitical benefits of aquaculture, such as food security and community resiliency?
- What are the predominant perspectives and attitudes within the commercial fishing community about the potential expansion of aquaculture development in the US? What impacts are most concerning and is there also an interest in potential benefits?
- How could a regulatory structure best engage fishermen? Could structures from the Magnuson Act, such as fishery management councils or plans, be utilized to inform aquaculture siting and permitting? Or could something akin to these structures be created specifically for aquaculture?
- What is the relationship between the development of domestic aquaculture and food security, since domestic offshore aquaculture may focus on luxury seafood products for the US market?
- What is the relationship between offshore wind and aquaculture siting? In thinking about the future use of ocean space, can we proactively identify benefits or regulatory challenges to co-siting or co-management of these possibly competing offshore ocean uses?

ECONOMICS

- Are the ecosystem constraints inherent in permitting sustainable, low-density offshore finfish aquaculture consistent with economically viable business models that require large scale operations to be profitable?
- What are the comparative advantages of different types of aquaculture development in the U.S. compared to other countries? Could bivalves have the highest comparative advantage, because growing and regulating them in the US could alleviate food safety concerns associated with importing products from a less stringent regulatory market?
- How will domestic seafood demand influence the development of aquaculture?