EXPANDING OREGON'S AQUACULTURE INDUSTRY

A report prepared for Oregon Aquaculture Association

May 2023

Zehra Siddiqui, Brady Anderson, Evan Ashe, Breanna Murrin

Acknowledgements

Our team would like to thank our client, Oregon Aquaculture Association, for the opportunity to create this report with special thanks to Dr. John Moehl and Professor Gil Sylvia for their invaluable insight and continued support. Their passion for creating a thriving and sustainable aquaculture industry was inspirational and a motivation for our team.

This capstone would not have been possible without the guidance of our Evans School Faculty Advisor, Dr. Grant Blume. His advice was critical to enhancing the design and development of the research and drafting of this report. Dr. Blume's mentorship elevated our work and strengthened our team's strategy and dynamics.

We would also like to thank Xavier Ajeto for his thoughtful review of our paper. Xavier's feedback improved our final product and we are grateful for the attention to detail he provided.

We extend gratitude to all the aquaculture producers and business leaders that generously gave their time to provide their expertise and reflections in our interviews. These shared experiences have been vital to developing informed recommendations to expand the aquaculture industry.

Finally, we acknowledge the Coast Salish peoples of this land, the land which touches the shared waters of all tribes and bands within the Suquamish, Tulalip and Muckleshoot nations.

Contents

Abbreviations

BMPs – Best Management Practices

DMR – Department of Marine Resources

DLCD – Oregon Department of Land Conservation and Development

EPA – Environmental Protection Agency

MVD – Montana Motor Vehicle Division

MSP – Marine Spatial Planning

NAA – National Aquaculture Association

NAO – North Atlantic Oscillation

NOAA – National Oceanic and Atmospheric Administration

NEPA – National Environmental Policy Act

NPDES – National Pollutant Discharge Elimination System

OAA – Oregon Aquaculture Association

OAAG – Oregon Aquaculture Advisory Group

ODA – Oregon Department of Agriculture

ODFW – Oregon Department of Fish & Wildlife

OSU – Oregon State University

PCSGA – Pacific Coast Shellfish Growers Association

PRV – Piscine Orthreovirus

RAS – Recirculating System

SFA – Sustainable Fisheries and Aquaculture

SPRS – Seafood Processors

USDA – United States Department of Agriculture

HACCP – Hazard Analysis Critical Control Point

WRAC – West Regional Aquaculture Center

Glossary

Adaptation

Refers to adjustments in ecosystems, social systems, or economic systems in response to climate change and its effects.

Aquaculture

The breeding, raising, and harvesting of shellfish, finfish, and the husbandry of aquatic organisms.

Aquaponics

Refers to the combination of aquaculture and hydroponics to use the waste produced by aquatic animals to supply nutrients for plants to mimic a natural ecosystem.

Carbon Mitigation

The efforts to reduce and prevent further emissions of greenhouse gases. Involves adjusting to actual or expected future climates to prevent planet from warming further.

Estuary

A body of water with one or more freshwater rivers or streams meets the ocean, creating a partially closed area of brackish water. Provide habitat for nearly 68% of US commercial fish catch and 80% of recreational catch.

Fish Hatchery

Establishment created for the artificial breeding and hatching of finfish and shellfish in the early life stages.

Finfish

Any species of fish with cartilage and/or bone. Examples include salmon, trout, tilapia, bass, sturgeon, and eel.

Freshwater

Refers to a body of water that is inland with a low salt concentration. Examples include catfish and trout.

Hydroponics

A method of growing plants without soil, where nutrients are directly supplied to the plant roots through a nutrient-rich water solution. The plants are typically grown in a soilless medium that provides support for the roots while allowing them to absorb water and nutrients.

Invasive Species

Refers to any non-native organism (plant, animal, or microbe) that has been introduced to an ecosystem with potential to cause harm to the environment, economy, or human health.

Ocean Acidification

A process that occurs when carbon dioxide from the atmosphere dissolves in seawater, forming carbonic acid, leading to a decrease in pH of the ocean. Linked to other issues, such as climate change, and can lead to changes in ocean circulation, oxygen levels, and nutrient availability.

Oregon, Department Oversight of Commodity Commissions

All 23 commodity commissions operate with oversight from the Oregon Department of Agriculture. The ODA Director appoints all commissioners and also reviews and authorizes each commission's budget annually.

Saltwater

Refers to the water from bodies of water with high salinity such as the ocean, as well as in saltwater lakes.

Shellfish

Refers to a group of aquatic invertebrates with an hard external shell or exoskeleton to provide protection for their soft bodies. Can be found in both saltwater and freshwater environments. Includes various species of mollusks, such as oysters, clams, mussels, and scallops, as well as crustaceans, such as crabs, lobsters, and shrimp.

Wetland

Areas where the water table is close to or above the soil surface, creating a saturated or flooded environment. Can include marshes, swamps, bogs, and fens. Often located at the transition between land and water.

Executive Summary

Oregon has a long history of aquaculture, and currently produces roughly $24 million in output from a mixture of saltwater and freshwater farms. Unfortunately, Oregon's aquaculture output lags its neighboring states. This report seeks to investigate this poor performance with three research questions:

1. What are key barriers to the U.S. aquaculture industry that prevent expansion?
2. What barriers disproportionately affect Oregon's aquaculture industry?
3. What are strategies Oregon's Department of Agriculture can deploy to overcome these barriers?

To address these questions, our team conducted a literature review which included academic papers, government websites and reports, agency financial statements, and news articles. The literature review focuses on Oregon but also includes information on U.S. aquaculture more generally in order to study our first two research questions. Our team then interviewed seventeen aquaculture producers from seven different states including Oregon. The states were chosen using criteria based on the amount of aquaculture production and geography and specific producers were selected by convenience and snowball sampling. We used the transcripts from the interviews to examine the different barriers aquaculture producers face, as well as some of the possible solutions to these barriers.

We found in both the literature review and the interviews that the barriers to aquaculture expansion in the United States fall under four broad categories: business dynamics, permitting and regulations, market, and public perception. Oregon producers face the same hurdles as other producers in the United States and producers revealed particular difficulty in acquiring initial funding, navigating permitting, and having enough business and management capacity. Other states have taken measures to mitigate these barriers which have resulted in healthier aquaculture industries compared to Oregon.

Our team came up with five possible strategies that ODA could implement to address these barriers to aquaculture. These strategies were drawn from both the literature review and from the interviews of producers in other states. The five potential strategies are:

- One-stop-shop
- Aquaculture Commodity Commission
- Market Access Expansion
- Marine Spatial Planning
- Information Campaign

The criteria we used to judge these strategies include cost, implementation period, risk to ODA, farm size advantage, and gender and race equity. Our group sees all of the strategies as useful and worth pursuing but recommends that ODA first start by advocating for an Aquaculture Commodity Commission and then work with the Commission to develop an Information Campaign. Targeting these two strategies will pave the way for the others and demonstrate ODA's commitment to expanding aquaculture in Oregon.

Chapter 1: Introduction

1.1 Background

Aquaculture is an industry where farmers use a partially-controlled or fully-controlled environment to raise and harvest aquatic species for consumption (National Oceanic and Atmospheric Administration, 2023). In 2019, aquaculture in the United States was valued at 1.5 billion USD, producing 658 million pounds of product annually (Office of Aquaculture, 2022). Aquaculture accounts for 7% of U.S. seafood production, which experts at the United Nations say will need to increase to supplement caught seafood in an increasingly food insecure population (Office of Aquaculture, 2022). Aquaculture products include shellfish, finfish, marine plants, and other aquatic organisms. These products can be grown or cultivated in a variety of ecosystems including marine, estuarine, and freshwater. Aquaculture products can differ significantly by location and countries or states often focus on a particular kind of aquaculture that best meets the needs of the environment and the demands of the market.

Currently the Atlantic Coast is the largest aquaculture producer in the United States, followed by the Pacific Coast and then the Gulf Coast (Office of Aquaculture, 2022). The U.S. Pacific Coast has ample resources to increase aquaculture production but will need to input further investments to keep up with growing demand both domestically and abroad. On the Pacific Coast, Washington and California substantially outperform Oregon in aquaculture production, with a large portion of all three states' aquaculture coming from shellfish (Perdue & Hamer, 2018). Oregon's aquaculture resulted in $24 million of sales and consists of 40 farms, 25 of which were freshwater and 15 of which were saltwater (Perdue & Hamer, 20). Oregon's significant coastline and varied ecology should make it well-positioned as a leader in aquaculture output among U.S states. Unfortunately, Oregon lags many states which are smaller or landlocked, in the percent growth of both total aquaculture output and number of farms (Perdue & Hamer).

Some proposed reasons for Oregon's lagging aquaculture industry include permitting and regulatory burden, difficulties with supply chains, environmental pushback on open water aquaculture, and lack of consumer demand. Many of these possible barriers are not specific to Oregon, but some of them may be disproportionately affecting Oregon.

1.2 Research Questions

Given the uncertainties behind why Oregon lags its peer in aquaculture production, our research questions are as follows:

1. What are key barriers to the U.S. aquaculture industry that prevent expansion?
2. What barriers disproportionately affect Oregon's aquaculture industry?
3. What are strategies Oregon's Department of Agriculture can deploy to overcome these barriers?

As well as these primary research questions, we are also interested in two sub-questions:

1. What amount and type of assistance do other states' Departments of Agriculture give to aquaculture producers in those states?
2. What are the different barriers, if any, faced by smallholder aquaculture vs larger scale aquaculture farmers?

1.3 Client Objectives

The Oregon Aquaculture Association (OAA) was established in 2004 with the goal of expanding information on the development of sustainable aquaculture (Oregon Aquaculture Association, 2023a). The OAA encourages scientific research, promotes the public's aquaculture knowledge, and supports legislation that fosters aquaculture growth. The OAA has also helped develop an online library and mapping tool used to make learning and investing in Oregon aquaculture easier called the Oregon Aquaculture Explorer Platform (OSU Libraries and Press & Institute for Natural Resources, 2023). The OAA is also assisting in elaborating a strategic plan with the Oregon Department of Agriculture and other agencies and stakeholders aimed at expanding the aquaculture industry in the state. Given commonalities in barriers to aquaculture expansion, this strategic plan could also be useful to inform aquaculture programs in other states. The goal of this report is to provide the OAA with analysis and possible recommendations that could be useful in developing such a strategic plan.

1.4 Report Outline

Chapter 2: Research Methods outlines our procedure for attempting to answer the stated research questions. This includes semi-structured interviews with aquaculture producers.

Chapter 3: Literature Review examines previous literature on the aquaculture industry both in Oregon and in the United States more broadly. We also investigate aquaculture laws and regulations, as well as any specific reports on how aquaculture output can be increased.

Chapter 4: Findings covers the information collected from the 17 aquaculture producer interviews. This information is separated into themes corresponding to the barriers found in our literature review.

Chapters 5: Strategies highlights strategies and implementation considerations that the Oregon State Department of Agriculture could carry out to address the barriers to aquaculture.

Chapter 2: Research Methods

Our research plan began with a comprehensive literature review that developed our understanding of Oregon's aquaculture industry and the unique barriers its producers face. We then administered semi-structured interviews to producers in Oregon and six other states which were chosen using methods listed in section 2.2. Producers also responded to a demographic survey which gave us information that is presented in Appendix C.

2.1 Literature Review

Our initial phase of research began with conducting a literature review focused on addressing our first two research questions:

- ***What are key barriers to the U.S. aquaculture industry that prevent expansion?***
- ***What barriers disproportionately affect Oregon's aquaculture industry?***

Within the literature review, we examined a body of information from government agencies, academic publications, and news articles to understand national aquaculture barriers, Oregon's aquaculture industry, and current barriers for expansion. We also studied the agencies involved in regulating Oregon's aquaculture industry as seen in Table 2 on page 20.

We then reviewed the performance of other states that produce aquaculture products and created in-depth profiles for the top five states that showed highest growth between 2013 and 2018, including New Hampshire, Indiana, Colorado, Wyoming, and Maryland. Profiles compare states' aquaculture sales, number of farms, and production techniques. We then looked at previous legislation such as the Clean Water Act (1972) and reports from the EPA and NOAA to uncover general challenges to aquaculture expansion in the United States. These sources described how barriers in place around regulations, public opinion, production costs, and climate change contribute to the slow growth of the United States aquaculture industry compared to the average global rate, as discussed in depth in section 3.2 on page 22.

2.2 Semi-structured Interviews

We conducted interviews with producers across the nation to further reveal barriers to U.S. aquaculture and their disproportionate effects on Oregon's aquaculture industry. Our interview candidates came from recommendations by Oregon Aquaculture Association and producers themselves. To broaden our scope, we also began contacting Aquaculture Associations and Sea Grant Networks from various states based on specific criteria. Criteria that maximized diversity of producers and environments while also sharing properties to Oregon's aquaculture industry were selected by the team. The states we included in our interview pool met the following criteria:

- Has an Aquaculture Association or Sea Grant
- Has both saltwater and freshwater farms
- Has more than five saltwater farms
- Is located on the coast

We then split the states that met the criteria into four quartiles that were based on the growth in the number of aquaculture farms between 2013 and 2018. Splitting states into quartiles ensured we would get interview responses from low, medium, and high-performing states. The team then selected a state from each quartile to create three tiers of five states each for us to reach out to. Tiers were developed to include geographic diversity among states. When we did not get responses from states, we continued to move to the next tier until we had a sufficient number of responses to work with. As interviews continued, we used snowball sampling to broaden our interview selection by asking producers to help identify additional candidates (Johnson, 2014).

All interviews were conducted virtually on Zoom in a semi-structured format and lasted approximately 45 minutes. Producers were made aware that their interview would be recorded and transcribed before starting and were also introduced to the purpose of our research and their role. The semi-structured format of the interviews allowed us to guide producers with open-ended questions that covered complex processes and personal stories (Johnson, 2014). We created an interview guide that grouped our questions into five separate categories, as listed in Appendix B. Our interviews began with general questions regarding barriers and expansion before going into questions on policy, markets, culture, and strategy. The interview guide was designed to address our initial research questions and was modeled after guides from previous aquaculture producer interviews (Ward et all, 2022). After each interview, we asked producers to complete a demographic survey through Survey Monkey before conducting an in-depth analysis of our results. The demographic survey was sent solely to producers and comprised of eight questions, as seen in Appendix A. The first five questions were identity profile questions ranging from topics of identifying race to identifying sexual orientation. The last three questions asked producers questions about their current production processes. These high-level questions allowed us to save time during our actual interviews and compile results to create profiles for the producers our team interviewed. In-depth interview guides are listed in Appendix B.

2.3 Analysis

Interview Analysis

We ultimately conducted interviews with 17 producers from 7 states, as seen in Table 1. We started by reviewing the generated transcription from Zoom's software and replaying each interview manually to ensure accuracy. Our team generated a list of barriers and factors that producers indicated were impacting their production (Ward et all, 2022). To maintain consistency throughout our analysis, our team appointed two members to conduct interviews and two to conduct transcription review for themes.

Table 1: Number of Producers by State

State	# Of Respondents
Alaska	2
California	1
Maine	3
Maryland	1
Virginia	1
Washington	4
Oregon	5
Total	17

Interview Coding

We used an open thematic coding approach to analyze the interviews our team conducted. Thematic coding allowed us to develop a general framework for analyzing the data rather than a closed coding approach that limited us to a specific codebook (Johnson, 2014). To reduce bias in coding, two members of the team were the sole participants in the coding process to determine common themes.

Demographic Survey Analysis

We analyzed survey results to look at trends and identify the types of people involved in aquaculture production today.

2.4 Research Methods Limitations

We believe that our findings represent a snapshot of current experiences in the United States aquaculture industry and that further research would be required to generate any generalizable results. We ultimately decided against conducting a nationwide in-depth survey to producers due to the limited time frame of the project. As a result, our findings should be interpreted in the context of our literature review and semi-structured interviews.

Interview Limitations

The inferences we can make from our data collections efforts are constrained by the low response rate we received despite reaching out to numerous states and their respective aquaculture organizations. Due to time restraints and low response rates, we chose to solely interview producers instead of including various stakeholders.

Low response rates are common within qualitative policy research and require us to use care in the inferences we make from our data (Johnson, 2014). We also experienced an uneven response rate that ultimately impacted our analysis of general barriers producers face in the country. Furthermore, our choice to use a snowball sampling technique to identify more interview candidates increased bias within our overall research (Johnson, 2014). The use of

snowball sampling often generates biased samples due to the higher proportion of similar characteristics between respondents and their social connections (Ilker et al.). On the other hand, snowball sampling is used most often to reach potential participants that are hard to reach (Ilker et al.). We acknowledge that without snowball sampling we would have had few producers to help give us a broader understanding of aquaculture within their respective states.

We had to conduct our interviews virtually through Zoom due to the varied locations of the producers across the country. While producers were comfortable with the virtual format, creating an environment to facilitate more honest conversation around topics sometimes proves difficult online. However, our choice to conduct virtual interviews allowed us to reach individuals we might not have had the time to reach otherwise.

Chapter 3: Literature Review

This literature review synthesizes information from academic publications, government websites and reports, agency financial statements, and news articles to develop a foundational understanding of Oregon's aquaculture industry and identify gaps where additional research is needed. This chapter first focuses on the current state of Oregon's aquaculture industry, including a description of primary stakeholders and regulatory regimes, then contextualizes Oregon's aquaculture within the broader U.S. The chapter concludes by identifying unique barriers faced by Oregon's aquaculture producers.

There is limited information about the extent to which Oregon producers are affected by barriers compared to producers from the rest of the United States. It is also unclear whether there are disparities between subgroups of producers because the Census of Aquaculture does not provide any breakdown of information by demographics. Another limitation to this review is that there has not been a deep analysis on the interactions among producers, investors, and agencies beyond basic licensing and regulations. Additionally, there is not a canon that describes the intersection between any meaningful or cultural significance tribal governments attribute to aquatic ecosystems and the expansion of the aquaculture industry.

3.1 Oregon's Aquaculture Industry

Background on Oregon's Aquaculture Industry

Aquaculture is an industry where farmers use a partially-controlled or fully-controlled environment to raise and harvest aquatic species for consumption (National Oceanic and Atmospheric Administration, 2023). The newest Census of Aquaculture was from 2018 and provides a snapshot of Oregon's aquaculture industry. Aquaculture contributed around $24 million to Oregon's economy (Perdue & Hamer, 2018). A state profile that provides an overview of Oregon's aquaculture based on the 2018 Census can be found in Appendix C. The industry consisted of 40 farms, 25 of which were freshwater and 15 of which were saltwater. The saltwater farms grew mollusks, whereas the freshwater farms included trout (15), catfish (3), sport fish (4), and ornamental fish (3). Between 2013 and 2018, Oregon's aquaculture industry grew in number of farms by 8% and in sales by 95% (Table 4).

Of the fifteen farms that harvested mollusks, twelve used bottom cages and thirteen used off-bottom production techniques including rack-and-bags, long lines, and rafts. These methods are considered "floating techniques" because they grow the shellfish at the surface instead of the ocean floor. Oregon shellfish are grown and harvested in ODA-approved areas including Clatsop Beach, Tillamook Bay, Netarts Bay, Yaquina Bay, Umpqua River and Triangle, Coos Bay, and South Slough (Oregon Department of Agriculture, 2023f).

On-Bottom vs Off-Bottom

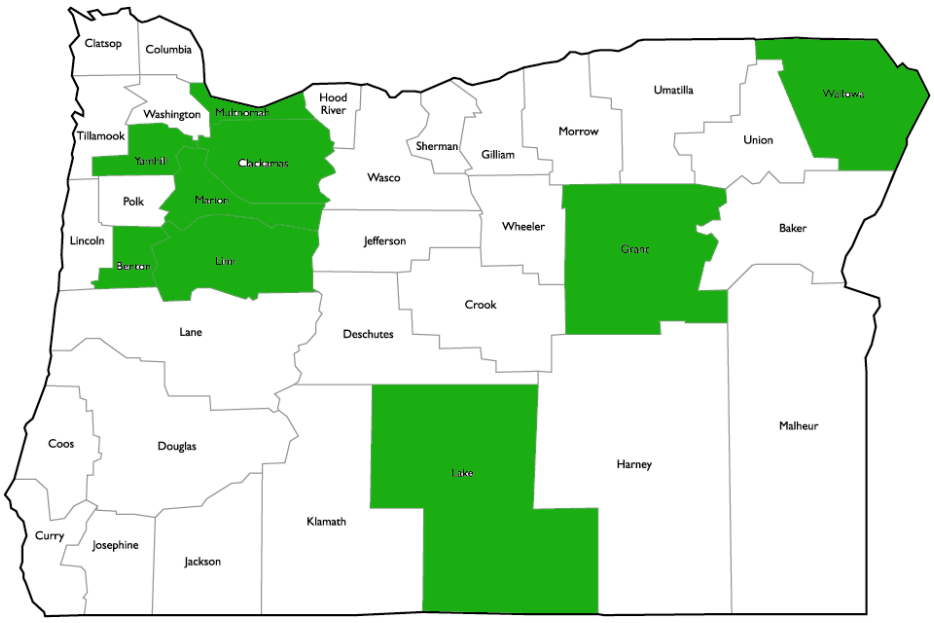
The benefits of bottom cages are that they mimic the natural environment of wild shellfish. While it is unclear whether bottom cages produce healthier shellfish, some experts indicate that the mollusks get more minerals and wave action (Lu, 2015). Disadvantages are that mollusks can suffocate without enough access to oxygen. Alternatively, floating techniques provide greater access to oxygen and are less susceptible to weather damage such as freezing or breaking. Unfortunately, the gear required for floating techniques is more expensive than alternatives and can present some permitting challenges by being an "eye-sore" for people who live on water-front property (The Council on Food, 2021).

The other 25 farms that raised fish in 2018 were all freshwater and used production techniques such as flowthrough raceways (10 farms), recirculating systems (7 farms), and non-recirculating systems (8 farms). Fish species raised in flowthrough raceways are typically trout, tilapia, catfish, and salmon. Artificial raceways can also be constructed with canals and an aerator (Institute of Ecolonomics, 2015). Four out of the seven recirculating systems were Aquaponics that have an additional hydroponics component. Hydroponics are soilless plants that are fertilized by fish waste and provide purification services to the water. Oregon Aquaculture Association lists farms operating in Linn, Clackamas, Lake, Wallowa, Multnomah, Grant, Yamhill, Benton, and Marion counties (Oregon Aquaculture Association, 2023b).

Flowthrough Raceways vs Recirculating Systems

Flowthrough raceways are systems that leverage a moving water source that provides oxygen to fish. These systems do not require electricity or aerators to operate. A recirculating system (RAS) uses tanks to raise fish and then reuses water by actively purifying it through mechanical filtration and a pump tank. RAS use limited water and provide a controlled environment for fish, therefore reducing the chance of disease. The drawbacks are that these systems need constant electricity to work and require trained specialists to operate (Aquaculture ID, 2023).

Image 1: Map of Farms in Oregon



*Information provided by OAA, map created by authors using World Atlas.

Agencies and Regulatory Regimes

Producers must fulfill requirements developed by lawmakers and enforced by agencies to operate commercially. These regulatory requirements safeguard consumer health, uphold environmental standards, and meet cultural needs of tribal nations. Some agencies also support the industry by providing additional resources on websites and offering grants that build producers' capacity and develop business. Oregon's Department of Agriculture (ODA) is the leading state agency that bridges the supply side and demand side of the industry.

Oregon Department of Agriculture (ODA)

The ODA offers ten programs that support agricultural activities and has a budget of about $140 million for 2021-2023, or 6% of Oregon's state budget. The distribution of funding among the ten programs has only shifted at most 2% in the last ten years (Oregon Department of Agriculture, 2023e). Two of these programs, the Market Access and Certification Program and the Food Safety Program, are used most by aquaculture producers and consist of 22% and 31% of ODA's total budget respectively.

The Market Access and Certification Program

Aquaculture producers can obtain official Free Sale, Origin, and Health/Sanitary certificates from ODA if they are selling products to other states or countries. ODA issues official letters to support any registration requirements for exporting to other countries (Oregon Department of Agriculture, 2023a). ODA provides Good Agricultural Processes and Good Handling Practices audits, although these certifications are more geared towards terrestrial growers. Beyond certifications, ODA created the Seafood Processors (SPRS) Grant Program to channel funds from the United States Department of Agriculture (USDA) to Oregon's seafood processors to respond

to any costs incurred protecting staff and consumers from COVID-19 (Oregon Department of Agriculture, 2023g). Additional services include supporting producers navigating USDA grant requirements that promote business development and reducing discrepancies in any weighing devices in Oregon's commercial marketplace (Oregon Department of Agriculture, 2023j).

Food Safety Program

This ODA program issues licenses and leases shellfish plats (Oregon Department of Agriculture, 2023i, 2023b). ODA issues two kinds of licenses relevant to aquaculture: food processing and commercial shellfish. Anyone packaging, canning, or freezing products must obtain a food processing license (Oregon Department of Agriculture, 2023c). If the product is shellfish, the producer must get their Hazard Analysis Critical Control Point (HACCP) plan approved by ODA prior to receiving a food processing license. The Commercial Shellfish License is required for anyone growing, harvesting, dealing, and processing shellfish. Shellfish include clams, oysters, mussels, or whole scallops. ODA designates areas that are approved for commercial shellfish harvesting after evaluating each for biotoxins and pollution. ODA also leases plats for shellfish growers who want to cultivate on state-owned tidelands. In addition, ODA offers resources to newer aquaculture producers and developed a user guide that outlines the key steps to begin in the industry (Oregon Department of Agriculture, 2015).

Other Stakeholders

The other state agency that interacts directly with producers is the Oregon Department of Fish and Wildlife (ODFW). ODFW provides licenses for private hatcheries that grow, transport, and sell their own fish and fish eggs. ODFW offers an online portal to obtain and renew licenses (Oregon Department of Fish and Wildlife, 2023b). Other stakeholders include Oregon Health Authority, Oregon Department of Environmental Quality, Oregon Department of Land Conservation and Development, Water Resources Department, and Department of State Lands, U.S. Army Corps of Engineers, Environmental Protection Agency, local land use municipalities, and Tribal Governments.

Regulatory Regimes

Oregon's aquaculture producers mostly engage these agencies to gain permits and licenses required for operating commercially. Permits and licenses vary depending on the producer's positionality in the supply chain, the type of product being sold, and the location of cultivation and harvesting. Table 2 depicts the roles of agencies in the licensing and permitting process.

Table 2: Oregon's Commercial Aquaculture Licenses and Permits by Agency

Agency	Role	License/Permits Offered
Oregon Department of Agriculture (ODA)	Issues licenses and leases pertaining to commercial shellfish, provides information on food safety and health, and creates certificates for shipping.	Commercial Shellfish License, Shellfish Plat Lease, Food Processor License
Oregon Department of Fish and Wildlife (ODFW)	Issues licenses pertaining to fishing hatcheries, provides regulatory guidance, monitors and reports on aquaculture production. Also propagates fish in publicly funded ODFW hatcheries.	**Licenses**: Fish Propagation, Commercial Fishing, Wholesale Fish Buyer, Shellfish Canning, Boat, Buyers, Wholesale Bait, Resident Limited Fish Sellers, Sturgeon Propagation **Permits**: Shellfish Harvest, Brine Shrimp Fishery, Transport
Oregon Health Authority, Oregon Department of Environmental Quality, Oregon Department of State Lands, Water Resources Department, and Tribal Governments	Influences the areas that can be used by aquaculture producers to grow and harvest.	None
U.S. Army Corps of Engineers	Provides permits required for shellfish and offshore farming on federal lands and waters.	Federal Land Use Permits, 404 Permits and Rivers and Harbors Permits (now "Nationwide Permits")
Oregon Department of Land Conservation and Development (DLCD)	Included in the pre-application meeting as part of the application process for leasing a shellfish plat.	None
Local land use municipalities	Leases shellfish plats on non-state-owned tidelands.	Shellfish Plat Lease (non-state-owned tidelands).
Environmental Protection Agency	Mandates federal environmental standards required of all aquaculture producers.	NPDES Permits

Other Resources

Producers in Oregon's aquaculture industry can also find local support and resources with Oregon Aquaculture Association (OAA) and Oregon Aquaculture Advisory Group (OAAG) (Oregon Aquaculture Association, 2023a). Up to date monitoring and tracking information related to aquaculture, such as potential hazards and natural resource availability, can be found in the Oregon Explorer Tool, among other information. Oregon Explorer was developed as a collaboration between OSU Libraries and Press and Institute of Natural Resources in 2007 and redesigned in 2015, with an additional Aquaculture Platform launched in 2019 with more developments ongoing (OSU Libraries and Press & Institute for Natural Resources, 2023). Beyond Oregon Explorer, regional support that connects Oregon aquaculture producers with others in Alaska, Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Washington, and Wyoming can be accessed with the West Regional Aquaculture Center (WRAC). WRAC is one of five regional centers established by Congress in 1987 with the mission to boost the aquaculture industry through funding research projects that support commercialization (Western Regional Aquaculture Center, 2023). On a national level, the National Aquaculture Association (NAA) is an organization that develops policies for local, state, and federal legislative bodies to protect and expand the United States aquaculture industry (National Aquaculture Association, 2023).

Oregon's Aquaculture Compared to Other States

Oregon's aquaculture industry is growing at a slightly slower rate than the broader United States, which has an average growth rate of 12% as shown in Table 3 (Perdue & Hamer, 2018). Out of the United States' $1.5 billion worth of aquaculture products, $430 million was from marine farms and $694 million from freshwater (National Oceanic and Atmospheric Association, 2019). Oregon had higher growth of farms that produced food fish (20%) and sportfish (33%) compared to the rest of the United States, which shrunk in its food fish and sportfish farms by 17% and 6% respectively. Alternatively, the number of Oregon farms that produced mollusks decreased by 12% compared to the broader U.S, which grew by 17%. These rates also correlate to production techniques, where Oregon demonstrated nine times the growth rate of the United States in adopting recirculating systems (Perdue & Hamer, 2018).

Table 3: Top 5 States with Highest Percent Change in Number of Farms and Positive Sales in 2018

State	Farms	Sales ($1,000)	Percent Change Between 2013 and 2018	
			Number of Farms	Sales
New Hampshire	32	$950	357%	25%
Indiana	23	$3,403	229%	56%
Colorado	47	$7,604	194%	55%
Wyoming	16	$547	167%	174%
Maryland	43	$28,139	139%	357%
Oregon	40	$23,668	8%	95%
United States	3,456	$1,515,680	12%	10%

A majority of states had a decline in aquaculture farms, with Arizona, Alabama, Minnesota, South Carolina, and Vermont as states with the greatest shrinkage. On the opposite side of the spectrum, the five states that demonstrated highest growth in number of farms between 2013 and 2018 and had an increase in annual sales were New Hampshire, Indiana, Colorado, Wyoming, and Maryland (Table 3). Twelve states showed a consolidation of wealth where there was a decrease in farms but an increase in sales.

State by State Profiles

An overview of each of the top five states with the highest growth in aquaculture between 2013 and 2018 is in Appendix C. The state profiles summarize information from the 2018, 2013, and 2005 Census of Aquaculture and are formatted similarly to the Census of Agriculture state profiles (Johanns & Buchanan, 2005; Perdue & Hamer, 2018; Unites States Department of Agriculture, 2017; Vilsack & Reilly, 2013).

Key Takeaways

Most of the states with the highest growth are in-land and demonstrate surging freshwater farms. Except for Wyoming, the other four high-growth states showed an increase in the average acreage of freshwater farms. Flowthrough Raceways and Non-Recirculating Systems became more prevalent production techniques for freshwater farms between 2013 and 2018, and there was an increase in trout and ornamental fish sales. Maryland and New Hampshire also showed growth with saltwater farms and those farms' average size. Both states had more farms growing mollusks in bottom cages, with Maryland having a dramatic increase in bottom cages compared to alternative floating methods. Notably, Oregon has experienced a decrease in the average size for both saltwater and freshwater farms over time and showed the biggest increase in using Recirculating Systems compared to other production techniques.

The coastal states had Best Management Practices (BMPs) in place and online license registration systems, but neither are considered one-stop-shops because multiple agencies are involved in licensing and permitting processes (Agricultural Best Management Practices Task Force & USDA Natural Resources Conservation Service, 2019; Maryland Aquaculture Coordinating Council, 2007; Maryland Department of Natural Resources, 2023b; New Hampshire Fish and Game Department, 2023). Alternatively, most in-land states had one agency that administers licenses and permits, but online registration systems were less prevalent.

Oregon, New Hampshire, Indiana, and Maryland all had some sort of monitoring and evaluation tool that tracked fish populations and stocks (Dr. Michael Chambers, 2023; Indiana Fish and Wildlife, 2023; Maryland Department of Natural Resources, 2023a; OSU Libraries and Press & Institute for Natural Resources, 2023).

3.2 Aquaculture Expansion Challenges in the United States

The United States aquaculture industry is growing at a rate slower than the rest of the world and was considered the 17th biggest producer in 2018. The global aquaculture industry produced roughly $160.2 billion worth of products and the United States sold only about 0.95%

of this (Office of Aquaculture, 2022). Common barriers mentioned across the United States that prevent the expansion of aquaculture revolve around regulations, public opinion, cost, competition in global markets, and climate change.

Regulations, Permits, and Licenses

Federal regulations that influence aquaculture must be adhered to by all the United States' producers and create farming standards across states. Such policies regulate production techniques, species farmed, and set environmental standards for aquaculture (National Association of State Departments of Agriculture Research Foundation, 2005). Federal regulation has the potential to restrict in-land, nearshore, and offshore aquaculture, and **does not have a single point-agency that issues all permits or time limits for permit approvals.**

The Clean Water Act (1972) is enforced by the Environmental Protection Agency (EPA) and aims to prevent pollution in bodies of water. This act requires state and tribal governments to set water quality standards for different uses of water such as public water protection, shellfish farming, fish propagation, and irrigation. Under the Clean Water Act, the EPA requires aquaculture producers to apply for a National Pollutant Discharge Elimination System (NPDES) permit that is issued by either the regional EPA office or a state authority (DEQ in Oregon's case). These permits allow producers to discharge waste at a point source into navigable waters (National Association of State Departments of Agriculture Research Foundation, 2005). The 404 permit is another requirement under the Clean Water Act for aquaculture producers that farm or harvest in wetlands. The U.S. Army Corps of Engineers (Corps) issues these 404 permits after the EPA reviews and approves applications (U.S. Army Corps of Engineers, 2023).

Section 10 of the Rivers and Harbors Act (1899) is also key legislation, as it empowers the Corps to limit construction of any offshore infrastructure in federal waters including docks (US Army Corps of Engineers, 2010). Any offshore aquaculture must obtain a Rivers and Harbors permit before setting up any finfish farms (Montgomery, 2019). In 2021, the Corps streamlined permits under the Rivers and Harbors Act and the 404 permits under the Clean Water Act to a single Nationwide Permit. These updated Nationwide Permits replace prior permits and aim to simplify the regulatory process for shellfish farmers (*Army Corps of Engineers Announces Publications of 2021 Nationwide Permits*, 2021). When the Nationwide Permits were originally announced in 2017, they were designed to apply to the entire shellfish industry. The Corps was sued by the Swinomish Indian Tribal Community of Washington under the claim that providing unlimited access to operate on the coast would put Eelgrass, an endangered species protected under the Endangered Species Act, in jeopardy. The Swinomish Indian Tribal Community won the case and the Corps redesigned the Nationwide Permits to be allocated individually (Sarah Sax, 2021).

The National Environmental Policy Act (NEPA) requires federal agencies to "assess the environmental effects of their proposed actions prior to making decisions" including on any choices regarding permits (Environmental Protection Agency, 2022). Under NEPA, the Corps issues Federal Land Use Permits. The Federal Land Use Permit is essential for projects that take place on jurisdictional wetlands and other waters such as commercial shellfish farming. To

obtain a Federal Land Use Permit, applicants must undergo a lengthy process that includes a pre-application meeting and a 30-day public notice period (US Army Corps of Engineers, 2021). Permits are not guaranteed and **present a risk for potential investment**. NEPA compliance is also required for offshore aquaculture producers that farm finfish.

Public Opinion on Aquaculture

A significant motivator for anti-aquaculture legislation and deterrent for investment comes from negative public perception about the industry. Most negative public perception around aquaculture stems from the beliefs that the industry introduces invasive species, spreads diseases, and has large-scale environmental impacts (Parks, 2021; Yue, 2008). A study showed that higher-income nations demonstrated more negative public opinions about aquaculture, particularly with offshore finfish, than lower-income countries. This study found that most perceptions paralleled news headlines and letter writing campaigns that did not mention the capacity for the industry to be sustainable. They also found that public perception was highly negative about aquaculture when indirect phenomena that affect fish populations, such as oil spills, occurred (Froehlich et al., 2017).

Predominant anti-aquaculture campaigns have largely been centered on nearshore Atlantic salmon farming. Atlantic salmon are endemic to Eastern shores but efforts to farm them on the West Coast have been growing since the 1950s. In 2017, pens that contained Atlantic salmon off Washington shores broke due to high tides, releasing the invasive species into waters home to native, wild Pacific salmon, causing alarm across the industry (Lora Shinn, 2018). There is no evidence of the escaped Atlantic salmon breeding on the West Coast, despite public concern over competition for food and breeding grounds between both species (Flatt, 2017). There is particular public concern about *Piscine Orthoreovirus* (PRV), an infectious virus common in Atlantic salmon that disrupts production cycles, spreading to wild Pacific salmon fish populations (Owens, 2021). A study by NOAA in 2014 largely disputed this claim by providing evidence that the risk of net-pen salmon spreading disease to wild salmon is low (Rust et al., 2014).

Production Costs

Startup and maintenance costs for aquaculture may be a potential barrier for producers. Costs vary significantly depending on the type of production technique being used and the species of fish raised. Production costs include both initial capital and ongoing expenses such as water, electricity, transport, and feed. These costs are on top of any permit or license fees. Annual revenue can fluctuate depending on weather conditions and disease outbreaks. Possible expenses for commercial shellfish farmers can include long lines, flip bags, bottom cages, floats, mesh etc. These items range from $6-$500 each and can be used in combination with each other (Hoopers Island Oyster Co., 2023). Most small-scale farms incur around $60,000+ for startup expenses in addition to purchasing a boat (Pacella, 2014). Annual expenses include any maintenance costs for the equipment and boat, labor, feed, seeds, water and energy inputs, and repair for damaged gear. Raising finfish can also be cost prohibitive depending on the type of equipment used and available financial assistance.

Table 4 compares the possible expenses of two finfish farmers in Corvallis, Oregon, that would be incurred to produce an average annual harvest of 500,000 pounds with a market size of one pound. The expenses and prices listed in Table 4 are estimated using the Oregon Explorer Financial Planning Tool and are exemplary of the industry (OSU Libraries and Press & OSU Libraries and Press, 2023). These expenses vary across states and vendors, but should be used as a point estimate for understanding the scale of this barrier.

Table 4: Example Startup and Maintenance Costs for a Trout and Hybrid Striped Bass Farmer

	Tilapia Farmer using RAS	Hybrid Striped Bass Farmer using Ponds
ITEM	**COST ($)**	**COST ($)**
Land cost	1,402	437,500
Equipment cost	750,000	550,000
Engineering/construction cost	420,000	350
Other startup expenses	0	410,000
TOTAL START UP COSTS	**1,441,402**	**1,792,500**
Annual transportation cost ($1.68 per ton-mile for feed and product shipping)	193,354	245,400
Annual operating cost	2,121,578	2,302,224
Operating loan (6%)	111,117	122,286
TOTAL ANNUAL COST	**2,426,049**	**2,669,910**
AVERAGE ANNUAL REVENUE	(1,500,000)	(1,200,000)
TOTAL STARTUP + ONE YEAR OPERATING COST	**2,367,451**	**3,262,410**

*Information for this table was obtained from the Oregon Explorer Financial Planning Tool.

Competition with International Market

United States aquaculture producers must compete with imported fish products to meet consumer demand. The total global aquaculture market size was valued at $285 billion in 2019 and is projected to be $378 billion by 2027 (Sumesh K & Roshan D, 2020). The U.S. currently imports 70-80% of its seafood and is the 17th aquaculture producer globally (National Oceanic and Atmospheric Association, 2019). Shrimp, shellfish, and tilapia are mostly imported from Asian and Ecuadorian producers, whereas salmon are imported from Canada, Chile, and Norway (Office of Aquaculture, 2021). The Asia-Pacific region is the world's largest producer and supplied 92% of global aquaculture demand in 2018. China was the top fish exporter ($25 billion), followed by Vietnam ($7.7 billion), then India ($7 billion) (De Silva & Yuan, 2022).

In efforts to increase U.S. competitiveness with the global market, President Trump issued an Executive Order in May 2020 that established an Interagency Seafood Trade Task Force under the Department of Commerce. The group was tasked with collaborating with other agencies to

develop key recommendations that could boost domestic production. Public hearings that supplied commentary on the recommendations revealed that producers were mostly concerned with being price-competitive with imports. Key recommendations included caps or tariffs on seafood imports, or subsidizing domestic production (Bittenbender, 2020).

Climate Change

The barriers described above have largely been focused on producers attempting to access the aquaculture industry. Climate change has significant potential to not only deter new producers from aquaculture, but also to harm producers that are well established in the industry. Carbon dioxide produced by burning fossil fuels accumulates in the atmosphere and prevents the sun's infrared radiation from escaping back into space in a phenomenon known as the "Greenhouse Effect" (May, 2017). The warming planet then changes the Earth's climate by altering the physical and chemical processes and systems.

For aquaculture, increased heat caused by climate change melts snow caps at a faster rate, causing sea-level rise. The rising temperature also correlates with a shift in the North Atlantic Oscillation (NAO), an atmospheric pressure changes over the Atlantic Ocean. This shift in the NAO causes "changes in wind speed, precipitation, evaporation, and the exchange of heat between ocean and atmosphere with strong impacts on oceanic conditions" (Barange et al., 2018). These changes in ocean conditions and volume result in more frequent storm surges that can destroy offshore and nearshore aquaculture infrastructure. A most well-known example is from 2013, where Typhoon Haiyan hit the coast of the Philippines and destroyed infrastructure for over 16,500 seaweed farmers (Food and Agriculture Organization of the United Nations, 2013). Storms also can cause mass fish death. If trees are uprooted due to wind or rain, their decomposition ultimately reduces available oxygen in the water and fish suffocate (Elliott, 2020). Sea-level rise and storm surges flood nearshore areas, particularly estuaries and wetlands, and bring saltwater to previously freshwater environments. Increased salinity can exacerbate nutrient pollution and begin eutrophication. Eutrophication is a process where algae blooms and available oxygen in the water dissolves, leading to fish death from hypoxia (United States Environmental Protection Agency, 2022).

Additionally, oceans are absorbing higher concentrations of carbon dioxide to equilibrate with the atmosphere and become more acidic as a result (United States Environmental Protection Agency, 2022). As the water absorbs carbon dioxide, it binds with carbonate, a chemical needed by shellfish to build their outer shells, to form bicarbonate (National Oceanic and Atmospheric Association, 2021). Weaker shells can make shellfish vulnerable to predation and increase mortality rates for larvae. Mollusks, in particular, have decreased survival rates up to 34% due to ocean acidification (Woods Hole Oceanographic Institution, 2021). According to a report done by Woods Hole Oceanographic Institution in 2021, the United States shellfish industry "is expected to lose more than $400 million annually by 2100 as a result of ocean acidification" (Woods Hole Oceanographic Institution, 2021). The Pacific Northwest, Long Island Sound, Chesapeake Bay, and the Gulf of Mexico have all been identified as hot spots for ocean acidification (National Oceanic and Atmospheric Association, 2021).

3.3 Aquaculture Expansion Challenges in Oregon

Oregon's aquaculture industry is growing at a rate slower than the broader United States, even though Oregon is facing the same barriers. Understanding what is uniquely holding back Oregon's growth will be critical to developing tailored strategies that boost production.

Permits and Licenses

To operate commercially, Oregonian producers must obtain similar licenses as producers in other states (full list is in Appendix D). There are steps that other states' agencies have taken to streamline licensing processes that Oregon has not yet completed. As shown in Appendix C, Oregon does not have an online licensing platform for all required aquaculture permits nor a "one-stop-shop" where producers can get all necessary licenses, permits, and resources. In a survey conducted by Oregon Sea Grant in 2022, 57% of Oregonian growers and 60% of prospective growers that responded found permitting processes somewhat or extremely difficult to navigate (Ehrhart & Doerr, 2022).

State Legislation

Some state legislation creates barriers for Oregon aquaculture expansion. A primary example is SB 569. This state law came into effect in 2008 and requires a $3,000 fee for any issuance of permits to rear green or white sturgeon, a cost significantly higher than other fish as seen in Appendix E (*Relating to Sturgeon; Creating New Provisions; Amending ORS 497.325; and Repealing ORS 497.330.*, 2008). SB 569 also gives the State and Fish and Wildlife Commission power to limit how many permits are issued each year. As a result, the Sturgeon Propagation Permit in Oregon costs $3,573 and must be annually renewed (Oregon Department of Fish and Wildlife, 2023c). Producers from other states that rear sturgeon do not face this financial burden. Other state legislation that had the potential to affect Oregon's aquaculture industry was the Oregon Aquaculture Act (SB 89) (*Oregon Aquaculture Act*, 2023). This legislative concept did not become law but had the potential to impact producers if passed. Community members would have been able to file for injunctions in counties with aquaculture facilities, which could ultimately shut down current and future farms. This legislative concept also required producers to reduce plastic use to the greatest extent possible. Finally, it required ODA to do an impact analysis of any commercial shellfish operations in proximity to proposed shellfish operations before granting the commercial shellfish license. Representatives from Pacific Coast Shellfish Growers Association (PCSGA) and Oregon Aquaculture Association (OAA) provided opposing testimonies that outlined these impacts on producers in greater detail (Bentz, 2023; Thompson, 2023).

Climate Change

Oregon is coastal and, unlike inland states, its aquaculture producers are at risk of climate impacts such as sea level rise, ocean acidification, salinization of nearshore bodies of freshwater, and storm surges. Sea level rise caused by climate change is projected to be higher than the natural uplift of Oregon's coast by mid-21st century, resulting in greater erosion and flooding (Ruggiero et al., 2010). Yaquina Bay has also demonstrated higher averages of sea-level rise and coastal erosion during bi-annual El Niño climate events that have potential to intensify

with increased climate change (Wang et al., 2019). Past hotspots for beach sand erosion due to El Niños include Neskowin, Cape Lookout State Park, Alsea Spit, Netarts Bay, and Port Orford (Ruggiero et al., 2010).

Community members from Neskowin formed a Neskowin Coastal Hazards Committee to address some of these climate impacts and are supporting the development of a Tillamook County Coastal Hazards Adaptation Plan (Ruggeri, 2010). As shown in 3.1.1 of this literature review, many of Oregon's commercial shellfish farms are in Tillamook County and Netarts Bay and are at risk of these environmental hazards. In 2007, the Whiskey Creek oyster hatchery in Netarts Bay experienced a mass die-off of oyster larvae due to ocean acidification (Houtman, 2020). It is also projected that the ecosystems in Oregon's 43 estuaries will experience stress from nearshore ocean changes. Stressors include a rise in algae blooms, higher possibility of invasive species, and the weakening of shells due to water acidification (Ruggiero et al., 2010).

Limited adaptive capacity to climate change may also pose a barrier for Oregonian producers. Currently, there is minimal diversity in the type of species being grown for aquaculture. Monoculture farms can be particularly vulnerable to climate effects and risk financial loss after a significant climate incident (Cafasso, 2020). Oregon aquaculture primarily comprises trout, tilapia, sturgeon, bass, shellfish, and a couple of seaweed farms (Oregon Dulse, 2023; Perdue & Hamer, 2018). While there have been salmon farms in the past, it is not a predominant fish raised privately in this region. It is unclear whether the lack of private salmon farms is directly influenced by the high cultural significance regional tribal nations place on wild Pacific salmon.

3.4 Conclusion

This literature review revealed that the barriers to expanding the United States aquaculture industry are permitting and regulations, public perception, market competition, production costs, and climate change. The next chapter will describe findings from interviews with aquaculture producers across the United States that further explore these barriers and the potential strategies to overcome them.

Chapter 4: Findings and Analysis

4.1 Overview

This chapter analyzes themes gathered from our interviews by barriers found within our literature review. The aquaculture producers interviewed were from the states selected based on the criteria presented in Chapter 3. Producers ranged from smaller family-owned farms to larger regional aquaculture company representatives. The interviews were conducted to gain insights into our three research questions:

1. **What are key barriers to the U.S. aquaculture industry that prevent expansion?**
2. **What barriers disproportionately affect Oregon's aquaculture industry?**
3. **What are strategies Oregon's Department of Agriculture can deploy to overcome these barriers?**

The interviews provided by the aquaculture producers and our initial literature review produced primary themes indicating barriers in relation to business dynamics, permitting and regulations, the economic and market, policy landscapes, and public perceptions.

- *Business Dynamics*: Business dynamics are factors that impact the nature of running a business.
- *Permitting and Regulations*: Captures the barriers that aquaculture producers encounter due to the permits they must apply for and regulations they must comply with.
- *Economic and Market Conditions*: Encompasses barriers that are due to economic and market conditions that are experienced by aquaculture producers.
- *Policies*: Captures the producers' views on barriers that occur due to the policy landscapes from a federal to a local level.
- *Public Perceptions*: Refers to barriers aquaculture producers encounter due to the beliefs and opinions held by the public and other stakeholders.

These themes will be outlined for producers across the United States. In the following section the themes will be analyzed specifically for Oregon’s aquaculture producers.

4.2 Interview Demographics

During the interviews, producers were asked to complete a demographic survey to help us better understand the characteristics of producers in the current market. The survey results, shown in Appendix C, allowed us to gather information such as age, gender, farm size, and production type to help inform our recommendations. The aquaculture producers our team interviewed produced shellfish, finfish, and aquaponics and spanned experiences from 7 states (Table 5).

Table 5: Aquaculture Producers by state and product

State	Shellfish	Finfish & Aquaponics	Total
Alaska	2	0	2
California	0	1	1
Maine	3	0	3
Maryland	1	0	1
Virginia	1	0	1
Washington	4	0	4
Oregon	0	5	5
Total	**11**	**6**	**17**

4.3 U.S. Aquaculture Barriers

Business Dynamics

Business dynamics are factors that impact the nature of running a business. This includes aspects such as funding, costs, or business management. Aquaculture producers across the United States faced barriers when starting and maintaining an aquaculture business.

The first significant barrier identified from the interviews is access to funding. Aquaculture businesses require high upfront capital investments for permits, equipment, production inputs, and other business expenses. Producers reported relying on self-funding, loans, and grants to obtain financing for their businesses. However, funding access was found to be a barrier, especially for smaller farms and those who do not have the capital to self-fund or get access to agricultural or small business loans. As one producer stated,

> *So unless you have a property or something to borrow against, it's pretty difficult to get to like traditional financing, and even the diversified financing that they have specific for operating aquaculture, you know, an 8% rate or something like not an amazing business.*

Moreover, grants were found to be limited and not widely accessible, as only a few producers reported success in receiving any grants. The reported difficulties in financing to run their businesses were even more burdensome for producers whose crops, such as shellfish, may take multiple years to turn a profit.

High costs associated with maintaining an aquaculture business resulted in additional financing-related barriers for producers. Ongoing costs for permits and production inputs led producers to build out their businesses slowly. Shellfish seeds are one such input that are expensive for producers. This is in part due to the limited number of hatcheries on the West Coast that sell the necessary seeds, which one producer noted as “a limitation.” In addition, the smaller seed supply was reported to drive up costs. This was challenging for smaller producers who potentially may not be a priority for companies, given the size of their orders and low economic buying power. Cost barriers also resulted in some producers relying on other financing sources,

such as a second job or a partner's income, to ensure they could provide for themselves and their families. Ultimately, producers expressed that the barrier for financing resulted in slower entries into the market, impacted producers' profit timelines, and for some impacted plans to expand their business.

A lack of business knowledge among new producers was also a common barrier that arose from the interviews. This knowledge includes understanding how to market and price products as well as how to manage employees and conduct payroll. Multiple producers mentioned that this lack of business knowledge made starting in aquaculture difficult, especially if they did not have a partner or spouse with these skills. This barrier can lead to adverse financial outcomes or business failure, with one producer noting that, "If you can't figure out how to function as a small business, you probably aren't going to make it" [in the aquaculture business]. One example of a state attempting to address this barrier is Maine offering educational courses to new producers that provided training on how to successfully run an aquaculture business.

Permitting and Regulations

Permitting and regulations that aquaculture producers must apply for and comply with lead to a significant set of barriers in the United States. Permits are issued by regulatory agencies that grant consent to conduct an act or process, while regulations are rules set forth by a regulatory agency that set standards with which all must comply. Aquaculture producers are faced with permitting and regulations throughout the life of their business. Producers reported that overburdensome permits and regulations cause unnecessary hurdles. This barrier extends from the federal to the state and local levels. This was exemplified by the comments from one producer who said,

> *Having the authority to come up with these harebrained ideas that are not even feasible or trying to put into place these rules that are arduous and duplicative like talking about 'We can't dump human feces into the water,' like okay, that should not even be a conversation we have to have because our product is reliant on clean water and that's already something that is regulated by the coast guard, so why is the city and borough trying to make additional regulations?*

Producers found the permitting and regulation process in their respective states to be unclear and cumbersome, with many regulations not helping to ensure safety or improve business operations. For example, one producer who worked in both Maryland and Virginia expressed the divergent experience between the two states regarding permitting stating,

> *No, Virginia was great wealth of information easily accessible. And yeah, I mean, the process here is real, straightforward, streamlined. I was able to change my residency development and get my Worcester leases all within about 3 month... I know that at the time Maryland's process was gonna take in the neighborhood of 14 to 18 months.*

Additionally, another producer expressed that well-intentioned regulations and restrictions sometimes "create worse problems than the problems we initially saw." Duplicative or

redundant permitting seemed to be a consistent trend across jurisdictions. Due to these barriers, some producers reported the need to hire consultants to assist them in getting permits or adhering to regulations, which added an additional cost burden to their businesses. Notably, the cost of individual permits was not a significant barrier reported by many producers. However, the overall costs of navigating the permitting and regulation process often caused producers to shift their focus away from aquaculture and toward dealing with bureaucratic processes.

Some producers mentioned that permits can take many months to even years to acquire. This barrier is particularly significant for small farms that lack the resources to navigate the complex permitting and regulatory landscape. Some small farms are run by only one person, making it challenging to manage the day-to-day operations of the farm, while also dealing with regulatory issues that are not clear and straightforward. As one producer noted, "it takes big corporations or big family businesses…to have the resources to ride that process out." This is because larger operations often have existing farms that are making money while they are waiting for new permits.

Economic and Market Conditions

The theme encompasses economic and market conditions that are experienced by aquaculture producers. The ability for producers to access and thrive within the market for aquaculture goods requires overcoming several barriers which include accessing the market and product distribution, setting a suitable price point, and competition.

Producers must navigate and decide on a strategy for getting their products to market. Options identified by producers to distribute their products include direct sales to consumers, direct sales to restaurants, and distribution companies. Each option presents unique barriers, making it challenging for producers to grow or maintain their businesses. For direct buyers, marketing and transportation are significant barriers. Producers must market their products effectively to acquire customers and find reliable transportation methods to get their products to buyers. Direct sales to restaurants, meanwhile, require relationship building with restaurant owners. As one producer in Maine expressed, this option was simple due to a singular license the state requires and allows them to sell the majority of their products with ease.

Additionally, producers must ensure that products are priced competitively in the market to ensure restaurants continue to buy their products. This presents a barrier for producers who do not have the necessary skills or capacity to relationship build or understand marketing a product. Distribution companies are a popular option for many producers, but producers face the challenge of limited options. For example, distribution companies are more readily available on the east coast, and only a few options are available for producers on the west coast. The limited number of companies available to distribute aquaculture goods makes it challenging for producers to contract with these companies. As one producer explained,

> *There are only less than a handful of distribution companies that you can deal with … You don't have much choice, you know, we need a ton of your product right now, and*

you may not have the kind of product they're looking for. But you have very few options of brokers...wholesale buyers to work with. So that can be a bit of a dance, you know. A bit of a challenge.

Additionally, producers may encounter a barrier to accessing distribution companies due to the quantity of products they can produce. Distribution companies may find that small quantities of a particular product are not cost effective to take on.

Global competition is also a significant barrier for aquaculture producers. For example, aquaculture products from Asian and South American markets saturate the U.S. market, making it difficult for smaller producers to compete. Imported goods are cheaper and come in larger quantities than what can be produced by U.S. aquacultural producers. This leads to U.S. producers being unable to compete effectively within their local and regional markets. Producers have had to find ways to differentiate their products and find niche markets to survive. One producer described this phenomenon by noting that, "I compete with imports. I cannot compete with metric tons coming in from Chile... like 90% of the fish we eat in this country come from another country...it's ridiculous." While these barriers are substantial, the producer went on to note that such market dynamics exacerbate already competitive pricing that excludes many domestic producers from the market. "And so I can't compete with those volumes and scales of price, so it's commodity pricing, and I am very limited on how many fish we can grow at this farm because of our resources. So, so I've gotta get a premium right now." Barriers to selling products within the producer's own state are also significant. Producers reported difficulties getting their products sold. These barriers can include a general lack of a market for aquaculture products, infrastructure to process and distribute their goods, governmental policies limiting market access, or permitting challenges that impede the sale of their products. Examples of these challenges include transportation permits and food processing licenses. Producers have found inventive ways to navigate these challenges and sell their products locally and regionally, such as starting their own restaurants, catering businesses, and going on the farmers market circuit. These barriers, however, must ultimately be addressed by public policy to build sustainable aquaculture businesses.

Policies

This theme captures producers' views on the policy landscapes from a federal to a local level. The policies set in place by the government at all levels was expressed to impact the aquaculture industry across the U.S. and can either hinder or incentivize the industry's growth. This section will start with producers' impressions of federal policy, then state policies, and finally local policies.

Historically, federal policies that were designed to require specific permits to place structures and farm in coastal waters have challenged aquaculture producers, particularly those implemented by the Army Corps of Engineers. Producers perceive these policies as unclear and not effectively communicated, leading to legal and permitting challenges for producers. One producer expressed, "we were trying to figure out what we were doing as farmers, there was also this, just, revolving door of regulatory things that the Army Corps was trying to figure out,

and there was a lot". This was problematic for the producer and hindered their ability to successfully run their business. However, recent efforts to streamline federal policy such as Nationwide Permit 48 through the Army Corps of Engineers have resulted in a single permit that covers all federal authorizing conditions, reducing some of the barriers producers face. Producers found the initial rollout of the Nationwide Permit jolting because it required all producers to reapply for the permit at once, inundating the Army Corps with applications and slowing approvals. The Army Corps' transition to spreading out expiration dates of permits alleviated some of this stress and made the process easier for producers.

At the state level, land and water use policies are a significant barrier for aquaculture producers. States control the ability to regulate public land and water use, which can create challenges for aquaculture businesses looking to establish operations. States that do not support aquaculture use of these lands and waters drastically impact the already limited space available to producers. In addition, the lack of state support for aquaculture is also a significant barrier, as policies supporting these businesses are necessary for them to thrive. Adopting policies like those used in terrestrial agriculture can help support the development of the aquaculture industry and provide states with a new sustainable industry.

Policies at the city and county levels also impact the aquaculture industry. Local policies surrounding the aquaculture industry are not clearly defined according to producers. Aligning these policies with state-level policies and creating incentives for aquaculture businesses can help ensure that policies do not overlap and that any dictated permitting or regulation based on the enacted policies are not duplicated. Additionally, due to unclear policies, producers have faced pushback from the government bureaucrats responsible for the day-to-day implementation of policies who may view aquaculture negatively. For example, producers viewed the Army Corps of Engineers office who are in charge of many of the federal permitting and regulations as having an anti-aquaculture bias. This bias was felt to be slowing down the process and jeopardizing a producer's business interest.

Public Perception

The theme of public perception refers to barriers aquaculture producers encounter due to the beliefs and opinions held by the public and stakeholders. This negative public perception of aquaculture can partly be attributed to lack of knowledge and understanding (Petereit et al. 2022). This negative public perception of aquaculture can partly be attributed to lack of knowledge or misinformation. For instance, some members of the public may believe that aquaculture practices harm wild fish populations or contribute to pollution (Froehlich et al., 2017). One producer stated that, "Well, I think most people have no idea what it [aquaculture] is. They've never seen it...". Without public support, funding and investment is difficult to come by and there is potential for legal challenges and increased regulatory scrutiny on producer operations. Public support can be especially difficult in areas that do not have much existing aquaculture. As one producer noted,

People have a hard time when you introduce something that's a change, people kind of fight it. So you're talking about things that they don't understand, and you know most of the people... have never really seen an aquaculture facility.

However, according to producers, the public perception of aquaculture can be changed by increasing awareness and understanding of the benefits and sustainability of the industry. Educating the public about the importance of aquaculture in providing a sustainable source of food, supporting local economies, and reducing pressure on wild fish populations can help to overcome this barrier. Some producers have successfully addressed this challenge by speaking and performing outreach to educate those who oppose aquaculture. In one example, a person who was explicitly anti-aquaculture eventually wanted aquaculture done on their own land:

> *Things can change. Just to give a concrete example here in Mason County, we were farming two parcels right next to a fellow that used to be the president of one of these anti-aquaculture associations, and he would come down on the beach as we were doing the farming, and have conversations with [him], and eventually he approached us and said, 'would you farm my beach for me?'*

This helps show why producers should engage with stakeholders and be transparent about operations to increase community acceptance of aquaculture.

4.4 Oregon Barriers

This final section revisits the themes outlined above with a specific focus on interviews conducted with only Oregon aquaculture producers. Themes found throughout the broader United States are also common in Oregon.

Business Dynamics

One barrier that producers in Oregon mentioned is difficulty accessing space to grow their products. Producers reported facing significant challenges in acquiring and maintaining access to land and water for their operations. A producer emphasized this point by saying “For somebody else that wants to get into aquaculture you need to make sure they have the correct water rights.” This was often due to complex regulations and policies at the state and local level that limited their ability to use public lands and waters for aquaculture purposes. Additionally, the high land cost in Oregon was a significant barrier for small-scale producers, who often lacked the financial resources to purchase or lease large tracts of land.

Another barrier identified by producers was the need for resources and training to run a successful aquaculture business. Many producers reported feeling unprepared to handle the business side of their operations, such as marketing, accounting, and managing employees. This lack of business skills and knowledge was identified as a major barrier to growth and profitability for many producers.

Access to funding was also identified as a significant barrier for new and existing aquaculture producers in Oregon. When discussing getting into the aquaculture business in Oregon, one producer said, "there was funding issues for sure, feeling nervous, about raising money, or you know, running out of money and all that kind of stuff." Another producer described the many difficulties in starting out in aquaculture by saying,

> *You know, it's very difficult to buy a farm. Okay, they're expensive. And you get in, you get it to a farm, and you don't have any equipment. You don't have any livestock, you know. You don't have any money to pay your bills. I mean, it's really rough.*

Many producers reported relying on personal savings or loans to fund their operations. A lack of available funding through traditional funding sources or governmental grants creates a significant barrier for producers to start or grow their businesses. Funding access was especially challenging for new producers lacking a track record of successful operations, as they often struggled to secure financing outside their own personal funds.

Permitting and Regulations

Aquaculture producers in Oregon highlighted several barriers related to permitting and regulations. One of the main barriers producers identified was that the current permitting system in Oregon is overly time-consuming, and would even go as far to say, “the problems with, mainly with aquaculture, is the government". Aquaculture producers reported spending considerable time trying to understand the complex permitting system, which takes away from their ability to conduct their business efficiently. For example, food safety permits, transportation permits, and permits to grow products were reported to be overly burdensome. One producer specified that, “it’s all small things, but when you have a hundred small things it adds up.” Food safety permits were viewed as burdensome due to their substantial number, and producers felt like the process could be easily streamlined. Transportation permits slowed producers' ability to market their products and increased opportunity costs. Finally, permits to raise a given product were burdensome for Oregon producers due to the overcomplex process and in some cases cost. Sturgeon, for example, was viewed to be a good fish for Oregon producers but the $3,000 permitting cost is seen as too expensive.

Another issue identified by aquaculture producers was the lack of standardization of procedures across jurisdictions. Producers reported that permitting and regulations vary widely between local and state offices, making it difficult for new producers to access the necessary information to navigate the system. Standardization of procedures could help reduce new producers' barriers to accessing information at any local or state office. Additionally, permits for different aquaculture products do not always go to the same place. For example, transportation permits for some finfish can be burdensome and are sent to a top biologist. The biologist's choice not to prioritize the transportation permit causes significant delays to producers.

Market

The aquaculture market in Oregon has created barriers for producers that prevent them from selling their products successfully. One particular barrier identified by Oregon producers was the need for a testing facility and processors to ensure that products could be cleared to sell for consumption. Finfish producers reported difficulty selling their products as meat for consumption and mainly marketed their products for stocking ponds, lakes, and rivers due to this barrier. Oregon producers also discussed what they view as an absence of support from the Oregon Department of Fish and Wildlife (ODFW.) ODFW used to buy fish from aquaculture producers but no longer does so, impacting the current aquaculture producers market. The market's decreasing size led to producers selling their products outside of Oregon. One producer mentioned that they sell some fish in Oregon, “but not the volume that we'd like to sell at."

Global market competition also poses a challenge to Oregon producers. One Oregon producer mentioned that aquaculture products imported from Mexico lead to increased competition and make it difficult for them to compete. Oregon producers argue that their products are held to higher environmental and safety standards than those imported from outside the United States. They also argue that these higher standards lead to higher quality products, which is a claim that there is some evidence for (Ortega et al. 2014). Market pressures from global competition create additional barriers for small farms struggling to compete with larger farms and producers.

Policies

Oregon producers identified barriers experienced in local and state policies. Producers indicated a prevailing perception that the state does not support aquaculture on the same scale as terrestrial agriculture. This lack of support makes it difficult for aquaculture businesses to thrive and compete with larger farms and other competition within the market. Participants emphasized the need for state policies to support farms. Specifically, smaller farms need greater support from state and local policies as they face more significant challenges in accessing resources, funding, and space. Additionally, producers stated that policies supporting the industry would reduce their burden and increase economic growth and development within the aquaculture industry.

The lack of robust pro-industry policies also creates a barrier to getting accurate information for Oregon producers. When contacting state and local officials, producers can face the challenge of getting conflicting information or no information at all. On the lack of support from the state, one producer noted that,

> *I think that in the future, if you're looking at aquaculture, the state of Oregon, or the Pacific Northwest, you know you really need to have guidance from the State, that they're gonna support aquaculture, and there needs to be major investment, which is what I've been working on for years on what needs to happen.*

The lack of supporting policies does not drive the industry forward, which reduces the investment companies will make to provide essential services to the aquaculture industry. Producers also called for state policy incentivizing aquaculture to address the need for a quality testing facility and processors. State policy incentivizing the aquaculture market would provide incentives for testing and processors to come to the region and allow aquaculture producers to expand their market and reduce costs. On the lack of processors in the state, one producer noted that, “I think it's the size of the industry. We don't have the industry that can support that."

Public Perception

Public perception negatively impacts Oregon producers. One of the main issues reported was that the greater Oregon public does not understand aquaculture and its potential benefits. Producers noted a need for more education and public awareness campaigns about aquaculture's sustainability and economic benefits. Finfish, shellfish, and aquaponics all carry different benefits and risks. The public needs to grasp better the actual risks associated with the industry to create a more inviting environment for aquaculture in Oregon. Producers reported that this lack of understanding leads to pushback against aquaculture investments, making obtaining funding and support from state and local governments more challenging.

Producers, however, also noted that where the industry is already established, local communities tend to be more supportive of aquaculture. Unfortunately, on a larger statewide scale, public perception can impact the state's willingness to invest in the industry. Therefore, it was suggested that efforts should be made to improve public perception and understanding of aquaculture in Oregon. This can lead to increased support from both the government and the public and reduce the associated barriers.

Oregon Findings

The findings for our producer interviews suggest that Oregon did not show a strong deviation from the wider U.S. aquaculture industry. Oregon producers face many of the same barriers that occur in all the states. Throughout the interviews we were looking for how Oregon may be different comparably to other States. Overall, States who showed more progress in overcoming barriers have invested in the aquaculture industry. This included things such as efficient permitting structures and investment in state policies that incentivize aquaculture. Chapter 5 of this report shows implementable strategies that Oregon can take to reduce barriers that can lead to increasing the aquaculture industry. These strategies were informed by the successful strategies discovered through the literature review and those reported to be effective by producers within states whose industry has increased in recent years.

4.5 Conclusion

Through analyzing the interview findings from various producers in the US, it is evident there are several challenges facing the current industry. The difficulty in streamlined permitting and regulations, coupled with low public perception has made it challenging for aquaculture businesses to thrive. Additionally, the need for market growth and the complexities of the

business dynamics in the industry pose significant obstacles for the growth and expansion of the aquaculture sector. Based on our findings, we conclude that ODA should work to streamline the permitting process and increase engagement with producers as well as the general public. Our recommendations on how ODA can accomplish this is further explained in Chapter 5.

Chapter 5: Strategies

This chapter focuses on possible strategies ODA can deploy to expand Oregon's aquaculture industry based on the findings presented in Chapters 3 and 4. These strategies require ODA to demonstrate its support to growing the aquaculture industry by increasing its budget, shifting staffing responsibilities, and potentially modifying or adding regulations. OAA will advocate for these strategies, but it is expected that ODA is the primary implementor. A full list of strategies distilled from interviews and the literature review beyond what is presented in this chapter can be found in Appendix E.

5.1 Criteria for Strategy Analysis

All strategies in this chapter have been analyzed against a set of criteria to assist ODA in its decisions and strategic planning in concert with other aquaculture stakeholders. A side-by-side comparison of each strategy against criteria can be found in the matrix in Appendix F. These criteria are based on interview responses and include the following:

- *Cost*: The annual cost for implementing the strategy. This includes costs such as funding, personnel, and technology to implement and is measured in USD.
- *Implementation period*: The approximate time it takes to implement the strategy.
- *Risk to ODA:* The type of risk posed to ODA in implementing the strategy. Possible risks include financial, regulatory, operational, reputational, and political. This is measured on a scale based on the extent of the risk by extent of low, medium, and high risk.
- *Farm Size Advantage:* Whether the strategy disproportionately affects aquaculture farms based on size. This is measured as a Yes/No.
- *Gender and race equity:* Whether the strategy promotes diversity and representation for aquaculture producers in Oregon. This is measured as a Yes/No.

For each analysis, our team used assumptions about how the strategy would be designed and implemented to create an "apples to apples" scorecard in Appendix F. As such, each analysis has a degree of uncertainty depending on the accuracy of those assumptions. It is recommended that ODA conducts further research into each strategy prior to selection to understand the full consequences of future implementation.

5.2 Overview of Strategies

Our team recommends that ODA pursues the following strategies: One-stop-shop, Aquaculture Commodity Commission, Market Access Expansion, Marine Spatial Planning, and Information Campaign. Table 6 provides an overview of each strategy including the barriers addressed, the ideal result, and any potential trade-offs with implementation.

Table 6: Overview of Strategies

	Barriers Reduced	Key Outcome	Key Tradeoff
One-stop Shop	Regulations and permitting, production costs	Efficient permitting system that reduces administrative burden and maximizes expediency.	High potential impact for increasing the industry's accessibility. Could require extensive resources and time to get started.
Aquaculture Commodity Commission	Regulations and permitting, public perception, production costs, market competition	Commission dedicated to expanding aquaculture comprised of industry experts.	Demonstrates ODA's commitment to expanding aquaculture. Requires legislative approval. Generating revenue for the commission could impact producers directly.
Market Access Expansion	Market competition, public perception, production costs	Expands public interest and promotes product and market development.	High potential to increase market growth and public perception. Requires significant investments and time to implement.
Marine Spatial Planning	Regulations and permitting, land and water use conflicts	Provides ODA a pre-determined data set that will allow an expedited permitting process for a specific aquaculture product.	High potential to increase efficiency around permitting for land and water use. Requires investment in personal and data management and could potentially reach beyond ODA's purview.
Information Campaign	Public perception	Improved public perception of aquaculture, which may lead to increased demand	Potential to lead to future aquaculture policy and investment. Does not address permitting barriers on its own.

In the rest of this chapter, the strategies are presented in rank order from highest to lowest based on what our team feels will make the most impact on Oregon's aquaculture community. We recommend that ODA implements all strategies to achieve the greatest growth of the industry. We believe that establishing an Aquaculture Commodity Commission first will significantly ease costs for some of the other strategies. The Commission can then lead the Information Campaign effort. An Information Campaign should come prior to any permitting changes because it will ideally result in buy-in from communities and policymakers and build momentum for the other strategies. We also recommend that Marine Spatial Planning should take place before establishing a one-stop shop because it will inform any future permitting processes and increase efficiency for the agency. More discussion regarding the different strategies is in the trade-offs section at the end of this chapter.

5.3 Strategies and Analysis

One-stop Shop

This strategy establishes ODA as the singular coordinating organization to facilitate a farm's aquaculture permitting and reporting. Interview findings indicate that navigating Oregon's permitting process is one of the biggest barriers new and long-time aquaculture producers face, and prevents further industry expansion. We propose this strategy include the following components:

1. *Create an online portal for licensing, permitting, and reporting:* ODA would develop an online portal that all fresh and saltwater aquaculture producers can use to access the information required for commercial permits and licenses. Such a system could even build upon the Oregon Explorer Tool and also allow an aquaculture producer to track the progress of their application as it moves from one approving agency to another. In the interviews, many producers stated that they faced the obstacle of needing to routinely interact with agencies because new or additional information was required for permits. Having one place where producers can supply information reduces the number of times producers must resubmit the same information to multiple agencies. Once information is supplied to the portal, applications should be automatically sent to the approving agency along with built-in reminders to encourage expediency. In addition, the portal would also be the central space for producers to fill out reports. This can include any survey information collected by NOAA or the Census of Aquaculture. One producer suggested that the portal serves these dual functions to increase accuracy of reliable data that can be used by agencies to enhance service delivery. Localizing reporting to one place could increase the likelihood producers respond to surveys because the producers would be familiar with the data collection mechanism.
2. *Hire a coordinating agent to monitor the portal and serve as the subject matter expert:* A coordinating agent would be hired to ensure applications get reviewed by agencies at a regular cadence to minimize waiting periods between stages of approvals. The agent would serve as a sort of client services representative for the portal and be the main

point of contact producers can reach with questions. Responses from interviews revealed that having an in-house agent that could be the subject matter expert of the permitting processes would both develop ODA's technical capacity regarding aquaculture and assist new producers with the steep learning curve of entering a heavily regulated industry. Some interview responses also requested that this coordinating agent be required to visit aquaculture farms as part of their scope of services to increase relationships between government agencies and the private sector. Mandatory site visits could also inform any future regulations or rules posed by agencies with local context. For example, ODA might be more inclined to standardize any county or city-level regulation to ease burden on Oregon producers wishing to expand business to other parts of the state.

3. *Bolster resources for producers:* A one-stop-shop for aquaculture could also serve as a learning hub for producers. Beyond permitting and regulating, the agency can share any resources or important information to the portal so that all registered producers can have access and increase the chance of visibility. Resources can include flow charts of permitting processes, notices about any changes to rules, or start-up guides for expanding to other production techniques or species. A couple of producers lamented at the lack of reliable information available to producers wanting to expand to newer aquaculture technologies. A singular portal can build up a library of resources over time that would strengthen Oregon's aquaculture foundation.

Criteria Analysis:

Cost: We estimate that creating a one-stop shop for aquaculture can cost anywhere between ***$112,000 and $1.5 million annually***. This large range accounts for the variety of ways this option has been implemented in other states. Cases where only a coordinator was hired tended to be cheaper whereas transitioning all aquaculture permitting into one state agency was more costly. More details on where these figures were derived from can be found in Appendix H.

Implementation period: The beginning of Oregon's fiscal year is July 1st and most biennium budgets for 2023-2025 are currently being fine-tuned before legislative approval. If funds to hire a coordinator have not yet been included in the budget, there will be a delay in implementation. Once the budget is approved, drafting a job description for a coordinator, posting the position, conducting interviews, and issuing a final offer can take anywhere from 2-5 months. Building an online portal, pre-testing its functionality, and transferring existing licenses over to the new system can take between 18 months and three years. In total, it is estimated that this option would take between ***5-7 years*** to fully implement.

Risk to ODA: This option poses a ***high financial risk*** to ODA, as they would fully fund this option through repurposing funds in its own budget, acquiring funds from ODFW if some permitting responsibilities are transferred, or finding additional revenue streams including requesting new resources from the legislature. This option also has ***low to moderate political risk*** depending on

whether there will be any shifts of funds or responsibilities between ODA and ODFW through the legislature. There are ***low safety concerns*** for producers or consumers because ODA also houses the Food Safety Program and can build synergies with the one-stop shop. Finally, there is ***low reputational risk*** because aquaculture producers would welcome streamlined permitting.

Farm Size Advantage: Establishing a one-stop shop would benefit smaller producers because there would be greater expediency in the permitting process that traditionally larger producers can handle due to their financial and human capital. This criterion receives a **Yes** because it provides smaller producers with an advantage.

Gender and Race Equity: A one- stop shop does not explicitly promote diversity in the aquaculture industry, because it is a strategy that targets all producers. *T*his criterion receives a ***No***.

Aquaculture Commodity Commission

We recommend ODA partners with OAA to identify and collaborate with key state legislators to draft a bill that establishes an aquaculture commodity commission under ORS 576.062 (Establishment of Commodity Commissions, 2009). Oregon does not currently have a commodity commission that promotes aquaculture, even though 23 commissions currently exist that support other types of agriculture (Oregon Department of Agriculture, 2023). Commissions are under ODA oversight within the Market Access Program and are tasked with being "active in the political-economic field to safeguard the interests of their commodity by A) being aware of legislation that will curb certain industry activities as well as B) legislation that benefits the industry" (Groder & Garoian, 1968). Commodity commissions also develop goals and policies that expand respective industries, acquire grants for research and development, and study legislation that would affect producer interests (Groder & Garoian, 1968). Establishing a commodity commission for aquaculture would demonstrate state support in expanding the industry and align public and private interests through shared goals and program development. If a bill is passed, activities for ODA include:

1. *Appointing commission members:* Under ORS.206, ODA would have the power to appoint five temporary members to the commission until the governor appoints permanent positions (Appointment of Temporary Members, 2009; *Boards and Commissions*, 2023) This process would provide an opportunity for the Director of Agriculture to connect with Oregon aquaculture producers, laying the foundation for future partnerships and building trust between the public and private sectors.
2. *Review and approve commission plans and projects:* ODA would have the authority to review any projects put forward by the aquaculture commission and ensure that those plans are "factual, not disparaging to other commodities, and consistent with the purposes of ORS 576.051" (Department Oversight of Commodity Commissions, 2009). Reviewing the proposed projects would inform the department of any shifts in research

and development towards new aquaculture production techniques and provide staff greater access to deep technical expertise brought in by commission members.

3. *Encourage cooperation among commissions:* As the governing body of all commissions, ODA would be aware of any possible synergies between the aquaculture industry and other commodities (Department Oversight of Commodity Commissions, 2009). This "birds-eye view" could be used to prioritize interventions that benefit multiple commodities and expand impact. Cooperation could also be bolstered between commissions that support commercial fishing and aquaculture, thereby reducing poor public perception towards seafood and increasing awareness of climate impacts in oceans.
4. *Review and approve commission budgets:* The Director of Agriculture would review and approve of the aquaculture commodity commission's annual budget. This approval power ensures that the commission will prepare its budget in accordance with ORS 576.416 and that the public will have a chance to weigh in on budget items in a public hearing (Preparation of Commission Budget, 2009). Hearings are critical for receiving input from stakeholders and would increase ODA's transparency with the public.

Criteria Analysis:

Cost: It is projected that managing a new aquaculture commission would annually cost ODA between **$15,000 and $20,000** (Appendix G). Commissions are responsible for securing their own funds each year and developing annual budgets based on projected activities. The cost of this option is low because ODA would only be providing oversight to the commission and supporting annual budget review. ODA might need to generate additional revenue to cover this cost such as repurposing funds or requesting a tax.

Implementation period: This option requires a bill to be proposed and signed into law by Oregon's state legislature. The implementation period of establishing an aquaculture commodity commission can be lengthy, given the series of obstacles it can take to pass a bill. One of the most recent authorizations of a commodity commission in Oregon was for hemp under HB2284. HB2284 had its first reading January 11th, 2021, and was signed into legislature September 25th, 2021 for a process of eight months (*Establishes Oregon Hemp Commission*, 2021). This time does not include any pre-work of aligning stakeholder interests and bill drafting. Therefore, this option is estimated to take *8-12 months*.

Risk to ODA: Establishing a commodity commission is not a new practice in Oregon. From a financial perspective, commodity commissions obtain their own funds through other sources so the only financial burden ODA would be responsible for is the marginal increase in administrative oversight costs. Politically, ODA already has demonstrated effective governance of the established 23 commissions so an additional unit would not expand any new scopes of services offered. There is a slight risk that ODA would achieve a more biased reputation

towards aquaculture through this option, but that risk is quite minimal given that it has a wide variety of commissions under its jurisdiction. All risk types for this option are ***low***.

Farm Size Advantage: This option does not give advantage to either small or large-scale producers unless there were specific criteria used by the Director of Agriculture when appointing temporary commission members ahead of the governor's selection. As such, this criterion receives a ***No***.

Gender and Race Equity: Projects or policies promoted by the commodity commission might result in greater access to the aquaculture industry by less represented groups, but that implication is not contingent on forming the commission itself. Therefore, this criterion receives a ***No****.*

Market Access Expansion

This recommendation establishes a public-private partnership among ODA, ODFW, and private farms to promote aquaculture production in Oregon through funding allocated to the ODA's Market Access Program. The ODA Market Access Program currently provides assistance to Oregon farmers to promote market and product development, but some producers and private farms are not included in their list of industry partners. By creating *Market Access Expansion* between ODFW and private hatcheries, ODA can expand public interest, show areas of opportunity for other investors, and support the development of the aquaculture industry in Oregon (Weirowski & Hall, 2008). Starting a public-private partnership for aquaculture in Oregon would involve the following steps:

1. *Identifying Potential Partners:* The first step to establishing a public-private partnership between ODFW and private hatcheries would be to identify potential producers, academic institutions, and non-profit organizations that have a shared interest in developing and promoting aquaculture in Oregon as well as incentivizing food safety labs for meat processing. The partnership would also result in hiring a fish pathologist or extension agent in ODA who is available for producer emergencies. The partners would then work alongside ODFW and ODA to identify the desired economic and environmental outcomes to finalize the types of aquaculture activities that need to be supported.
2. *Establishing Governance & Funding Mechanisms:* The funding for this partnership would largely come from the ODA's Market Access Program; private sector partners should not carry significant financial burdens in this partnership. However, ODA should establish a governance structure for the partnership, including decision-making processes and funding mechanisms that can be expanded upon. This may include creating a joint management committee or an advisory board to oversee the partnership's activities and allocate funding based on each biennium.
3. *Implementation & Evaluation of Progress:* Once the partnership is established, it would begin implementation in supporting areas such as food safety and quality, supply chain management, and capacity building around aquaculture practices in Oregon. The partners would also regularly monitor and evaluate the partnership's progress towards its goals and adjust as needed to ensure its success.

Criteria Analysis:
Cost: Implementing the Market Access Expansion program will cost approximately ***$69,000 and $2.4 million annually*** depending on the number of producers ODA agrees to work with. Each partnership would require initial legal fees for developing an agreement, plus ongoing costs for both parties to attend meetings and any additional amount for projects undertaken by the partnership. These costs could be subsidized by grants or investments made by third parties. An example budget for this recommendation can be found in Appendix G.

Implementation Period: In general, the process of establishing a public-private partnership for aquaculture practices can range from several months to several years. The length of time it would take to establish an *Market Access Expansion* will vary depending on the size and scope of the partnership, funding availability from ODA, the number of stakeholders involved, and the level of planning and coordination required. While the exact timeline will depend on a variety of factors, it is important to allocate sufficient time and resources to ensure that the partnership is established in a way that is effective and sustainable over the long term. Therefore, Market Access Expansion is estimated to take 2-6 years to implement.

Risk to ODA: Market Access Expansion poses a ***high financial risk*** to ODA because they would initially need to use funds from their Market Access program to establish marketing and interest surrounding the partnership. However, as time goes on, this risk would decrease due to potential investments from the private sector. These investments will improve cost-effectiveness by taking advantage of the private sector and allowing ODA to take on a regulatory role that focuses on planning and monitoring food safety services (Weirowski & Hall, 2008). Due to the potential for private hatcheries to form partnerships with public institutions to support education and research, public-private partnerships have a ***low political and safety risk***. Since these partnerships require collaboration across various sectors, there is a ***medium reputational risk*** associated with this partnership if ODA is unable to incentivize multiple public and private sector partners.

Farm Size Advantage: Although a public-private partnership has the opportunity to improve capacity building and accessibility around aquaculture in Oregon, of the 40 private farms in Oregon smaller producers will likely have less time and resources to devote into the partnership. This ultimately gives an advantage to larger producers. Therefore, this criterion receives a ***Yes***.

Gender & Race Equity: A public-private partnership through ODA would expand public interest, increasing interest for demographics who previously were not involved in aquaculture due to barriers such as around food safety processing. This criterion receives a ***Yes***.

Marine Spatial Planning

We recommend ODA partners with the Department of Land Conservation and Development (DLCD) to create an Aquaculture Marine Spatial Tool within their Coastal Management Program. Marine spatial planning (MSP) is a process that is used to identify and understand the distribution of human activities in the marine environment, including aquaculture. ODA can use

MSP tools developed under the Oregon Coastal Management Program to allocate suitable areas for aquaculture and streamline the permitting process for growers. This option would involve creating a decision framework that integrates information such as any chosen ecological, economic, and social factors that are crucial for identifying areas for aquaculture use in Oregon and integrating that into Oregon's Ocean Planning program. Additionally, the process would also involve consultation with Oregon stakeholders to ensure that the plan is fair and equitable among communities. ODA, using MSP, can make informed decisions to permit growing specific aquaculture products in certain areas or regions and ensure that the process is more efficient, and reduce conflicts with other marine uses.

ODA and the Department of Land Conservation and Development would need to develop a comprehensive MSP plan for aquaculture in Oregon. Spatial data and maps are already available through Oregon's other MSP initiatives. Inshore spatial data and permitting information for aquaculture already is available through the Oregon Explorer tool, which could be incorporated. ODA, DLCD, and other participating agencies will also need to gather any additional data and information not already gathered by other sources on factors such as water quality, land use, marine ecology, and social impacts. The gathered information then would be analyzed using the MSP tools to create interactive maps showing the most appropriate locations for specific aquaculture products. Stakeholders, including local communities, industries, conservation organizations, and governmental agencies, would also be consulted. Potential land use or social conflicts might be identified with the aid of this consultation process, which would also guarantee that the wants and concerns of all stakeholders are considered.

ODA can streamline the permitting process for aquaculture growers based on information within the MSP tools once implemented. The MSP will identify areas that are suitable for aquaculture products, ODA then can prioritize permitting in these areas and reduce the time and costs associated with the permitting process. Additionally, the MSP plan can also help to improve the sustainability of Oregon's aquaculture industry. The MSP policy can help to reduce the environmental impacts of aquaculture and ensure that the industry operates more sustainably.

**Any nearshore or offshore aquaculture activities within this tool will require additional actions to be incorporated into Oregon's Territorial Sea Plan before ODA could fully utilize the tool.

Criteria Analysis:

Cost: The cost of Marine Spatial Planning could range from **$127,000 and $2.7 million annually**, depending on the amount of geospatial data the Department of Agriculture already has on file. Grants could also subsidize this option or cost-sharing could be potentially explored with the DLCD. Our team found little evidence of program budgets associated with this activity except for a case study in Washington State that set up an MSP tool for coastal management.

Washington's coastal management plan remained stagnant until a budget infusion of 2.1 million dollars occurred (Trosin et al. 2016). Our team speculated potential costs that could be associated with MSP in Appendix G.

Implementation period: Implementing the MSP option will depend on multiple factors, such as the complexity of the MSP tools, the currently available data and information, and the extent of stakeholder consultation. Due to this, developing and implementing the MSP policy in Oregon may take several years before ODA can plan aquaculture projects with the tool. However, it is essential to note that the MSP policy is a solution that can provide significant benefits for the state of Oregon over time. The benefits of the MSP plan include more efficient permitting, sustainable aquaculture practices, and economic growth which will outweigh the initial cost of implementation. It is estimated that implementing this option would take approximately *five to eight years.*

Risk to ODA: Risk is associated with ODA and DLCD implementing an MSP tool for aquaculture. Some potential risks to ODA to consider include potential legal challenges from stakeholders who feel that their needs or concerns have not been addressed, opposition due to the negative public perception from stakeholders who disapprove of aquaculture, and difficulty in accurately predicting the environmental impacts of aquaculture activities in certain areas due to lack of data. However, these risks can be mitigated by engaging with stakeholders early in the process and developing a comprehensive and transparent MSP plan that considers the needs of all stakeholders. Additionally, given DLCD has experience in MSP will reduce potential risks. This criterion receives ***low*.**

Farm size advantage: The implementation of this strategy could have implications for farm size advantage, as it could prioritize permitting in areas that are most suitable for larger aquaculture producers. *Farm size advantage:* The implementation of this strategy could have implications for farm size advantage. This could benefit larger aquaculture operations with the resources and capacity to operate in these areas, while smaller operations may struggle to compete for permits in certain areas. This criterion receives an **Uncertain**.

Gender and race equity: The MSP plan can promote economic growth and job opportunities in coastal communities, which would benefit women and minority groups who may face barriers to employment and economic opportunity that are not currently present in the region. This criterion receives a ***Yes***.

Information Campaign

This strategy creates an information campaign to improve the public perception of aquaculture. Interview findings indicate a perception among producers that negative public perception of aquaculture is a barrier on multiple fronts. Some people view fish food produced via aquaculture as less healthy than wild fish, and others view aquaculture in general to have serious environmental and health problems. A public information campaign could help better inform individuals with either of these beliefs to hopefully improve the perception of

aquaculture. Improved public perception could lead to greater demand for aquaculture products, as well as increased political support for favorable aquaculture policy and expansion of aquaculture investment.

This public campaign would be led by ODA (although much or all of the tasks in this strategy could be contracted out to a marketing company) and would involve two main components:

Media Outreach: ODA would use multiple media to disseminate information covering the science of aquaculture and some of the common misconceptions. This media could also present aquaculture-produced food in a more positive light. ODA's website could house a section on aquaculture that covers misconceptions and provides useful links to more in depth scientific and industry sources. ODA's website could also highlight Oregon's aquaculture producers to better show where customer's food is coming from. ODA could use social media to more easily spread positive messages related to aquaculture, including recipes using aquaculture produced fish, biographies of local producers, and condensed scientific information covering misinformation on aquaculture. Lastly, ODA could also include TV advertisements that showcase local producers and quickly cover aquaculture misconceptions. For both the social media and the TV advertisements, ODA could specifically highlight aquaculture producers who are women and/or people of color.

Local Events and Connections: ODA could help partner local aquaculture producers and local seafood eateries to host small food festivals focused on aquaculture products. These events would be used to show Oregon residents the benefits of aquaculture and hopefully help to increase associations with health and sustainability. These events could be focused on areas where there is known environmental pushback to aquaculture. Besides general events, ODA should coordinate with aquaculture producers to help put on small events on college campuses in Oregon. These events could contain food from aquaculture and experts speaking about the science of aquaculture. These events would be focused on improving the public perception of aquaculture for younger Oregon residents in particular, as they often have more questions about where their food comes from (Chase, 2022).

Criteria Analysis:

Cost: An Informational Campaign on aquaculture would cost ODA between **$35,000 and $750,000 annually**. A campaign can range in expenses depending on the frequency and size of outreach, available expertise in-house, and the recyclability of past campaign materials. Campaigns can result in higher demand for the product and incur a positive Return on Investment (ROI). For example, the Department of Agriculture invested $526 million for dairy ads, including slogans like 'Got Milk?' and 'Milk Life', that increased sales eight-fold (Dalzell, 2021). The assumptions behind this range and examples of these costs can be found in Appendix G.

Implementation period: This option's implementation period would vary based on when the biennium budget cycle starts in relation to the biennium cycle. At the minimum, it would take two years for new funding to be added to the budget and for ODA to work on planning the details of the option. If this recommendation is chosen right after a budget has been put in place, this process will take the full two years just to be included and approved in the budget. Depending on how much of the media outreach can be completed in-house versus contracted out, the total information campaign should take between one and two years to be completed after it is funded. This includes hiring or contracting any media employees, coming up with the outreach plan, producing the media, and planning the events. Some of these pieces could be completed before a new budget is approved if ODA has any funds that could be re-allocated from existing outreach and marketing programs. It is estimated that in total, this option would take *2-4 years* to fully implement.

Risk to ODA: This option poses a ***moderate to high financial risk*** to ODA. This is dependent on the size of the informational campaign and how much funding can be added to ODA's budget. The risk is if the campaign is costly with limited or no associated increase in public perception of aquaculture. This option has a ***moderate political risk*** based on the likely need to increase ODA funding for the budget that includes the informational campaign. There could be political pushback on whether aquaculture needs a public campaign and whether ODA should focus its efforts on aquaculture safety. There is ***low reputational risk*** because aquaculture producers would be more favorable to ODA with increased focus on aquaculture. There may be some reputational risk coming from a small group of adamant aquaculture detractors, but this would be low.

Farm Size Advantage: This strategy would not give advantages to either small or large producers because this option should improve public perception of aquaculture across the board. This criterion receives a ***To be Determined***.

Gender & Race Equity: This option is focused on the consumers of aquaculture and is not focused on increasing the diversity of producers. Therefore, we gave this criterion a ***No***.

5.4 Trade-Offs

All strategies presented would reduce barriers faced by aquaculture producers, but none can be considered a 'silver bullet' so we recommend ODA implements all of them. As mentioned above, we suggest ODA starts by advocating for an Aquaculture Commodity Commission and then jointly work with the Commission to spearhead an Information Campaign to develop buy-in for future strategies. We also think it is important for ODA to undergo Marine Spatial Planning before creating a one-stop-shop to streamline permitting and regulations. Additional strategies ODA can explore in collaboration with OAA can be found in Appendix E. ODA would be well served by further financial analysis on each recommendation, depending on how strategies are designed and implemented.

Both a one-stop-shop and Market Access Expansion would increase access for new producers to the industry and potentially decrease any gender or race disparities depending on how benefits are distributed. The one-stop-shop is the only strategy out of the five that would directly benefit smaller producers by streamlining permitting processes and reducing resources required to operate commercially. The MSP strategy also has the potential to make permitting more efficient depending on the decision-making that results from data supplied by the map.

Market Access Expansion and the establishment of a commodity commission are two methods that ODA can use to collaborate with producers, technical experts, and other agencies. This collaboration is especially fruitful for developing mutual goals and aligning strategies to boost efforts and synergies among the various stakeholders. The Market Access Expansion program would be easier to implement than a commodity commission because it would not necessarily require approval through the legislature. However, a commodity commission would be self-funded, and the oversight ODA would need to provide is relatively straightforward given ODA's role with other agriculture commissions.

Two strategies that could reduce the barrier of public perception are establishing a commodity commission and an information campaign. Members of a commodity commission are responsible for being aware of legislation that might affect the interests of the aquaculture sector and can work with state actors to be mindful of the local context. Similarly, an information campaign might make policymakers more attuned to challenges producers face and to dispel any myths that would sway political action. The campaign's impact would be particularly strong if implemented in areas where future production might take place in order to reduce the chance of any permit appeals. A successful MSP strategy could also assuage some concerns by environmental groups about reducing the chance of invasive species and the spread of disease. MSP could also have powerful impact on public perception if the data is used to designate where particular species should be grown based on criteria of reducing environmental harm and preserving meaningful connections between tribal communities and the natural environment.

An MSP can also bolster carbon mitigation and enhance adaptation against climate impacts. Findings from the MSP could indicate where certain species should be grown together to foster production, increase biodiversity and ecosystem health, and provide protection against climate impacts. In particular, this strategy should provide insight into the relationship between eelgrass and shellfish. Similarly, the Market Access Expansion strategy could be used to test different feed using ODFW's public hatcheries. If there are types of feed that can make fish populations stronger and more resistant to disease, a public-private partnership could easily share findings of any feed research with private hatcheries.

5.5. Conclusion

The strategies outlined for ODA offer various approaches to promoting the growth and development of the aquaculture industry in Oregon. By implementing these strategies, ODA can help streamline the permitting process, improve market access through public-private partnerships, enhance the public perception of aquaculture, establish legislative support through a commodity commission, and support sustainable development through creating a Marine Spatial Mapping Tool. The implementation of these strategies has the opportunity to contribute to the growth and success of Oregon's aquaculture industry by creating new economic and collaborative opportunities for stakeholders and ODA.

Appendix A: Aquaculture Producer Demographic Survey Questions

Identity Profile Questions (Optional)

1. Identify your age range
    a. Under 18
    b. 18-24
    c. 25-34
    d. 35-44
    e. 45-54
    f. 55-64
    g. 65+
2. Identify your race
    a. White
    b. Black or African American
    c. Hispanic or Latino
    d. Asian or Asian American
    e. American Indian or Alaska Native
    f. Native Hawaiian or other Pacific Islander
    g. Another race
3. Identify your sex
    a. Male
    b. Female
    c. Prefer not to respond
4. Identify your gender
    a. Woman
    b. Man
    c. Transgender
    d. Non-binary/non-conforming
    e. Prefer not to respond
5. Identify your sexual orientation
    a. Straight
    b. Gay
    c. Lesbian
    d. Bisexual
    e. Prefer not to respond
6. Which of the following bodies of water do you produce in? Check all that apply
    a. Freshwater
    b. Saltwater
    c. Estuary
    d. Other (please specify)
7. Which of the following aquaculture products do you produce? Check all that apply
    a. Mussels
    b. Oysters

    c. Mollusks
    d. Trout
    e. Catfish
    f. Tilapia
    g. Salmon
    h. Other (please specify)
8. How many people are employed with your aquaculture farm?
    a. Between 0 and 5
    b. Between 6 and 10
    c. Between 11 and 15
    d. 15+

Appendix B: Aquaculture Producer Interview Guide

Introduction script:

Thanks for agreeing to meet with me today for this interview! My name is [insert name] and I am a graduate student at the University of Washington working on a capstone project for the Oregon Aquaculture Association. We are trying to better understand barriers aquaculture producers face and the possible strategies that can be deployed to overcome them. We are very interested in hearing about your personal experience with the aquaculture industry.

I have questions prepared that I expect will likely take us between 30 min to an hour to move through, but we can skip some as time allows. I will be recording this Zoom session for my fellow team members, but please know that we'll be deidentifying all responses and will delete the recording and transcripts at the beginning of June when the project ends.

At the end of our time together, I will put a link to a quick demographic survey in the chat that I request you fill out immediately after we finish our call. This 2-minute survey will help our team have a better picture of who we are interviewing and how everyone engages with the aquaculture industry. Let's get started!

Survey Link: https://www.surveymonkey.com/r/YFRY5R2

Interview Questions:

Remember to be curious. As these are semi-structured interviews - if something is brought up that is interesting ask more about it.

General Questions:

1. How long have you been in the aquaculture business? What drew you to start an aquaculture business?
    a. Prompts:
        i. New or previous experience in the industry?
        ii. Investment potential?
2. Did you face any barriers (i.e., an obstacle which prevents or limits your ability to conduct an aquaculture business) when you initially started your business?
    a. Prompts:
        i. permits
        ii. land use or plats
        iii. regulations (federal, state, local)
3. Do you currently perceive any barriers now that you have established your business that are impacting your company and profits?
    a. Prompts:
        i. permits
        ii. land use or plats
        iii. regulations (federal, state, local)
4. Do you have plans to expand your business?
    a. What barriers do you encounter if you want to expand?
    b. What aquaculture products do you anticipate expanding into?

5. Does your company produce aquaculture in another state? If yes, what states and did you encounter similar barriers?
6. Are you worried about climate related events impacting your business? Or have they already?
    a. What types of events are you worried about?
    b. Prompts:
        i. Ocean Acidification
        ii. Intense and more frequent storms
        iii. Sea-level Rise
        iv. Hypoxia
        v. Invasive Species

Policy Questions:

1. From your perspective, did your state or local government change any policies that helped incentivize aquaculture?
2. Did you find any state/local government programs or tools especially helpful?

Improvise any specifics given the response to the previous barrier questions.

Market Questions:

1. From your perspective, what is the state of the aquaculture market in your state?
    a. Do you find the market for aquaculture expanding, shrinking, or remaining steady?
    b. Are you encountering increased competition?
2. What is the process for you to get your product to market (i.e., direct to consumer, third party processors/distributors)?
    a. Do you encounter any barriers that make this process more difficult?
3. How did you initially get access funding to start your business?
    a. Prompts:
        i. Was this a difficult process? What barriers caused this?
        ii. Now that you have gone through this process, do you have a specific recommendation to increase access to funding?

Culture Questions:

1. Do you find people in your community support your business? What is the perception of Aquaculture in your state and community?
    a. Prompt:
        i. In your opinion, is there a solution to the negative perception of aquaculture.
        ii. In your opinion, why do people in your state perceive aquaculture in a positive light.

Strategies (5-7 min)

1. Are there any strategies you would recommend for agencies, policymakers, or advocacy groups to take in order to overcome any of the barriers we talked about today?

2. What would you like agencies to take into account when developing these strategies?

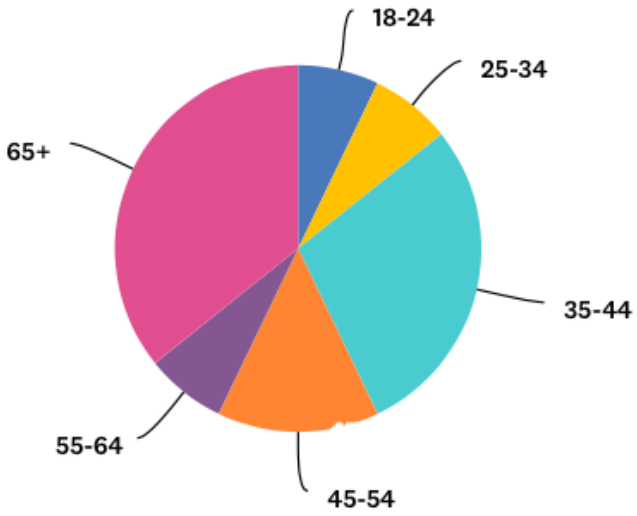
Wrap Up (5 min)

1. Is there anything else you would like to add that we haven't covered here today?
2. Is there anyone else you would suggest we reach out to in order to better understand these barriers?

Appendix C: Aquaculture Producer Survey Results

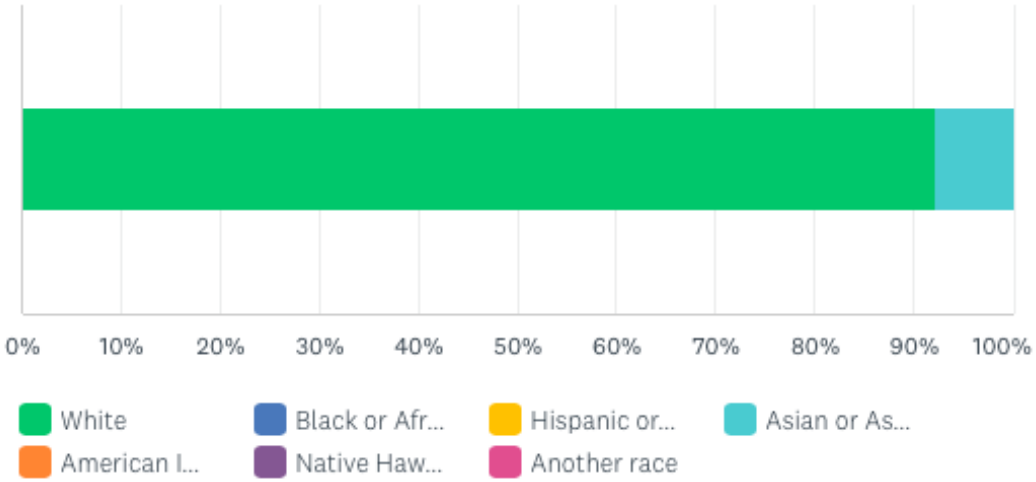
This survey was administered through Survey Monkey with 14 total respondents. The survey was given to producers directly following their interview. The aim of this survey was to understand the demographics of the producers interviewed by our team.

Question 1: Identify your age range.



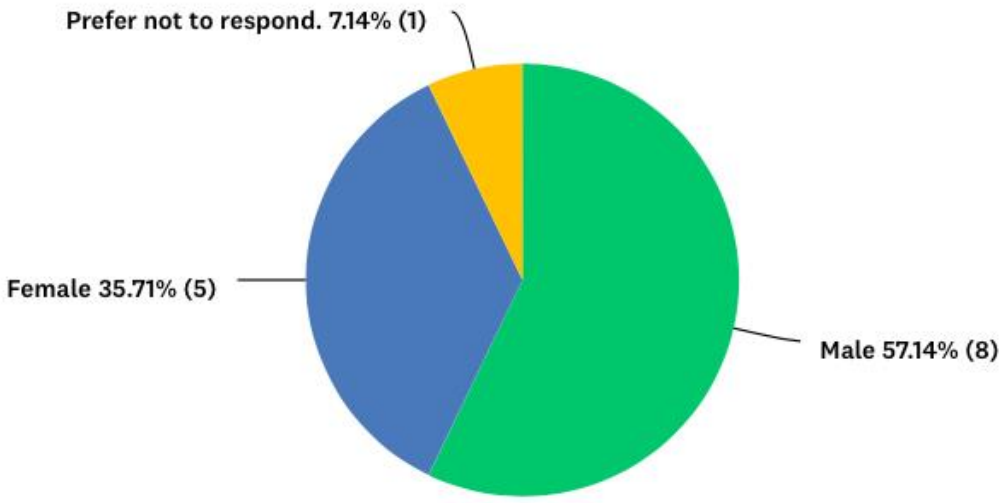
Answer Choices	Percentage	Responses
Under 18	0%	0
18-24	7.14%	1
25-34	7.14%	1
35-44	28.57%	4
45-54	14.29%	2
55-64	7.14%	1
65+	35.71%	5
Total	-	**14**

Question 2: Identify your race.



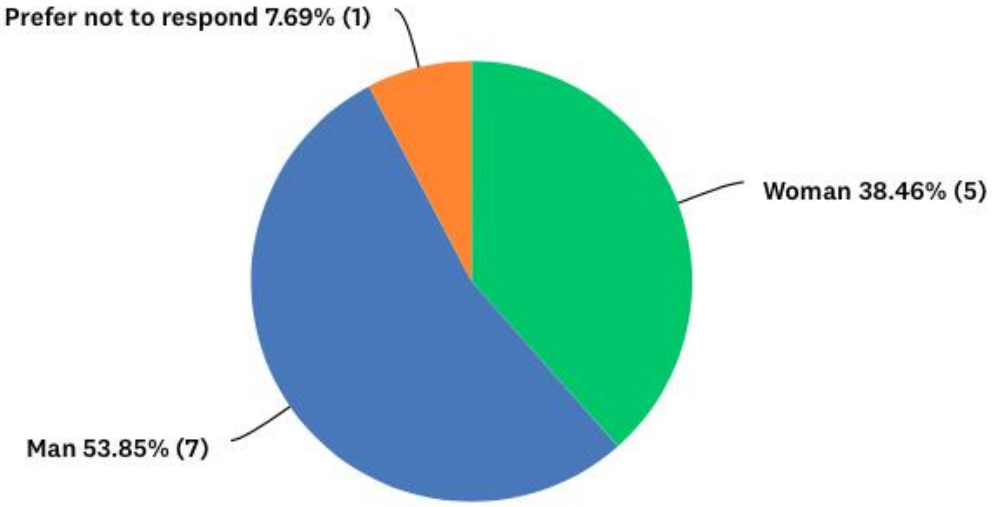
Answer Choices	Percentage	Responses
White	92.31%	12
Black or African American	0%	0
Hispanic or Latino	0%	0
Asian or Asian American	7.69%	1
American Indian or Alaska Native	0%	0
Native Hawaiian or other Pacific Islander	0%	0
Another race	0%	0
Total	-	**13**

Question 3: Identify your sex.



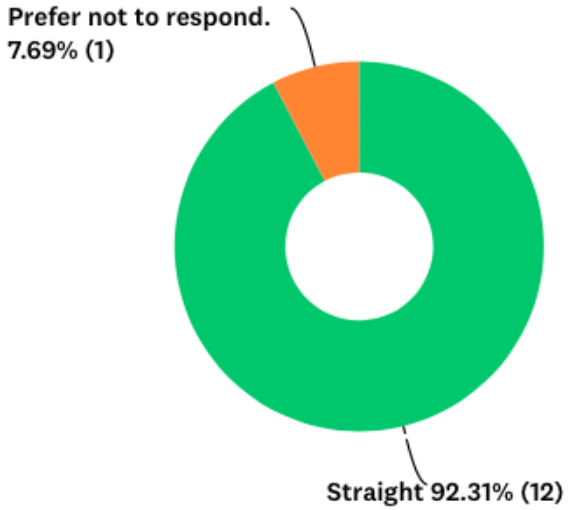
Answer Choices	Percentage	Responses
Male	57.14%	8
Female	35.71%	5
Prefer not to respond	7.14%	1
Total	-	**14**

Question 4: Identify your gender.



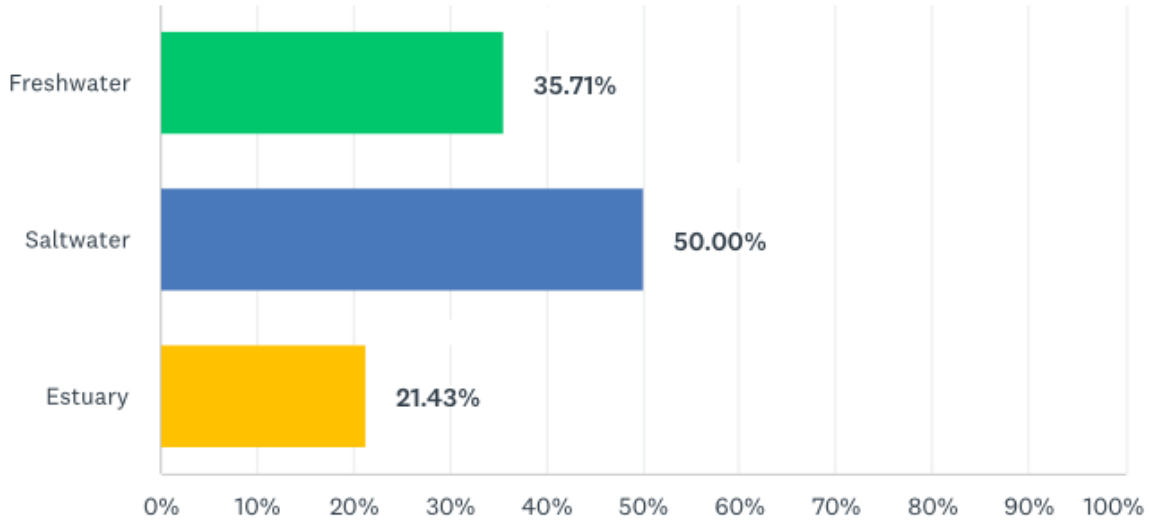
Answer Choices	Percentage	Responses
Woman	38.46%	5
Man	53.85%	7
Transgender	0%	0
Non-binary/non-conforming	0%	0
Prefer not to respond	7.69%	1
Total	-	**13**

Question 5: Identify your sexual orientation.



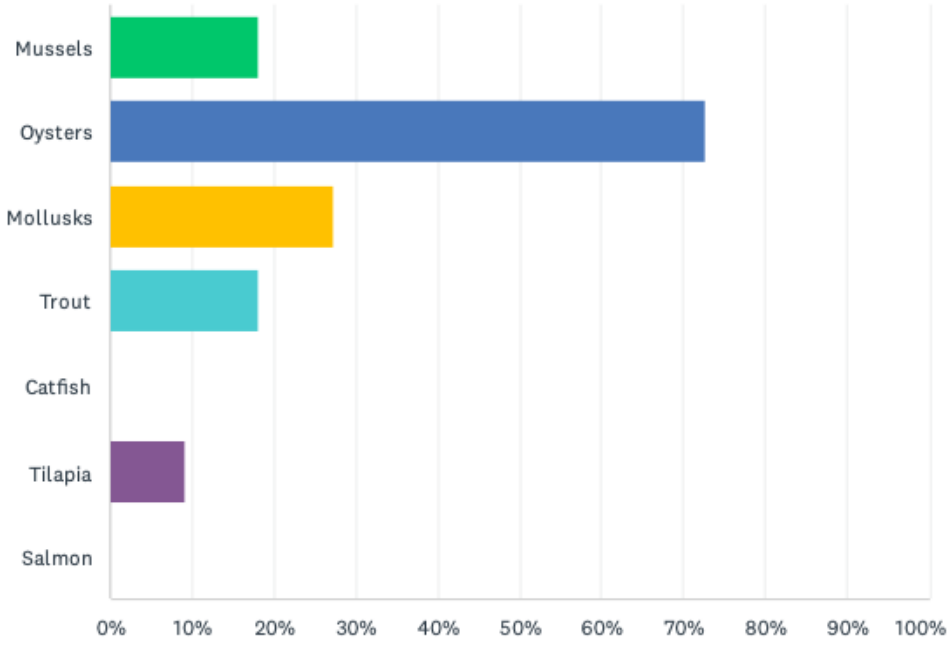
Answer Choices	Percentage	Responses
Straight	92.31%	12
Gay	0%	0
Lesbian	0%	0
Bisexual	0%	0
Prefer not to respond	7.69%	1
Total	-	**13**

Question 6: Which of the following bodies of water do you produce in? Check all that apply.



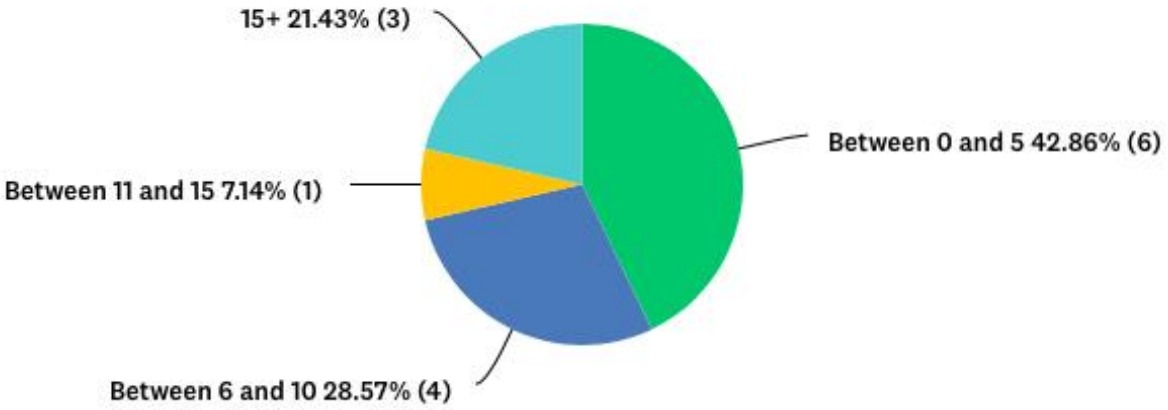
Answer Choices	Percentage	Responses
Freshwater	35.71%	5
Saltwater	50.00%	7
Estuary	21.43%	3
Total	-	**14**

Question 7: Which of the following aquaculture products do you produce? Check all that apply.

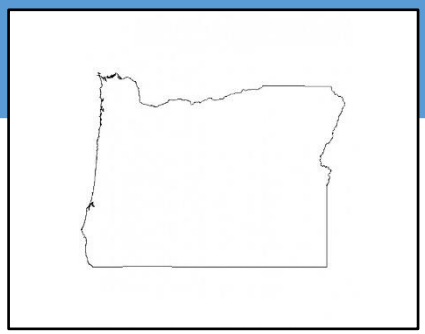


Answer Choices	Percentage	Responses
Mussels	18.18%	2
Oysters	72.73%	8
Mollusks	27.27%	3
Trout	18.8%	2
Catfish	0%	0
Tilapia	9.09%	1
Salmon	0%	0
Total	-	**13**

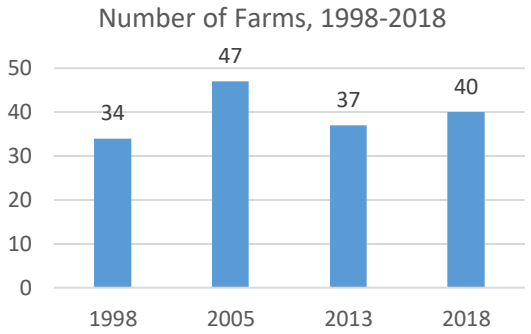
Question 8: How many people are employed with your aquaculture farm?

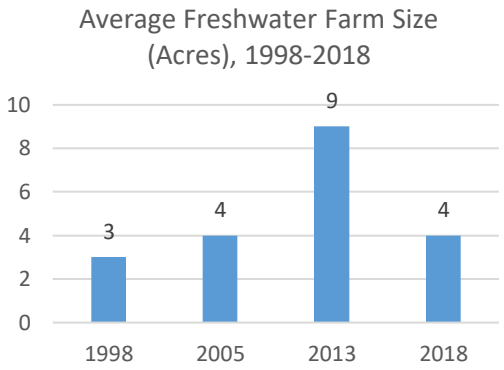


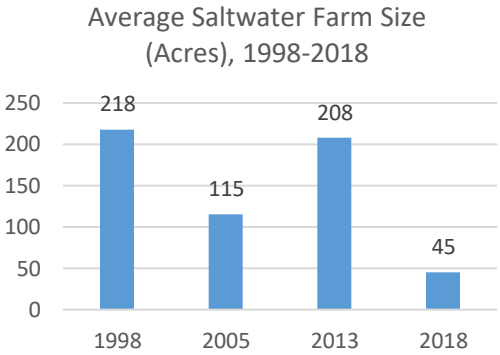
Answer Choices	Percentage	Responses
Between 0 and 5	42.86%	6
Between 6 and 10	28.57%	4
Between 11 and 15	7.14%	1
15+	21.43%	3
Total	**-**	**14**



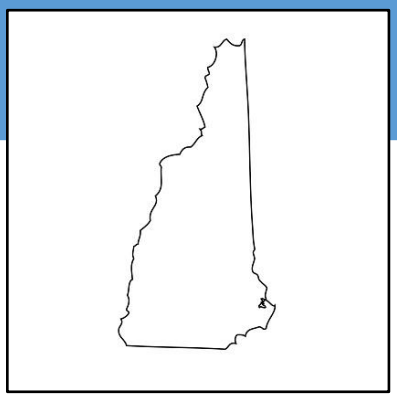
Total Overview 2018 and percent change since 2013	2018	% change
Number of farms	40	8
Saltwater farms	15	-12
Freshwater farms	25	25
Annual Sales ($1,000)	23,668	95
Production Techniques	(Farms)	
Ponds	18	29
Flow Through Raceways	10	25
Recirculating Systems	7	250
Non-Recirculating Systems	8	60
Cages or Pens	0	0
Aquaponics	4	0
Cropland used for Crawfish	0	0
Mollusks on bottom	12	-20
Mollusks off bottom	13	225
Product	(Farms)	
Food fish	18	20
Sportfish	4	33
Baitfish	0	0
Crustaceans	0	0
Mollusks	15	-12
Ornamental Fish	3	-25
Miscellaneous Aquaculture	0	0
Online registration system		No
Monitoring Tool		Yes
One-stop-shop		No
Best Management Practices		No





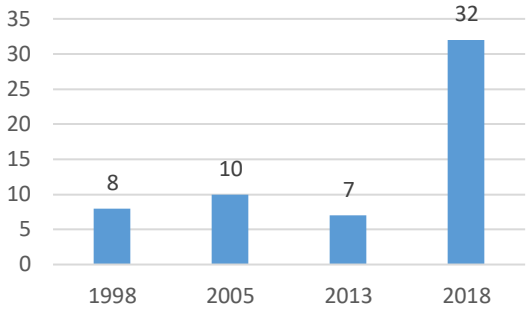


Agency for permits: Department of Agriculture, Department of Fish and Wildlife
Additional resources: Oregon Aquaculture Association, Oregon Aquaculture Advisory Group, Oregon Explorer Tool, West Regional Aquaculture Center (WRAC), Pacific Coast Shellfish Growers Association

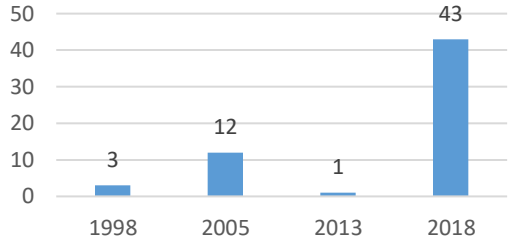


Total Overview 2018 and percent change since 2013	2018	% change
Number of farms	32	357
Saltwater farms	21	2000
Freshwater farms	17	143
Annual Sales ($1,000)	950	25
Production Techniques	(Farms)	
Ponds	1	0
Flow Through Raceways	13	550
Recirculating Systems	3	-50
Non-Recirculating Systems	8	100
Cages or Pens	10	0
Aquaponics	0	-100
Cropland used for Crawfish	0	0
Mollusks on bottom	14	0
Mollusks off bottom	15	0
Product	(Farms)	
Food fish	4	0
Sportfish	0	0
Baitfish	0	0
Crustaceans	3	200
Mollusks	18	0
Ornamental Fish	1	-67
Miscellaneous Aquaculture	2	100
Online registration system		Yes
Monitoring Tool		Yes
One-Stop-Shop		No
Best Management Practices		Yes

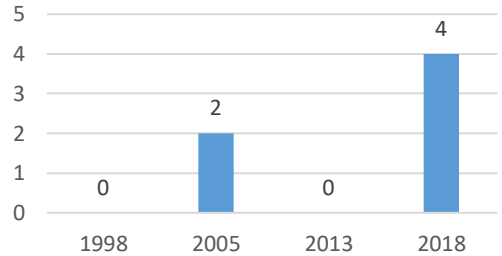
Number of Farms, 1998-2018



Average Freshwater Farm Size (Acres), 1998-2018

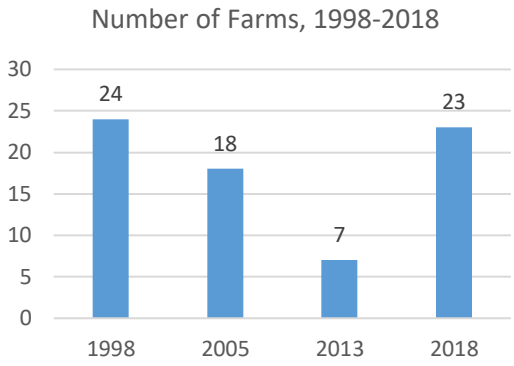


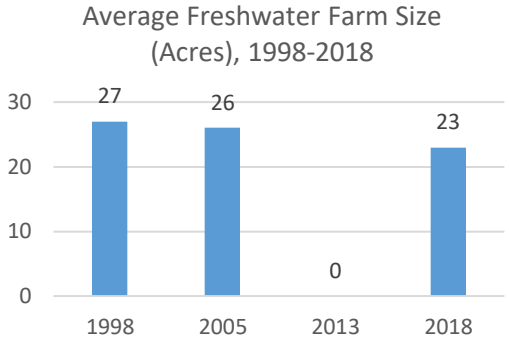
Average Saltwater Farm Size (Acres), 1998-2018

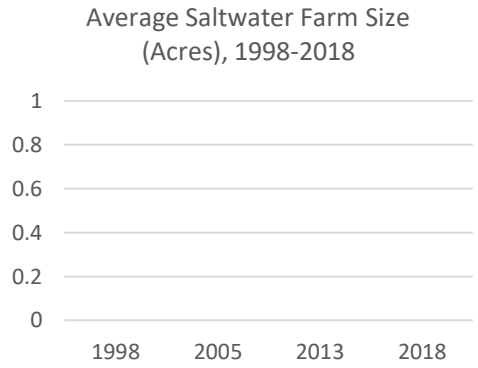


Agency for permits: Fish and Game Department, Department of Health and Human Services
Additional resources: East Cost Shellfish Growers Association

Total Overview 2018 and percent change since 2013	2018	% change
Number of farms	23	229
Saltwater farms	0[1]	0
Freshwater farms	23	229
Annual Sales ($1,000)	3,403	56
Production Techniques	(Farms)	
Ponds	18	157
Flow Through Raceways	4	300
Recirculating Systems	5	67
Non-Recirculating Systems	4	300
Cages or Pens	3	0
Aquaponics	0	0
Cropland used for Crawfish	2	0
Mollusks on bottom	0	0
Mollusks off bottom	0	0
Product	(Farms)	
Food fish	6	50
Sportfish	9	80
Baitfish	1	0
Crustaceans	0	0
Mollusks	0	0
Ornamental Fish	3	200
Miscellaneous Aquaculture	1	0
Online registration system		Yes
Monitoring Tool		Yes
One-Stop-Shop		Yes
Best Management Practices		No

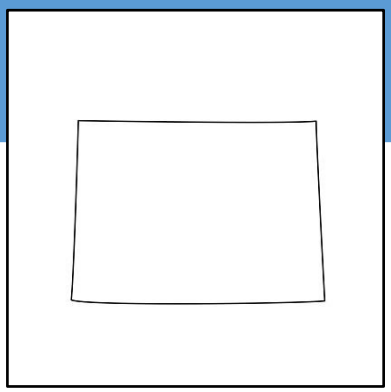




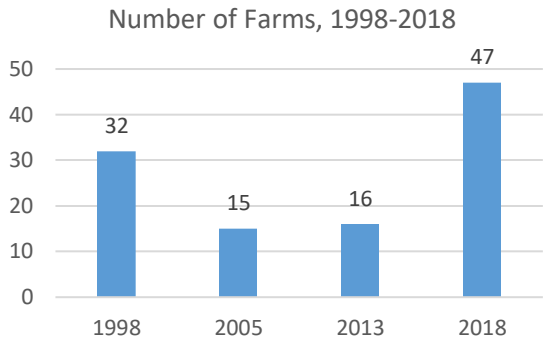


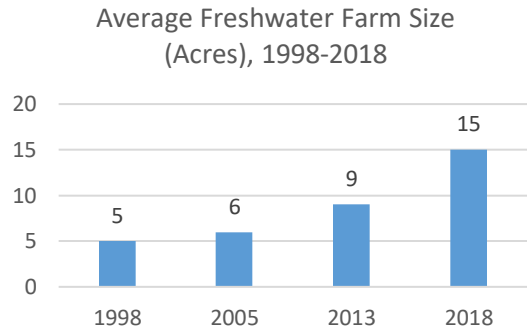
Agency for permits: Indiana Department of Natural Resources
Additional resources: Indiana Aquaculture Association, Indiana Department of Environmental Management

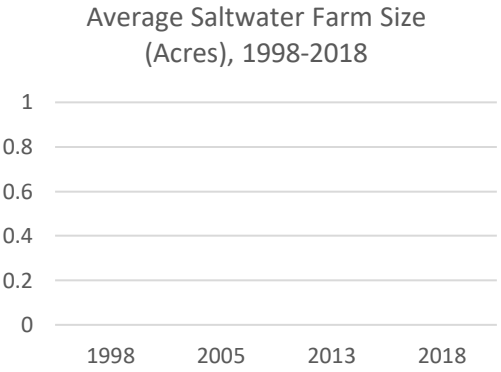
[1] There are no saltwater farms in Indiana.



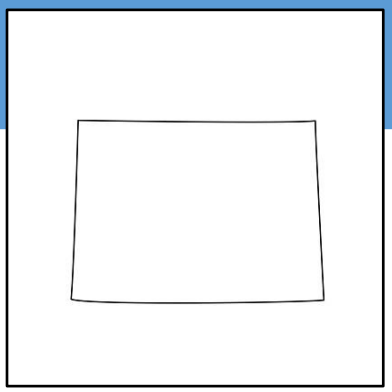
Total Overview 2018 and percent change since 2013	2018	% change
Number of farms	47	194
Saltwater farms	1	0
Freshwater farms	47	194
Annual Sales ($1,000)	7,604	55
Production Techniques	(Farms)	
Ponds	18	200
Flow Through Raceways	28	180
Recirculating Systems	8	100
Non-Recirculating Systems	13	1,200
Cages or Pens	0	0
Aquaponics	1	0
Cropland used for Crawfish	0	0
Mollusks on bottom	0	0
Mollusks off bottom	0	0
Product	(Farms)	
Food fish	16	23
Sportfish	3	-25
Baitfish	2	0
Crustaceans	1	0
Mollusks	0	0
Ornamental Fish	0	0
Miscellaneous Aquaculture	1	0
Online registration system		No
Monitoring Tool		No
One-Stop-Shop		No
Best Management Practices		No





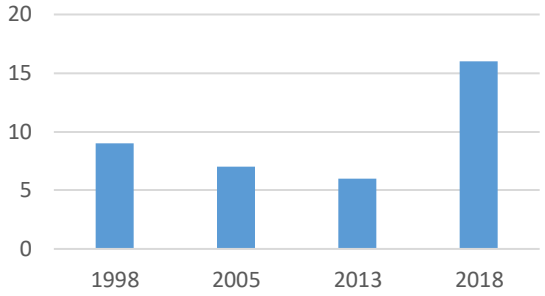


Agency for permits: Colorado Department of Agriculture, Colorado Parks and Wildlife
Additional resources: Colorado Aquaculture Association, US Trout Farmers Association, West Regional Aquaculture Center (WRAC)

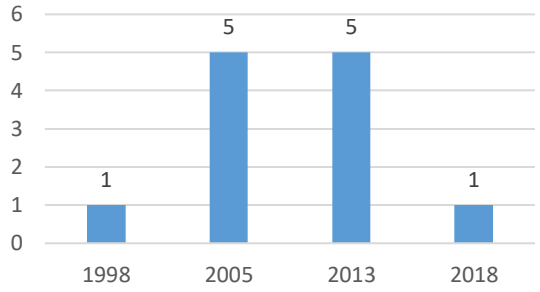


Total Overview 2018 and percent change since 2013	2018	% change
Number of farms	16	167
Saltwater farms	0	0
Freshwater farms	16	167
Annual Sales ($1,000)	547	174
Production Techniques	(Farms)	
Ponds	2	-60
Flow Through Raceways	14	1,300
Recirculating Systems	1	0
Non-Recirculating Systems	13	1,200
Cages or Pens	0	0
Aquaponics	0	0
Cropland used for Crawfish	0	0
Mollusks on bottom	0	0
Mollusks off bottom	0	0
Product	(Farms)	
Food fish	2	-50
Sportfish	0	0
Baitfish	0	0
Crustaceans	0	0
Mollusks	0	0
Ornamental Fish	0	0
Miscellaneous Aquaculture	1	0
Online registration system		No
Monitoring Tool		No
One-Stop-Shop		Yes
Best Management Practices		No

Number of Farms, 1998-2018

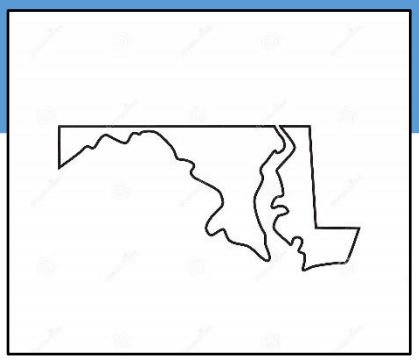


Average Freshwater Farm Size (Acres), 1998-2018

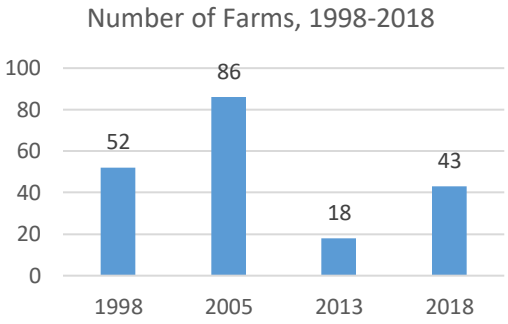


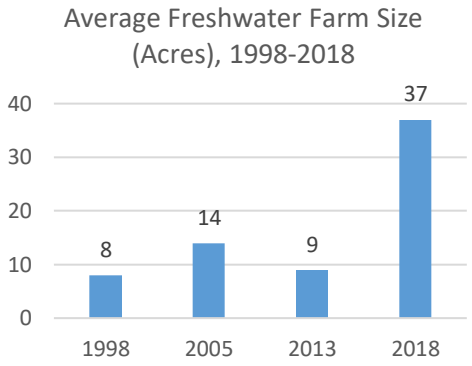
Average Saltwater Farm Size (Acres), 1998-2018

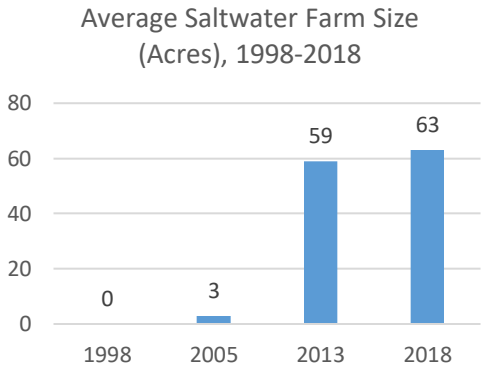
Agency for permits: Wyoming Game and Fish Department
Additional resources: West Regional Aquaculture Center (WRAC)



Total Overview 2018 and percent change since 2013		
	2018	% change
Number of farms	43	139
Saltwater farms	28	133
Freshwater farms	15	150
Annual Sales ($1,000)	28,139	357
Production Techniques	(Farms)	
Ponds	6	200
Flow Through Raceways	4	300
Recirculating Systems	4	0
Non-Recirculating Systems	9	125
Cages or Pens	13	333
Aquaponics	2	0
Cropland used for Crawfish	0	0
Mollusks on bottom	17	183
Mollusks off bottom	15	1,400
Product	(Farms)	
Food fish	5	150
Sportfish	0	0
Baitfish	0	0
Crustaceans	2	0
Mollusks	30	200
Ornamental Fish	3	50
Miscellaneous Aquaculture	2	0
Online registration system		Yes
Monitoring Tool		Yes
One-Stop-Shop		No
Best Management Practices		Yes







Agency for permits: Department of Natural Resources, Department of Environment
Additional resources: Maryland Aquaculture Coordinating Council, Maryland Shellfish Growers Network, Northeast Regional Aquaculture Center (NRAC)

Appendix E: Cost of Permits and Limits in Oregon

All license and permit information come from the Oregon Department of Agriculture and Oregon Department of Fish and Wildlife (ODFW, 2023; Oregon Department of Agriculture, 2023d; Oregon Department of Fish and Wildlife, 2023a).

Product	Producer	License/Permits Required	Cost
Commercial Shellfish	Shellfish Growers	Commercial Shellfish License	$200-$800 per year
		Shellfish Plat Lease (cultivating on state-owned tidelands)	$250 non-refundable plat filing fee
		Fish Propagation License (cultivating in private hatcheries)	$151.5 per year
	Shellfish Harvesters	Commercial Shellfish License	$125-$250 per year
		Commercial Fishing License (harvesting wild shellfish or Razor Clams)	$102 per year
		Shellfish Harvest Permit (harvesting wild shellfish)	N/A
		Scallop Limited Entry Permit (harvesting Scallops)	$127 each
		Dungeness Crab Limited Entry Permit (harvesting Crab)	$202 each
		Bay Clam Dive Limited Entry Permit (harvesting Clams)	$127 each
	Shellfish Shippers/Dealers	Commercial Shellfish License	$200-$900 per year
		Wholesale Fish Buyer License	N/A
	Shellfish Shucker-Packers	Commercial Shellfish License	$300-$1,200 per year
		Food Processor License	$381-$1,077 per year
		Shellfish Canning License (Clams and Mussels)	N/A
		Bond (Clams and Mussels)	$1,000
Non-Shellfish	Raising Fish in Hatcheries	Fish Propagation License	$151.5 per year
		Commercial Fishing License	$102 per year
		Transport Permit	$14 each
		Sturgeon Propagation License (Sturgeon)	$3,573 per year
	Fish Dealers	Wholesale Bait License	$127 per year
		Bond (Bait)	$25 each
		Resident Limited Fish Sellers License and Bond (if selling directly off vessel)	$302 per year
	Marine Aquaculture	Boat License	$402-452

All Commercial Aquaculture	Fish Dealers	Wholesale License	$502 per year
		Bond	$1,000 each
		Buyers License	$277 per year

Appendix F: Full List of Strategies

Our Team's Top Five Strategies

1. One-stop-shop
2. Aquaculture Commodity Commission
3. Market Access Expansion
4. Marine Spatial Planning
5. Information Campaign

Policy Strategies

1. Hold imported aquacultural products to the same environmental standards that U.S. producers face.
2. Minimize regulation for smaller producers or create exceptions for smaller farms.
3. Standardize aquaculture regulation across states and counties to ease expansion.
4. Participate in any efforts to establish a regional coalition supporting aquaculture.
5. Analyze the benefits and costs associated with switching from issuing individual permits to programmatic permitting.
6. Establish a BMP verification program with EPA to connect local producers to carbon markets.

Market Strategies

1. Develop food safety labs within Oregon that can test fish before processing.
2. Improve fish feed so that it is more efficient, affordable, and not imported. Must meet feed rate conversions.
3. Build the pipeline for future producers by developing internship opportunities for agricultural students.
4. Promote aquaculture tourism to private hatcheries or oyster bars.
5. Create shellfish hatcheries that prioritize genetic resistance to climate-related impacts.

Other Agency Strategies

1. Create a grant program for producers. This could be modeled after Virginia's MARBIDCO program.
2. Subsidize oxygen and electricity for Recirculating Systems or provide insurance for hatcheries that use Recirculating Systems just in case power goes out and they lose fish.
3. Hire a fish pathologist or an extension agent for ODA. There should be a hotline for emergencies.

4. Remove some of ODFW's hatcheries and purchase fish from private Oregonian hatcheries to reduce competition.

Appendix G: Strategy Analysis Matrix

	Cost ($)	Implementation Period	Risk to ODA	Farm Size Advantage	Gender and Race Equity
One-stop-shop	112,000-1.5 million	5-7 years	Financial- high Political- low to moderate Reputational and safety- low	Yes	No
Aquaculture Commodity Commission	15,000-20,000	8-12 months	Financial, reputational - low Political- high	No	No
Market Access Expansion	69,000-2.4 million	2-6 years	Financial- High Political- Low to Moderate Reputational - Moderate	Yes	Yes
Marine Spatial Planning	127,000 – 2.7 million	5-8 years	Low	Uncertain	Yes
Information Campaign	35,000-750,000	2-4 Years	Financial- Moderate to high Political- Moderate Reputational - Low	To be Determined	No

Appendix H: Cost Analysis

One-stop-shop

Total Cost: $112,000-$1.5 million

Mock Budget and Point Estimates:

Table 1 depicts mock budgets for three scenarios that vary in the degree to which the one-stop-shop consolidates responsibilities into a single agency.

- The first tier would be if ODA chooses to hire a coordinator to be responsible for shuffling permit applications among agencies for their various approvals and to communicate with the producers their status in the application process.
- The second tier would include the coordinator in Tier 1, plus an additional cost for developing an online portal for aquaculture producers to use for all their required permits.
- The third tier would be the potential cost for consolidating all permitting responsibilities under one agency. This would require legislative approval because the permitting authority of ODFW would shift to ODA.

Table 1: Mock Budget for a One-stop-shop

One-stop-shop	Cost ($)		
	Tier 1	Tier 2	Tier 3
Aquaculture Permitting Coordinator	112,000	112,000	0
Permitting Portal Developer and tech support	0	88,000	88,000
Permitting responsibilities for both salt and freshwater producers	0	0	1,500,000
Total Cost	**112,000**	**200,000**	**1,588,000**

Costs in Table 1 are estimated using the following assumptions:

- Maine's Department of Marine Resources (DMR) estimated an aquaculture administrator to be $112,312 annually in their FY23 state budget (Miramant & McCreight, 2021).
- DMR's Bureau of Policy and Management, which is responsible for permitting of all aquaculture in the state, had a total budget of $3,066,499 for 2022-2023, or about $1.5 million annually (Miramant & McCreight, 2021).
- Washington's Department of Ecology had a budget line for aquaculture of $716,000 in its 2021 biennium budget, or $358,000 annually (*Department of Ecology 2021-2023 Biennium Operating Budget Comparison*, 2021). This department supports the Shellfish

Interagency Permitting (SIP) team created under the Washington Shellfish Initiative in 2011 (Lund & Hoberecht, n.d.). The SIP team has hired an aquaculture coordinator at this point and aims to develop a singular permitting and reporting portal in the near future.

- Glassdoor estimates that a software developer on average makes an annual salary of 88,000 (*How Much Does a Software Developer Make?*, 2023).

Aquaculture Commodity Commission

ODA budgeted $766,128 for "Commodity Commission Oversight" under the Market Access Program for the 2021-2023 state budget (Oregon Department of Agriculture, 2023b). This amount covered auditing and administrative expenses incurred by ODA to support 22 commodity commissions for two years. Personnel and programmatic funds used by the commissions are supplied by other sources and do not financially impact ODA. If it is assumed that ODA spends equal amount of time performing oversight for each commission, then each commission would cost ODA **$17,412 every year**.

Market Access Expansion

Total Cost: $69,000-$2.4 million

Mock Budget and Point Estimates:

Table 2: Mock Budget for a Market Access Expansion

Market Access Expansion	Costs ($)
Fish Pathologist	74,000
Legal & Administrative Fees	1,250
Potential market development, food safety, and product distribution project	2,400,000
Oregon Sea Grant	(127,500)
Total Cost	**$2,347,750**

Costs in Table 2 are estimated using the following assumptions:

- The average salary of a fish pathologist ranges from $68,742-$79,000/year (Oregon Live, 2018). The median of this range is $74,000.
- Legal and administrative fees to draft partnership agreements average between $500-$2000 (Spadaccini, 2005). The median of this range is $1,250.
- Projects that support market development, food safety, and product distribution can cost farmers up to $2.4 million annually (Oregon Explorer Map Viewer).
- Oregon Sea Grant receives $5.1 million funding from NOAA Sea Grant and currently has strategic goals to increase understanding around seafood and aquaculture industries

(Oregon Sea Grant, 2023). If Oregon Sea Grant distributed its funding from NOAA evenly among the 40 aquaculture producers in Oregon, each farmer would receive $127,500.

Marine Spatial Planning

Total Cost: $127,000 and $2.7 million

Mock Budget and Point Estimates:

Table 3 depicts a mock budget for the types of expenses our team speculated would be included with Marine Spatial Planning. Further exploration of costs should be considered prior to pursuing this option.

Table 3: Mock Budget for Marine Spatial Mapping

Marine Spatial Planning	Unit Cost ($)
Data Scientist	127,000
Marine Biologist for ground-truthing satellite data	60,000
GIS Software	765
Community Outreach Manager	63,000
Policy Analyst	75,000
Venue rental for public hearings	$960
Total Cost	**326,725**

Costs in Table 3 are estimated using the following assumptions:

- According to Glassdoor, the average salary for a data scientist is $126, 536 (Glassdoor 2023)
- According to Glassdoor, the average salary for a Marine Biologist that could ground truth GIS maps produced by satellite imagery is $59,680 (*How Much Does a Marine Biologist Make?*, 2023).
- Esri sells its GIS software, ArcGIS Pro, for an annual subscription of $765 (*Buy GIS Software | ArcGIS Products*, 2023).
- According to Glassdoor, a Community Outreach Manager who can lead public hearing efforts to receive community feedback on the MSP makes an average salary of $63,195 (*How Much Does a Community Outreach Program Manager Make?*, 2023)

Information Campaign

Total Cost: $35,000-$750,000

Mock Budget and Point Estimates:

Table 4 depicts mock budgets for three different campaigns that range in scope and available expertise in-house.

- **Tier 1** supports an informational campaign if Oregon Department of Agriculture has in-house communication support already available or if they already have undergone a campaign for another product and can recycle materials. This tier would potentially require a videographer to gather case studies that can be promoted on ODA's website (*Rethink the Ranch*, 2023). This tier would be a cheaper and smaller campaign that could be used as a pilot for future, larger campaigns or could be complimentary to other recommendations.
- **Tier 2** is a scenario where ODA does not have in-house expertise available and would hire a smaller, public relations firm to conduct most of the campaign activities including the development of key messaging, social media outreach, and potentially an event. This scenario would pair the public relations firm with a local visual media consultant to broaden reach and complement expertise.
- **Tier 3** would be hiring a public relations firm to do a much larger campaign and conduct all communications activities. This option assumes no in-house expertise or recycled materials from previous campaigns.

Table 4: Mock Budget for an Information Campaign

Information Campaign	Costs ($)		
	Tier 1	Tier 2	Tier 3
Local visual media consultant	40,000	40,000	0
Public Relations Firm	0	250,000	700,000
In-house social media manager	48,000	0	0
Total Cost	**88,000**	**290,000**	**700,000**

Costs in Table 4 are estimated using the following assumptions:

- One informational campaign from the Montana Motor Vehicle Division (MVD) cost less than $40,000 (Worts, 2018). To keep costs this low, MVD used a local company to produce the visual media but kept the website making and media outreach in-house. Also, MVD collaborated with marketing students and professors at a local university to help with marketing. It was estimated that if MVD had hired a professional marketing firm, this process would have cost $250,000.
- Professionally-done, state-level informational campaigns can cost over $700,000 and upwards of a few million dollars, as has been the case with anti-DUI and anti-smoking campaigns.
- According to Glassdoor, the average social media manager salary is $47,772 per year in the United States (*How Much Does a Social Media Manager Make?*, 2023).

Works Cited

Agricultural Best Management Practices Task Force, & USDA Natural Resources Conservation Service. (2019). *Manual of Best Management Practices (BMPs) for Agriculture in New Hampshire*. https://www.agriculture.nh.gov/publications-forms/documents/best-management-practices-bmp-manual.pdf

Aquaculture ID. (2023). *Recirculating Aquaculture System*. Aquaculture ID. https://www.aquaculturеid.com/recirculating-aquaculture-system/#:~:text=A%20recirculating%20aquaculture%20system%20is%20an%20almost%20completely,with%20oxygen%20and%20returned%20to%20the%20fish%20tanks.

Army Corps of Engineers announces publications of 2021 Nationwide Permits. (2021, January 13). US Army Corps of Engineers. https://www.usace.army.mil/Media/News-Releases/News-Release-Article-View/Article/2470506/army-corps-of-engineers-announces-publication-of-2021-nationwide-permits/

Barange, M., Bahri, T., Beveridge, M. C. M., Cochrane, K. L., Funge-Smith, S., & Poulain, F. (2018). *Impacts of climate change on fisheries and aquaculture*. https://www.fao.org/documents/card/en/c/I9705EN

Bentz, C. (2023). OAA Testimony on SB 89. In *Oregon State Legislature*. https://olis.oregonlegislature.gov/liz/2023R1/Downloads/PublicTestimonyDocument/42086

Bittenbender, S. (2020, August 6). *Seafood task force submits recommendations to US Trade Representative*. SeafoodSource. https://www.seafoodsource.com/news/supply-trade/seafood-task-force-submits-recommendations-to-us-trade-representative

Cafasso, S. (2020, March 18). Crop diversity can buffer the effects of climate change. *Stanford University*. https://earth.stanford.edu/news/crop-diversity-can-buffer-effects-climate-change

DasGupta, R., & Shaw, R. (2017). Mangroves in Asia-Pacific: A Review of Threats and Responses. In *Participatory Mangrove Management in a Changing Climate* (pp. 1–16). https://doi.org/10.1007/978-4-431-56481-2_1

De Silva, S., & Yuan, D. (2022). *REGIONAL REVIEW ON STATUS AND TRENDS IN AQUACULTURE DEVELOPMENT IN ASIA-PACIFIC – 2020* . https://www.fao.org/3/cb8400en/cb8400en.pdf

Dr. Michael Chambers. (2023). *Aquafort and IMTA*. University of New Hampshire. https://seagrant.unh.edu/our-work/aquaculture/aquafort-imta

Ehrhart, A. L., & Doerr, A. N. (2022). *Oregon Marine Aquaculture: Barriers, Opportunities and Policy Recommendations [White paper]*. https://seagrant.oregonstate.edu/sites/seagrant.oregonstate.edu/files/oregon_marine_aquaculture_2022_final_accessible.pdf

Elliott, K. (2020, September 22). *The Effects of Hurricanes on Aquaculture*. Aquasend. https://www.aquasend.com/industry-news/effects-of-hurricanes-on-aquaculture/

Environmental Protection Agency. (2022). *What is the National Environmental Policy Act?* EPA. https://www.epa.gov/nepa/what-national-environmental-policy-act

Flatt, C. (2017, August 25). *So Why are Atlantic Salmon in the Northwest?* OPB.

Food and Agriculture Organization of the United Nations. (2013, December 11). *Philippine fishers and fish farmers facing immense damage to sector*. Food and Agriculture Organization of the United Nations. https://www.fao.org/news/story/en/item/209889/icode/

Froehlich, H. E., Gentry, R. R., Rust, M. B., Grimm, D., & Halpern, B. S. (2017). Public Perceptions of Aquaculture: Evaluating Spatiotemporal Patterns of Sentiment around the World. *PLOS ONE*, *12*(1), e0169281. https://doi.org/10.1371/journal.pone.0169281

Hoopers Island Oyster Co. (2023). *Equipment- Oyster Farming*. Hoopers Island Oyster Co. https://hoopersisland.com/oyster-aquaculture-equipment/

Houtman, N. (2020, February 13). Farming the Waters. *Terra Research*. https://terra.oregonstate.edu/2020/02/farming-the-waters/

Indiana Fish and Wildlife. (2023). *Indiana Fish Stocking*. Indiana Fish and Wildlife. https://www.in.gov/dnr/fish-and-wildlife/fishing/indiana-fish-stocking/

Institute of Ecolonomics. (2015, January 22). *Quick & Easy Fish Farming – the Raceway Aquaculture System*. IOE. https://ecolonomics.org/quick-easy-fish-farming-the-raceway-aquaculture-system/#:~:text=Raceway%20aquaculture%2C%20or%20a%20flow-through%20system%2C%20uses%20a,through%20man-made%20canals%20or%20channels%20into%20purpose-built%20ponds.

Johanns, M., & Buchanan, G. (2005). *2005 Census of Aquaculture*. https://agcensus.library.cornell.edu/wp-content/uploads/2002-CensusOfAquaculture-Full-Report-revised-2.7.07-1.pdf

Lora Shinn. (2018, January 3). Something Fishy: The Trouble with Atlantic Salmon in the Pacific Northwest. *NRDC*. https://www.nrdc.org/stories/something-fishy-trouble-atlantic-salmon-pacific-northwest

Lu, C. (2015, July 3). *The Different Methods of Growing Oysters*. Pangea Shellfish Company. https://www.pangeashellfish.com/blog/the-different-methods-of-growing-oysters

Maryland Aquaculture Coordinating Council. (2007). *Best Management Practices: A Manual For Maryland Aquaculture*. https://www.dffe.gov.za/sites/default/files/legislations/guidebestmanagementpractice_aquaculturedevelopmentandoperation_maryland.pdf

Maryland Department of Natural Resources. (2023a). *The Maryland Shellfish Aquaculture Siting Tool*. Maryland Department of Natural Resources . http://dnrweb.dnr.state.md.us/fisheries/aquatool/aquatool.asp

Maryland Department of Natural Resources. (2023b). *Welcome to COMPASS*. Maryland Department of Natural Resources. https://compass.dnr.maryland.gov/dnrcompassportal

May, S. (2017, August 6). *What is Climate Change?* NASA. https://www.nasa.gov/audience/forstudents/k-4/stories/nasa-knows/what-is-climate-change-k4.html

Montgomery, K. (2019). *Opportunities and Barriers Facing Offshore Finfish Aquaculture in the Untied States*. https://escholarship.org/uc/item/2xj3477x

National Aquaculture Association. (2023). *Mission and Policies*. NAA. https://thenaa.net/mission-and-policies/

National Association of State Departments of Agriculture Research Foundation. (2005). *Environmental Laws Affecting Oregon Agriculture*. https://efotg.sc.egov.usda.gov/references/public/OR/Archived_OregonLaws_170831.pdf

National Oceanic and Atmospheric Administration. (2023). *What is aquaculture?* NOAA. https://oceanservice.noaa.gov/facts/aquaculture.html

National Oceanic and Atmospheric Association. (2019). *U.S. Aquaculture*. NOAA. https://www.fisheries.noaa.gov/national/aquaculture/us-aquaculture

National Oceanic and Atmospheric Association. (2021). *Understanding Ocean Acidification*. NOAA. https://www.fisheries.noaa.gov/insight/understanding-ocean-acidification

New Hampshire Fish and Game Department. (2023). *New Hampshire Fish and Game's Online License Sales System*. New Hampshire Fish and Game Department. nhfishandgame.com

ODFW. (2023). *OREGON DEPARTMENT OF FISH AND WILDLIFE Licensed Propagators with Fish for Sale*. https://www.dfw.state.or.us/fish/license_permits_apps/docs/licensed_operators_who_have_fish_for_sale.pdf

Office of Aquaculture. (2021, June 8). *Global Aquaculture*. National Oceanic and Atmospheric Association. https://www.fisheries.noaa.gov/national/aquaculture/global-aquaculture

Office of Aquaculture. (2022, September). *National Oceanic and Atmospheric Administration*. NOAA. https://www.fisheries.noaa.gov/national/aquaculture/us-aquaculture

Oregon Aquaculture Act, (2023). https://olis.oregonlegislature.gov/liz/2023R1/Downloads/MeasureDocument/SB89/Introduced

Oregon Aquaculture Association. (2023a). *Oregon Aquaculture Association: What We Do*. OAA. https://www.oregonaquaculture.org/

Oregon Aquaculture Association. (2023b). *Pond Stocking and U-Catch*. OAA. https://www.oregonaquaculture.org/fish-for-pond-stocking.html

Oregon Department of Agriculture. (2015). *User Guide: A snapshot of the processes to follow to start an aquafarming business in Oregon*. https://www.oregon.gov/ODA/shared/Documents/Publications/MarketAccess/AquacultureUsersGuide.pdf

Oregon Department of Agriculture. (2023a). *Certificates for Shipment*. ODA. https://www.oregon.gov/oda/programs/MarketAccess/MACertification/Pages/CertificatesShipment.aspx

Oregon Department of Agriculture. (2023b). *Commercial Shellfish Licensing*. ODA. https://www.oregon.gov/oda/programs/FoodSafety/FSLicensing/Pages/CommercialShellfish.aspx

Oregon Department of Agriculture. (2023c). *Food Processing and Warehouse Licensing*. ODA. https://www.oregon.gov/oda/programs/FoodSafety/FSLicensing/Pages/ProcessingWarehouse.aspx

Oregon Department of Agriculture. (2023d). *Food Safety License Fee Schedule 2022-2023*. https://www.oregon.gov/oda/shared/Documents/Publications/FoodSafety/FoodLicenseFeeSchedule.pdf
Oregon Department of Agriculture. (2023e). *Oregon Department of Agriculture 2021-2023 Legislatively Adopted Budget*. https://www.oregon.gov/oda/shared/Documents/Publications/Administration/21-23LAB.pdf
Oregon Department of Agriculture. (2023f). *Recreational Shellfish Biotoxin Closures*. ODA. https://www.oregon.gov/oda/programs/FoodSafety/Shellfish/Pages/ShellfishClosures.aspx
Oregon Department of Agriculture. (2023g). *Seafood Processors (SPRS) Grant Program*. ODA. https://www.oregon.gov/oda/programs/MarketAccess/Pages/SeafoodProcessorsGrant.aspx
Oregon Department of Agriculture. (2023h). *Shellfish Aquaculture Leasing Process for State-Owned Lands*. https://www.oregon.gov/oda/shared/Documents/Publications/FoodSafety/ShellfishLeaseFlowchart.pdf
Oregon Department of Agriculture. (2023i). *Shellfish Plat Leasing*. ODA. https://www.oregon.gov/oda/programs/FoodSafety/Shellfish/Pages/ShellfishPlat.aspx
Oregon Department of Agriculture. (2023j). *Weights and Measures*. ODA. https://www.oregon.gov/oda/programs/MarketAccess/WeightsMeasures/Pages/AboutWeightsMeasures.aspx
Oregon Department of Fish and Wildlife. (2023a). *Licenses and Limited Entry Fishery Permits*. ODFW. https://www.dfw.state.or.us/fish/commercial/licenses_limited_entry.asp
Oregon Department of Fish and Wildlife. (2023b). *ODFW Licensing System*. ODFW. https://odfw.huntfishoregon.com/login
Oregon Department of Fish and Wildlife. (2023c). *Private Fish Hatcheries*. ODFW. https://www.dfw.state.or.us/fish/license_permits_apps/fish_propagation.asp
Oregon Dulse. (2023). *Oregon Dulse*. Oregon Dulse. http://www.oregondulse.com/
OSU Libraries and Press, & Institute for Natural Resources. (2023). *Oregon Explorer*. Natural Resources Digital Library. https://oregonexplorer.info/content/about-site?topic&ptopic
OSU Libraries and Press, & OSU Libraries and Press. (2023). *Oregon Explorer Financial Planning Tool*. Natural Resources Digital Library. https://tools.oregonexplorer.info/OE_HtmlViewer/index.html?viewer=aquaculture&run=Financial_Planning
Owens, B. (2021, May 26). *How aquaculture is spreading a Salmon virus*. Hakai Magazine. https://hakaimagazine.com/news/how-aquaculture-is-spreading-a-salmon-virus/
Pacella, R. (2014, February 28). *Clam, oyster farming start-up cost $60,000 per 1 acre*. Delmarva. https://www.delmarvanow.com/story/news/2014/02/28/clam-oyster-farming-start-up-cost-60000-per-1-acre/5896379/
Parks, B. (2021, June 21). *Aquaculture advocates want to bring more Oregon-grown fish from farm to table*. OPB. https://www.opb.org/article/2021/06/21/fish-farming-aquaculture-oregon/

Perdue, S., & Hamer, H. (2018). *2018 Census of Aquaculture*. https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Census_of_Aquaculture/index.php

Relating to sturgeon; creating new provisions; amending ORS 497.325; and repealing ORS 497.330., (2008). https://olis.oregonlegislature.gov/liz/2007R1/Downloads/MeasureDocument/SB569/A-Engrossed

Ruggeri, L. (2010). Group hopes to unveil coastal erosion plan next month. *Tillamook Headlight Herald*. https://www.tillamookheadlightherald.com/news/group-hopes-to-unveil-coastal-erosion-plan-next-month/article_f7f0353a-0250-11e0-84d4-001cc4c03286.html#:~:text=The%20erosion%20problem%20prompted%20creation%20of%20the%20Neskowin,layered%20on%20an%20embankment%20slope%20to%20prevent%20erosion.

Ruggiero, P., Brown, C., Komar, P., Allan, J., Reusser, D., & Lee, H. (2010). Impacts of climate change on Oregon's coasts and estuaries. *Oregon Sea Grant*. https://nsgl.gso.uri.edu/oresu/oresur10021.pdf

Rust, M. B., Amos, K. H., Bagwill, A. L., Dickhoff, W. W., Juarez, L. M., Price, C. S., Morris, J. A., & Rubino, M. C. (2014). Environmental Performance of Marine Net-Pen Aquaculture in the United States. *Fisheries*, *39*(11), 508–524. https://doi.org/10.1080/03632415.2014.966818

Sarah Sax. (2021, December 28). A Shellfish Company Gets into the Weeds. *High Country News*. https://www.hcn.org/issues/54.1/north-food-a-shellfish-company-gets-into-the-weeds

Sumesh K, & Roshan D. (2020). *Aquaculture Market by Environment (Marine Water, Fresh Water, and Brackish Water), and Fish Type (Carps, Mollusks, Crustaceans, Mackerels, Sea Bream and Others): Global Opportunity Analysis and Industry Forecast, 2021-2027*. https://www.alliedmarketresearch.com/aquaculture-market

The Council on Food, A. and R. E. (2021). *Aquaculture in the Northeast*. C-FARE. https://www.cfare.org/new-blog/aquaculture-in-the-northeast

Thompson, K. (2023). PCSGA Testimony on SB 89. In *Oregon State Legislature*. https://olis.oregonlegislature.gov/liz/2023R1/Downloads/PublicTestimonyDocument/42119

United States Environmental Protection Agency. (2022, November 29). *EPA Researching the Impacts of Freshwater Salinization Syndrome*. EPA. https://www.epa.gov/sciencematters/epa-researching-impacts-freshwater-salinization-syndrome

Unites States Department of Agriculture. (2017). *Race/Ethnicity/Gender Profile Census of Agriculture 2017*. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Race,_Ethnicity_and_Gender_Profiles/cpd99000.pdf

US Army Corps of Engineers. (2010). *Summary of Law- Rivers and Harbors Act of 1899*. National Oceanic and Atmospheric Association. https://www.coast.noaa.gov/data/Documents/OceanLawSearch/Summary%20of%20Law%20-%20Rivers%20Harbors%20Act%20of%201899,%20Section%2010.pdf#:~:text=The%20River

s%20and%20Harbors%20Act%20of%201899%20%28RHA%29,to%20the%20navigable%20waters%20of%20the%20United%20States.

US Army Corps of Engineers. (2021). *Application and Permit Process*. US Army Corps of Engineers. https://www.spl.usace.army.mil/Missions/Regulatory/Permit-Process.aspx#:~:text=The%20U.S.%20Army%20Corps%20of%20Engineers%20%28Corps%29%20issues,than%20minimal%20individual%20and%20cumulative%20adverse%20environmental%20effects.

U.S. Army Corps of Engineers. (2023). *Obtain a Permit*. U.S. Army Corps of Engineers. https://www.usace.army.mil/missions/civil-works/Regulatory-Program-and-permits/Obtain-a-Permit/

Vilsack, T., & Reilly, J. (2013). *2013 Census of Aquaculture*. https://agcensus.library.cornell.edu/wp-content/uploads/2012-Census-of-Aquaculture-aquacen.pdf

Wang, B., Luo, X., Yang, Y.-M., Sun, W., Cane, M. A., Cai, W., Yeh, S.-W., & Liu, J. (2019). Historical change of El Niño properties sheds light on future changes of extreme El Niño. *Proceedings of the National Academy of Sciences*, *116*(45), 22512–22517. https://doi.org/10.1073/pnas.1911130116

Western Regional Aquaculture Center. (2023). *Western Regional Aquaculture Center*. University of Washington. http://depts.washington.edu/wracuw/

Woods Hole Oceanographic Institution. (2021). *Report on the Ocean Acidification Crisis in Massachusetts*. https://www.mass.gov/files/documents/2021/12/15/massachusetts-ocean-acidification-report-feb-2021.pdf

Yue. (2008). *The Welfare of Animals in the Aquaculture Industry*. https://www.wellbeingintlstudiesrepository.org/cgi/viewcontent.cgi?article=1001&context=hsus_reps_impacts_on_animals