Supply Chain Challenges and Opportunities for Expanding Maine's Seafood Markets

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MAINE AQUACULTURE ASSOCIATION

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Executive Summary

This report summarizes work conducted as part of a National Sea Grant funded project '*Expanding Maine's Blue Economy*' within the task of '*Describe Seafood Supply Chains and Explore Vulnerabilities and Opportunities to Growth*'. To investigate supply chain challenges and opportunities, the team reviewed recent studies and conducted a series of semi-structured interviews, soliciting information from supply chain businesses that connect Maine's seafood producers and consumers. Prior to conducting the interviews, the team also spoke with 7 regional experts on the topic of seafood production and supply chain. The interviews targeted seafood dealers and wholesalers, as well as restaurants and grocery stores. In total, 31 businesses were contacted and 15 businesses were interviewed. The interview analysis consisted of the following themes: the characteristics of supply chain businesses and distribution channels, challenges in sourcing and distributing seafood products harvested in Maine, opportunities for expanding the market for seafood products harvested in Maine, and how the COVID-19 pandemic impacted regional seafood supply chain.

Our interviews offer new insights to support growing conversation and action within the State regarding diversifying and expanding Maine's seafood economy and supply chains. Through interviews with different supply chain actors within the State, we highlight the diversity of current seafood businesses and supply chains, and present a number of challenges, opportunities and cross-cutting themes. Many of these themes are already being actioned, or planned, within the State, providing much needed momentum. Continuing momentum into the future will depend on concerted and coordinated actions and investments as well as deeper research (including futures thinking and visioning) that considers the contexts and needs of the diversity of seafood businesses and products.

Summary of Findings

- Maine's seafood supply chain business and distribution channels are diverse. While many farms sell only their product, several aquaculture farms have started to act as distributors, aggregating products from other small-scale aquaculture farms.
- Restaurants and chefs are regarded as a key customer base for dealers. Among those who were interviewed, all businesses that trade shellfish regarded restaurants as their main outlet.
- The majority of the interviewees indicated that out-of-state customers share a significant component of their business.
- Sourcing-related challenges include inconsistent supply and low product volumes. Additionally, lower product quality was noted as one of the challenges associated with trading finfish from this region (e.g., New England).
- Handling and distribution-related challenges include inadequate and inaccessible infrastructure. Cold storage and freezers are noted as still lacking. Transportation within Maine is a challenge.
- Maine harvested shellfish products such as oysters and mussels are known for their high quality and can capture higher prices. If Maine chooses to enter into volume competition, it may face price competition with products from other regions.
- Policy and regulations, including the aquaculture leasing process, are limiting market growth and product diversification opportunities. The Food Safety Modernization Act is another regulatory hurdle discussed by shellfish and seaweed producers.
- Social dynamics and relationships in the seafood sector pose challenges for new participants. This is especially true if no family or friends have ties to seafood sectors.
- Maine's current model – a 'boutique' or 'niche' model –produces low volume and sells at high prices, and has been successful. This, however, is seen as a potential factor that limits businesses' abilities to scale up.
- Opportunities for market growth include increased support for new entrants and additional consumer education.
- Seafood from Maine captures positive perceptions in the seafood market. Niche or boutique products can be marketed to engage new audiences or customers.
- Improved logistics and transportation infrastructure will help reduce current fragmentation and can contribute to moving products in and out of the state more efficiently. Improvements in logistics and transportation from Downeast and Midcoast Maine are needed.
- COVID-19 caused short-term changes in farm schedules and operations (e.g., changes in harvesting and seeding), which impacted the availability of oysters when customers returned to restaurants. This impact appears to be only temporary.

- COVID-19 also impacted business operations. Those who targeted restaurants as the main sales outlet diversified their sales outlets to retailers and direct sales. Post-pandemic, generally speaking, businesses appear to have mostly reverted back to focusing on restaurants.

Additional insights shared at Maine Fishermen's Forum (March 2025)

The project team hosted a seminar *Expanding Maine's Seafood Economy: An In-depth Look at Aquaculture Production, Distribution, and Consumer Preferences* at the Maine Fishermen's Forum. During the seminar discussion, participants shared the following recent experiences and insights. These are emerging issues that require further investigation. While it is beyond this project's scope to fully address these emerging issues, we ask the readers to keep these following points in mind while reading this report:

- Some medium-scale oyster farms have recently been experiencing a situation where an influx of oysters from Canada and Massachusetts caused them to lose sales or receive lower prices. Maine farms must compete and now are fighting for space in the market against products from other locations.
- There was an interest to increase efforts to market and promote oysters from Maine. However, this requires funding and further investigation is needed to gauge the industry's willingness to invest in such efforts. There was sentiment that Maine brand recognition, being based on high quality products, is at stake. There was interest for establishing an appellation system, or a similar model, to help ensure quality products continue to be produced and marketed.

Introduction

The state of Maine has continually been recognized for its high-quality seafood and thriving marine economic sector (Murray et al., 2017). In 2019, the seafood sector contributed over $3.2 billion dollars in total economic output to the Maine economy, and supported 33,000 jobs statewide (SEAMaine, 2023). Seafood not only contributes economically to Maine's businesses and coastal communities, but also culturally and socially through aspects such as place attachment and identity, health and wellbeing, and traditional and cultural practices. Yet, Maine's coastal communities face significant potential future uncertainty from impacts resulting from climate-driven changes in marine resources, changing seafood consumption patterns, as well as broader regional and global market shifts (Shanshack et al. 2019; Colburn et al. 2016; Hare et al. 2016; Stoll et al. 2018; Froehlich et al. 2021). Such challenges increase the importance of supporting the resiliency and diversification of current seafood supply chains to enable their ability to adjust to future shocks and stressors, while also ensuring business and community current and future needs are met.

Supply chains are pivotal networks within the seafood economy, involving a series of processes, people and logistics that bring seafood from shore to plate, and are crucial for ensuring that seafood products are handled efficiently, safely and maintain product quality. However, seafood supply chains are complex and multi-scale systems, involving multiple actors, processes, businesses and seafood products, often across different spatial and temporal scales. Such complexity means that understanding challenges and opportunities for diversifying Maine's seafood economy and supply chains requires examining different actors and levels within the supply chain, including producers/harvesters, processors, wholesalers, retailers, and consumers. For example, for producers, research indicates that supply chains that support their farm size, logistics, and access to transportation for markets of interest are important, as well as traceability in distribution as this can maintain safe standards in case of a product recall (Love et al., 2020). Maintaining food safety and quality is also of importance for seafood processors and handlers to help reduce disease or contamination risks, which depends on best handling practices and appropriate equipment, technologies and infrastructure (Love et al. 2021). For consumers, locally sourced seafood labels can increase willingness to pay (Brayden et al. 2018; Witter et al. 2021), as consumers often consider wild and local origin information a signal for higher food safety and quality (Hoque et al. 2022).

Evidence is growing that a range of challenges can affect and disrupt seafood supply chains both in Maine and more broadly. For example, climate-driven shifts and altered availability in wild-captured species populations can affect supply and production of seafood products (Davis

et al. 2023; Hare et al. 2016; Roberts et al. 2024). Lobster forms the backbone of Maine's seafood economy, but is increasingly vulnerable to climate change (Le Bris et al. 2018; Steneck et al. 2011). Recent storm events and coastal flooding have affected important working waterfront businesses, infrastructure and facilities (Mills, 2024; Martens, 2024). The COVID-19 pandemic also caused many supply-chain disruptions for seafood producers across the United States. With respect to aquaculture, these impacts began with stocking infrastructure, as inadequate and irregular supply of seed from hatcheries during this time posed trouble for farmers (Mangano et al., 2022; Ahmed & Azra, 2022). Additional increases in transportation prices and restrictions on transportation availability led to a profit decrease for farmers, as they could not reach emerging markets for their product (Mangano et. al., 2022). More broadly, changes in market availability and accessibility led many seafood producers to pivot their marketing strategies, in some cases leaving the supply chain entirely for a direct-to-consumer approach (Smith et al., 2020). This opportunity can provide better revenues for producers as well as fresher products to the consumer (Love et al., 2020; Stoll et al., 2015); however, this method can be less convenient, time consuming and costly for harvesters and producers, and carries limited options in product selection.

Given these mounting challenges, expanding and diversifying the seafood economy can provide new opportunities for Maine's businesses and coastal communities, while also providing greater resilience to future shocks and stresses. As part of this diversification, aquaculture has grown within the state of Maine, and is an industry which contributed $138 million and provided 1,078 full and part-time jobs to the state economy in 2014 (UMaine AIR, 2017). A growing, sustainable aquaculture industry could play a key role in supporting the resiliency of rural, economically challenged coastal communities. Other broader efforts within the State to diversify and expand the Maine seafood economy from fisheries and aquaculture perspectives are outlined within the recent SEAMaine Roadmap (2024) and include: investing and developing post-harvest processing such as infrastructure, facilities, training and support; diversifying jobs and opportunities for business owners; maintaining and expanding working waterfront access; and expand marketing efforts, development, and export logistics for different seafood products.

As action to expand and diversify Maine's seafood economy grows, so too must research. While much focus of seafood research within Maine has historically focused on the harvesting sector, understanding other levels within the supply chain is of increasing importance. To help contribute to this developing knowledge base, this project aims to examine the current seafood supply chain for products harvested in Maine (excluding lobster) to a) investigate flow of aquaculture and other related seafood products as well as their values in the supply chain,

and b) investigate barriers and opportunities for diversifying Maine's seafood economy. Specifically, we sought to ask three questions:

1. How is seafood from Maine distributed?
2. What challenges exist for expanding the market?
3. What opportunities exist?

For this report, the phrase 'expanding/diversifying Maine's seafood economy' is not intended to have specific or prescriptive goals in mind. Rather, it echoes wider conversations being held in the State, encapsulates a general need to consider a seafood sector in Maine with less sole dependency on lobster, and is designed to invite conversations regarding the directions of current and future growth in (non-lobster) seafood products and aquaculture. As such, we engaged with seafood businesses that trade both wild-capture and aquaculture products. These included aquaculture growers who are also aggregating and selling other farms' products, as well as broader aquaculture and seafood dealers, processors, distributors and businesses that sell to end-consumers (e.g. chefs, retailers). These conversations helped to generate broad insights into people's perspectives of Maine's current and future seafood supply chain challenges and opportunities.

Within this report we refer to Maine seafood as seafood excluding lobster. While some of the businesses we examined also traded lobster, we did not include lobster and lobster-specific issues in our analysis. Further, in the following, we reserve the term 'shellfish' to indicate molluscs only and use 'crustaceans' to indicate other commercially important species of shellfish, including lobster.

Methods

Data Collection

Interviews were conducted with seafood producers, wholesalers, processors, distributors, retailers, and chefs. Participants were identified through a snowball sampling approach, whereby participants recommended other contacts to connect with and invite to interview. An initial contact list to begin the process was developed through conversation with GMRI, the Maine Aquaculture Association, and Maine SeaGrant staff. Where possible, participants across the coast and state were invited to interview to hear voices from different regions within Maine. Most participants lived and/or had businesses within Maine, and three were in Massachusetts and New Hampshire. Interviews were around one hour, with the majority conducted over phone or zoom, and some in person (in the Portland area). Interviews were semi-structured in design, with questions (a) exploring different types of seafood supply chain businesses and logistics related to sourcing and selling seafood products, and (b) supply chain bottlenecks and opportunities to expanding markets for Maine seafood. A copy of the interview protocol is provided in Appendix 1.

A total of 15 interviews were conducted. A further 16 were contacted to participate but either declined or did not respond to our request. Prior to conducting the interviews, we also spoke with seven regional experts on the topic of seafood production and supply chain. The research was approved by the University of Maine Institutional Review Board (IRB 2021-01-15) before any interviews were conducted.

Analysis

Interviews were transcribed by hand and/or using the audio transcription software Otter.ai. Analysis for Objective A (investigating the flow of aquaculture and other related seafood products as well as their values in the supply chain) were undertaken through qualitative analysis software MAXQDA24, using a deductive and inductive thematic analysis. Deductive coding was used first to identify sections that described attributes of their business activities based on i) products, ii) sourcing, iii) selling and market. This was then followed by an inductive coding process using a 'KJ method' to develop visual diagrams (Scupin, 1997). For each business activity attribute, labels were created to identify specific product types, locations and types of entities they were sourcing their products from, and locations and types of entities they were selling and marketing their products to. Each label was then sorted by their affinities to each other within each section. After all the affinity groupings were completed for the three

attributes, diagrams representing the supply chain connections were developed by cross examining the affinity groupings developed for each attribute. These diagrams were then sorted based on their affinity to each other to examine differences in supply chain structure.

Analysis for Objective B (investigating barriers and opportunities for diversifying Maine's seafood economy) was conducted in NVivo software (version 1.7.1), using an inductive thematic analysis. Due to limited research examining such issues and the small sample size, an inductive approach was adopted to capture and reflect emergent themes from participants. After initial familiarisation with the data, multiple rounds of coding were undertaken to develop overarching themes and sub-themes that represented high frequency topics of discussion across participants. During each coding round, codes were discussed among the project team to ensure consistency in analysis and to develop themes that appropriately reflected the conversations that were held.

Who Did We Speak With?

We caveat that our findings are based on a small sample of individuals interviewed and thus should not be viewed as fully comprehensive or representative across sectors or species/product type within the supply chain. We also note that a number of businesses either declined or were not able to participate in the interviews. While we were able to speak with businesses that vary in species they trade and their business structure, the findings may not be representative of all industry participants. Our results highlight high frequency themes that arose across participants, and we encourage future research and efforts be directed to understanding these issues and opportunities more fully, particularly at the species/product level.

Supply Chain Businesses and Distribution Channels

Products

Interviewees were asked to identify the species they trade. Our interviews included businesses that traded the following categories of products: farmed shellfish, wild shellfish, seaweed, farmed salmon, tunas and swordfish, other finfish and squid, and crustaceans (lobster, crab, shrimp). Table 1 lists number of interviewed businesses that indicated trading of each product category. Nine out of 15 businesses traded multiple product types, of which eight businesses traded more than three product types. Five businesses indicated farmed shellfish as the only product type they traded. Henceforth, we refer to them as 'farmed shellfish specialist'.

Table 1. Product Types

Product Category	**Farmed shellfish**	**Finfish, squid**	**Wild shellfish**	**Lobster, crab, shrimp**	**Seaweed**	**Farmed salmon**	**Tuna, swordfish**
Number of Interviewed Businesses	**9**	**8**	**7**	**5**	**4**	**4**	**4**

Oysters and mussels were the two major local species mentioned. Scallops dominated the conversations related to wild shellfish species, while soft-shell clams and hard clams (quahogs) were also mentioned as important Maine wild-harvested shellfish species. We spoke with wild seaweed harvesters and traders as well as at least one business that trades farmed seaweed products. Important wild finfish species mentioned included pelagic species (e.g., mackerel,

bluefin tuna) and groundfish species (e.g., cod, haddock, monkfish, pollock, hake, flounders), with a special mention of Maine halibut (i.e., halibut caught by State-managed halibut fishery).

Sourcing

Our interviewees represented a mix of businesses who sourced exclusively from the harvesters, sourced from both harvesters and other dealers or processors, and sourced directly from harvesters as well as harvesting by themselves. One business indicated that they primarily dealt imported products. The majority of the businesses we interviewed dealt directly with harvesters. Out of the five farmed shellfish specialists, three of the businesses themselves produced and harvested the products while the other two sourced directly from harvesters.

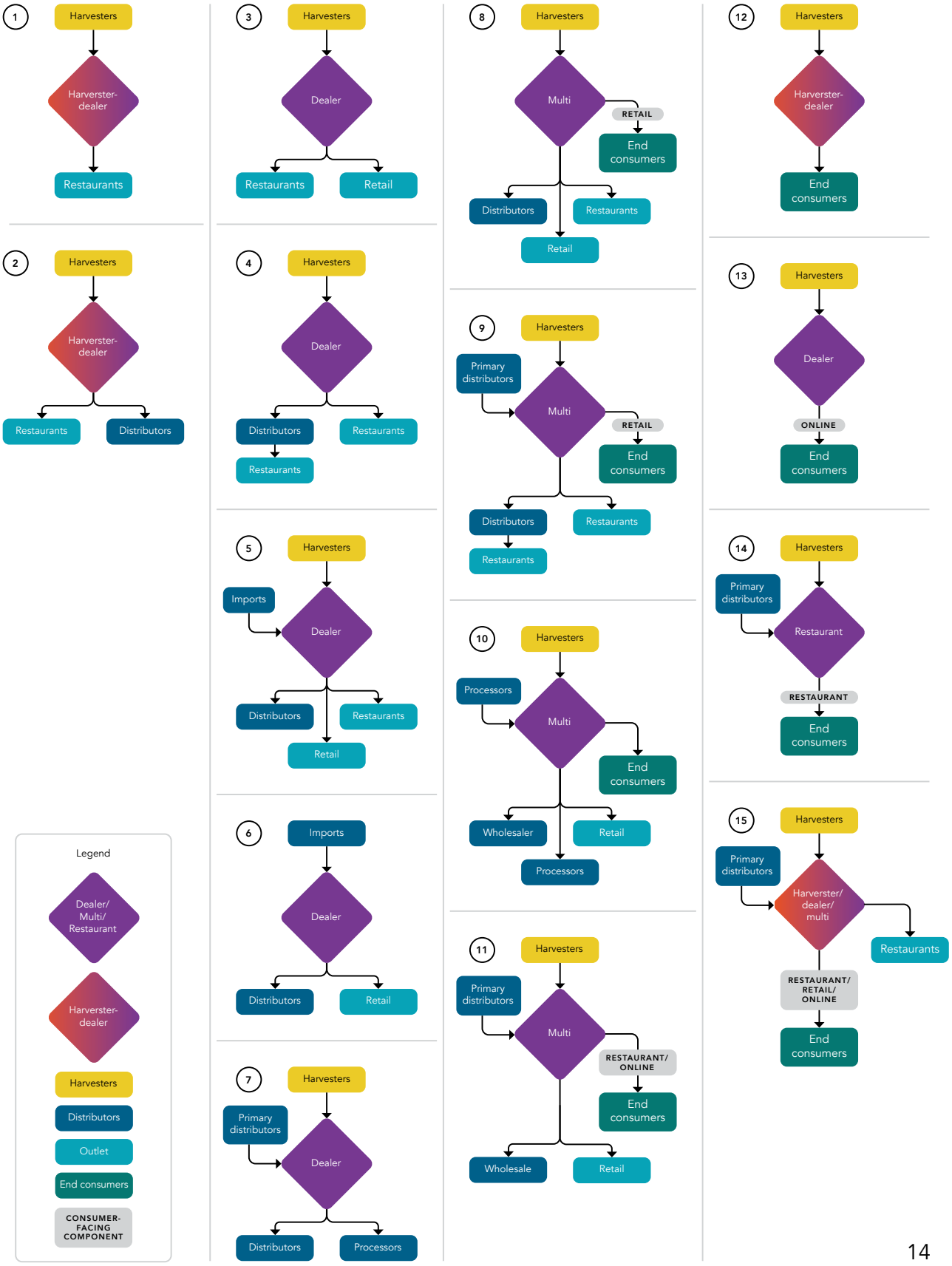
Table 2. Product sourcing

Sourcing from	Number of Interviewed Businesses
Self + Direct	4
Direct	4
Direct + Dealer/Processor	5
Direct + Imports	1
Imports	1

Selling and Market Destination

The majority of the businesses (10 businesses) we interviewed indicated restaurants as at least one component of their market. These 10 businesses include all nine businesses who indicated that they sell farmed shellfish. Almost all businesses clearly stated that they served out of state customers, with at least half of all the interviewees we interviewed indicating that out of state customers were a significant component of their business. Moreover, six businesses clearly stated that the out of state component formed a majority of their business. Seven businesses indicated that they dealt directly with end consumers, including three businesses that only or almost exclusively served end consumers. These businesses who served end consumers directly represented various models, including owning their own restaurant and/or retail outlets, selling online, and having repeat individual clients. Seven businesses indicated that they sell to downstream dealers, processors, or distributors. At least nine businesses indicated that they have multiple sales outlets, meaning that they served at least a combination of four types of sales outlets: dealer/processor/distributor, restaurant/dining services, retail, and direct to end-consumer.

Figure 1. Varied distribution channels. For the figure description, see Key Results on page 15.



Key Results

Types of Supply Chain Businesses Identified

We found varied distribution channels among the businesses interviewed, ranging from simple to more complex operations (Figure 1). In the figure, gradient color represents businesses that have mix of harvesting and distribution operations (Harvester-dealer). Solid color fill represents those that do not themselves harvest the raw products, including those businesses that solely focus on product distribution or have a mix of distribution, retail, and/or restaurant operations. Business #15 is a type where harvester-dealer with multiple product outlets, including multiple direct-to-consumer outlets. There were four businesses who produced their own products as well as sourcing from other producers (Businesses #1, 2, 12, 15). Among other businesses who act as dealers or restaurants, (Businesses #3 – 11, 13, 14) four businesses were considered to act exclusively as primary distributors (Businesses #3, 4, 8, 15). The remaining seven businesses sourced products both from harvesters (thereby acting as primary distributors) as well as from other dealers, processors, and distributors (Businesses #5 – 7, 9 – 11, 14). Two of the distributors indicated as having retail outlets (Businesses #9, 15). Three of the businesses interviewed also had restaurants (Businesses #11, 14, 15).

Challenges and Opportunities

A total of nine themes were identified, which were mapped to four overarching categories: sourcing, handling and distribution, cross-cutting topics, and opportunities. We describe these in turn below.

Sourcing Challenges

Consistency in supply

Many interviewees discussed how a lack of consistency in supply of seafood products throughout the year or in relation to demand in particular seasons posed a challenge for their businesses. Discussion primarily centered on finfish and oysters. For finfish, the seasonal nature of species availability and the low volumes of fish that are landed in Maine meant that sourcing these products could be difficult for buyers and those creating value-added products, and created uncertainty in relying on consistent supply of particular species or volumes. For businesses sourcing oysters, interviewees discussed how production of oysters varied throughout the year, leading to instances when there was over-supply or under-supply in relation to fluctuating market demands and oyster farm production. Throughout the year, the

end of summer and start of fall was highlighted as when a 'glut' on the market of oysters occurs but often when there is lower market demand, compared to in the spring when oyster production is lower with less supply but market demand is higher. Part of this supply consistency challenge is also due to the general low production volumes of oysters across many small farms in Maine currently (although the farms are growing, along with year-round harvesting). Overall, these issues pose challenges for buyers from an inventory perspective: balancing customer needs with grower/producer needs, producers who may not be able to sell their product to buyers, and distributors who don't have enough space to store and ship the product in times of over-supply.

Low product volumes

Intimately linked to discussions surrounding consistency in supply was the subject of general low production volumes of seafood in Maine. Groundfish is currently landed in low volumes in Maine (due to a range of social, regulatory and economic factors), while many of the producers of aquaculture products are from small farms that do not produce high volumes of product. Some suggested this meant Maine had a more 'niche' or 'boutique' model approach to seafood production, which can provide opportunity for higher quality products and/or higher pricing, but also pose challenges for competing with out-of-state or internationally sourced products that are available in higher volumes at lower price points. This also creates issues integrating into 'traditional' supply chains (e.g. lobster) that are dependent on high volume consistency.

Product quality

A final theme discussed in relation to sourcing and to consider in conversations regarding 'diversifying the seafood economy' in Maine was regarding product quality. Sourcing high quality products was discussed as important to satisfy end-customers (e.g. retail, restaurants), yet it was noted there could be inconsistency in this (e.g. Maine-landed finfish). For aquaculture products, others spoke to how newer farms growing oysters and seaweed with less growing experience may not be producing as high-quality products compared to those from older/more established farms or compared to wild sourced counterparts, leading to product inconsistency and jeopardizing perceptions of quality from end-customers. Due to the low volume issue noted above, having high quality products were seen as crucial to help maintain higher price points for such seafood.

Handling and Distribution

Infrastructure

Participants discussed how, within Maine, finding and having access to sufficient or suitable infrastructure posed challenges for being able to hold, process and distribute different products. Cold storage and freezers provide opportunities to preserve freshness and shelf life, and in some cases develop value added products; however, due to a lack of this type of infrastructure in Maine, this was viewed as a limiting factor for the supply chain. In some instances, participants discussed utilising existing lobster infrastructure to fulfil these needs, such as storage, but these did not necessarily have the same strictness of health and safety standards as required for certain seafood (e.g. oysters, mussels) and so limited their ability to depend on such infrastructure for other needs (e.g. processing). Other types of infrastructure, such as canneries (which historically were more numerous in Maine) were also discussed as being in low supply which limited opportunities to develop and distribute new value-added products and prolong shelf-life.

Transportation and logistics

Many participants raised issues regarding transportation of seafood products within Maine, particularly from areas in the Midcoast and Downeast to key distribution points like Portland, and onwards (e.g. Boston). Transportation was discussed as being uncoordinated, fragmented and 'piecemeal', without consistency and reliability in getting products shipped out of State. Different forms of transportation currently used were discussed, with some relying on putting product on large trucks already transporting seafood (primarily lobster), UPS trucks, own deliveries and trucking by producers, or third-party logistics. These options could be expensive, unreliable or have their own individual issues.

While using lobster transportation could be beneficial, some suggested that this could place producers in precarious positions of being undercut by price or losing customers by the businesses that ship the product, and freshness of products may be compromised due to different transportation requirements for each species. Mismatches in where aquaculture products were produced and where lobsters were landed could also result in difficulties convincing distributors to collect their product, especially if it was in small volume, creating uncertainty in reliability as this could mean they were not prioritised for shipping.

This uncoordinated and fragmentated issue in part relates to the 'low volume' and 'infrastructure' themes discussed above, whereby the smaller volumes produced by smaller farms or producers and limited number of large storage/holding facilities in Maine meant that it wouldn't be worthwhile for a larger truck or shipper to pick these up individually. One

participant suggested this fragmentation meant that they lost out to European finfish suppliers, who could provide more consistent and readily available products. As one participant discussed, the lobster supply chain demonstrated (to them) that seafood supply chains can work effectively in Maine despite the rurality of the State, likely due to the reliability in consistency and high volumes in that product. The issue for them was more because the supply chain 'just isn't designed to bring boutique products to market.' As such, and as raised by other participants, having more coordinated approaches to logistics and transportation, alongside storage infrastructure, could be a useful way to reduce the current fragmentation. Some suggested that Portland could be developed into a hub where product gets brought together and aggregated, to help increase volume and efficiencies and incentivise shipment of products onward to, for example, Boston and New York.

Cross-Cutting Topics

Cross-cutting themes represent topics that participants discussed that did not fall into a particular part of the supply chain, but rather were multi-scale.

Seafood pricing

Participants discussed the competitiveness of seafood pricing. Some discussed how Maine seafood can be more expensive due to factors including the way it's produced, its quality, and handling practices. Additionally, higher prices due to lower volumes produced locally, such as for finfish and oysters, meant it can be challenging to compete with other places or companies that can sell at lower price points due to their higher volumes. This was described as particularly challenging in retail locations, where due to a lack of transparency in sourcing and awareness of why similar products may have different costs (e.g. locality, method of production, higher quality, *etc.*), customers may not understand and appreciate why those price disparities exist. Restaurants were highlighted as an opportunity where people expect to pay more for their food and provides opportunity to connect customers to local seafood and its value.

Policy and regulations

Several different topics in the theme of policy and regulations were highlighted by participants. Aquaculture leasing processes in Maine were discussed (at a general, high level) as being slow and laborious, which was perceived to limit innovation in the sector and be discouraging for new entrants to the industry. Another challenge for shellfish (non-lobster) producers/harvesters and distributors that was raised centred on current US-EU trade shipping rules, which currently only allow molluscan shellfish harvested and processed from U.S. approved growing areas - Massachusetts and Washington - to be exported to certain EU Member States. Shellfish within

this category includes live, chilled, frozen, and processed products. This therefore acts as an important barrier to Maine shellfish from being exported to new international markets.

Another, more general, regulatory hurdle that was discussed by those working with shellfish and seaweed products was regarding FSMA (Food Safety Modernization Act, regulated by the Food and Drug Administration) rules. These were highlighted as difficult to navigate due to their complexity and challenging for new businesses in particular who had to learn and comply with the different types of regulations that are required. One participant discussed how FSMA rules can be too generic when considering the potential diversity of species within Maine's supply chain. 'Broadbrush' regulations may not make sense, be appropriate, or reflect the needs of individual species and the differences in how species are processed and handled; thus, having potential to create regulatory hurdles or barriers. This is particularly important when newer products or harvested/farmed species are developed and regulations are applied before there is sufficient work and outreach done to understand the food safety regulatory needs for that particular product/seafood item (e.g. seaweed). Finally, some participants noted that while diversifying portfolios can be useful to help reduce reliance on particular species, diversification also comes at a cost of additional 'paperwork,' as well as different permitting and regulations to navigate.

Social dynamics

Participants discussed how working in the seafood supply chain meant the need to develop and manage relationships with different people to source, ship and sell products. Networking was perceived to be important to success, but simultaneously some businesses or individuals were discussed as being partially secretive, resistant to revealing trade/business 'secrets' or contacts due to risks of being undercut, losing out on business and customers, or 'stepping on toes'. This was due to the competitiveness and price dynamics of the seafood industry, making it particularly difficult for those starting out in the seafood industry to build their networks through businesses and customers alike. Another participant talked about how the multi-generational nature of some actors within the industry meant they had a lot of power in the supply chain and over social networks, making it challenging to develop relationships with businesses or customers these actors were already working with.

Future growth of Maine seafood businesses

A final cross-cutting theme highlighted by participants was based around the current and future approach Maine, *writ-large*, has to producing seafood. Participants discussed how, within Maine's current model, it was common for many businesses to be producing lower volumes of products for higher prices – described as a 'boutique' or 'niche' model approach. Due to the increasing number of smaller-sized aquaculture farms compared to bigger sized

operations (which some perceived to be something Maine as a State values), some fragmentation or uncoordinated growth in the industry has occurred, leading to some of the volume, transportation, and logistics challenges described above. Scaling-up businesses, which could provide more volume (and thus, assumptively, lower or more competitive prices) was noted as being a challenge for existing farms, potentially requiring new infrastructure and operations. Some participants discussed that to address some of the challenges currently seen within the industry, there is a need to have some medium and larger-sized businesses (predominately aquaculture due to perceptions of wild-harvested fish being currently restricted in how much they can catch) who could provide greater volumes, ***if*** the goal of seafood industry growth in Maine is to have more emphasis on price-competitive, globally traded commodities. Importantly, as one participant reflected, there is not necessarily a right or wrong approach, but it more depends on '*what's the problem we're trying to solve, what do we wish were different*'? Future growth and diversifying Maine's seafood economy therefore depends on visioning future directions of the industry, and importantly as another participant highlighted, noting that opposed to a 'one-size-fits-all' approach, different seafood products will demand different support and strategies.

Opportunities

Supporting new entrants

Capitalising on the growth of new entrants into the aquaculture industry was discussed by some participants as being an area where new opportunities for Maine's seafood economy could be explored. Supporting new aquaculturalists, as well as wild harvesters, navigate permitting and regulations, how to go about selling and distributing their products, developing networks within the supply chain, and learning about supply chain logistics were seen as important given these can be steep learning curves and complex to understand for new entrants. Specifically for fishing, one participant spoke to the importance of supporting younger people to enter into fishing and providing education as to how to make it a livelihood - this was noted as particularly important for those without generational ties to the occupation.

Marketing and branding of Maine seafood

Participants suggested leveraging the positive perceptions people have regarding the high quality of Maine seafood through further marketing and branding of seafood. This was discussed through expanding current emphasis away from lobster to other products that are available. Some participants made analogies to the craft brewing and wine tasting (terroir, or merroir for oysters) industries as ways to highlight success in how particular niche or boutique products can be marketed and engage new audiences or customers.

Participants also suggested that a key part in marketing and branding of seafood should center on highlighting where and how seafood is sourced/produced and handled and its localness or sustainability, as there is a perceived lack of transparency particularly in retail and many restaurants regarding this, especially for fish. This can help with ensuring traceability of products and informing consumers why some Maine seafood products can be more expensive compared to seafood sourced from other places (e.g. European or other seafood imported at high volumes). Some participants discussed investing in their marketing strategies (e.g. photography, developing the 'story') and centering the connections between end-product and the local farm and producer/harvester were effective, while another said focusing on the responsible sourcing messaging was more successful.

Awareness and education for consumers

Linked to branding and marketing, some participants noted that there is opportunity to help increase awareness of consumers regarding how seafood is produced, where it's sourced, and the value of supporting local/seasonal seafood and sustainability. Importantly, educating consumers how to use and cook existing or newer seafood products is also needed. Strategies for doing this can be diverse, with participants listing online materials on producers or seller's websites, to public and community events such as talks, hands-on demonstrations, and seafood 'festivals'.

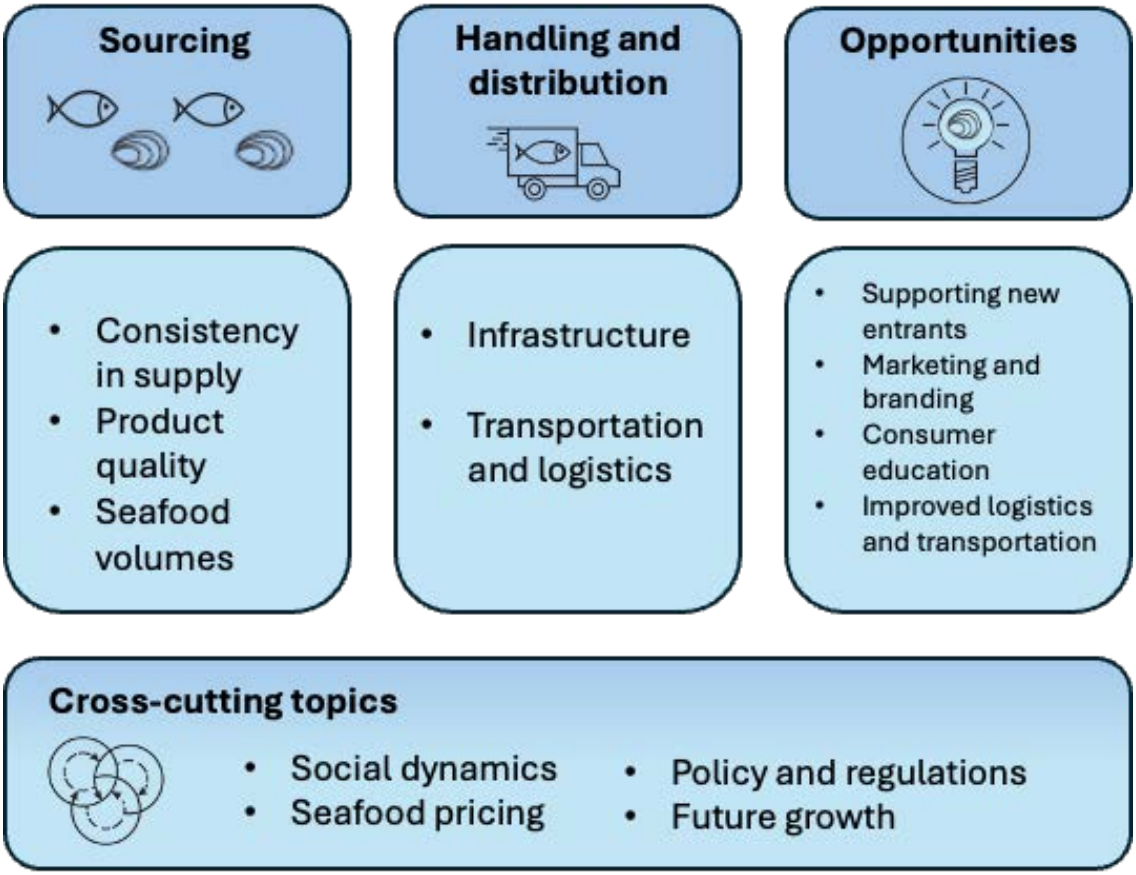
Improving logistics and transportation

A final key opportunity area focused on improving logistics and transportation. Many participants discussed how reducing current fragmentation and improving efficiencies would help in being able to more effectively handle and move products both in and out of state. One example suggested by several participants centered on the Portland Fish Exchange as becoming more of a seafood 'hub' to enable product to be aggregated there before being shipped onwards. This could reduce transportation costs and improve logistics, as well as be a way to connect distributors more easily to the diversity of seafood that Maine produces. Producers could also benefit through better market access and diversifying their customer base. Creation of such a hub would likely include the need for new infrastructure, for example cold storage facilities, processing facilities, transportation and/or packaging infrastructure. However, while a hub could be valuable, participants still noted that improvements in shipping products from Downeast and Midcoast Maine should also be prioritised, although specific ideas were not discussed in the conversations.

Others discussed the role of technology in helping to address some of the fragmentation and logistics challenges. As opposed to a physical hub, one idea considered developing an online centralized marketing platform. This would allow smaller producers, dealers, or distributors to

list their products and help aggregate volume, expanding customer access to products. This would likely depend on new infrastructure to help with storing and aggregating products in centralized locations for ease of transporting/accessing them. Others talked about investing in online platforms for their own businesses as a way to streamline their operations, such as tracking inventory to sales orders and purchasing to tagging, labelling, and logging products and shipments.

Figure 2. Summarised themes from participant interviews.



Food for Thought

Our work provides new insights into understanding the complexities, challenges, and opportunities associated with diversifying Maine's seafood economy. While our results are based on a limited sub-sample of Maine's supply chain actors, our analysis revealed a number of general important findings which reflect broader conversation and action underway in the State on these topics. We encourage further research to continue supporting these efforts, including examining species and product level considerations, specific system-level challenges and opportunities, as well as the needs of different actors and businesses within seafood supply chains.

Our analysis highlighted the diversity of different businesses' supply chains currently within Maine. Diversity is important for the resilience of individual businesses as well as for the broader supply chain and wider seafood economy, enabling flexibility and adaptability to potential disruptions (Subramaniam et al. 2023). Recognising diversity is also important when considering future actions and strategies aimed at supporting and expanding the seafood economy in Maine. Interviewees highlighted that different species, products, businesses and actors have multiple needs and considerations that require understanding and attention. Holistic approaches that can support broad aims for overall growth of the sector, but also balance individual specific needs, will be particularly valuable to help ensure that strategies aimed at supporting certain parts of the supply chain (species/product, supply chain level, etc) do not pose barriers for other parts (and *vice versa*). This applies both to industry interventions as well as through policy or regulatory development, and will require coordinated efforts and sustained funding. The SEAMaine model, alongside the creation of a Maine Seafood Council for promotional and marketing efforts[1], provide a valuable example of the opportunities to progress such holistic approaches, bringing together multiple stakeholders and supply chain actors through regular convenings and activities (Pentallect & Merritt Carey, 2022; SEAMaine, 2024).

Solutions and Opportunities

Interviewees identified a number of challenges and opportunities associated with expanding and diversifying Maine's seafood economy. Many of these reflect wider work that initiatives such as SEAMaine and the Maine Aquaculture Hub have revealed (University of Maine, n.d.).

[1] At time of writing, a 2 year pilot Seafood Council has been formed and funded through the Maine Department of Economic and Community Development

Logistics, infrastructure, and transportation within the State remain a key challenge, with the SEAMaine and Maine Aquaculture Roadmaps both emphasizing the importance of investing in, developing, and expanding key infrastructure to support the seafood supply chain (Sea Maine, 2024; Sadusky et al. 2022). However, recent developments have been made, such as new cold storage facilities recently constructed in Portland (Harrington, 2025). Highlighted issues around product volumes and supply are dependent on a number of factors that differ by species and product, underscoring a need for more research to understand these issues more fully, such as market, business and regulatory constraints/enablers, as well as values, perceptions and needs of actors including industry and consumers. Opportunity areas identified by interviewees are also seeing increasing action within the State. For example, the pilot Maine Seafood Council provides new direction and momentum to progress activities regarding consumer awareness, education, and broader marketing initiatives (Maine Seafood Promotional Council, 2024). Schemes such as the Aquaculture Apprenticeship Program and Eastern Maine's Skippers Program provide valuable learning and knowledge exchange opportunities for new entrants into fishing and aquaculture (Maine Aquaculture Association, n.d. ;Maine Center for Coastal Fisheries, n.d.). Furthering such existing, or developing new, initiatives to equip people with the skills for navigating supply chain considerations and issues could be useful, for example: identifying, building and maintaining business networks and relationships across the supply chain; business operations, 'paperwork' and pricing; and product development, retail, and marketing.

For aquaculture molluscan shellfish products, early efforts in the 1980s-90s to produce high quality products that target niche or high-end markets have led to a significant growth of aquaculture in the state. Maine has been recognized for producing consistent and high-quality rope-grown mussels. Maine is now also known for boutique farms producing high-quality oysters. While this approach can increase perceptions of high-quality seafood and provide opportunities for higher pricing among each farm, it creates logistical hurdles for the shipment and delivery to new and emerging markets outside of Maine. From a seafood dealer's perspective, it is more costly to deal with a large number of small farms. Stringent food safety and traceability requirements are associated with dealing molluscan shellfish, while additionally, the slow and arduous process for new entrants to acquire a leasing license has discouraged many, potentially limiting market growth which is needed to sustain diversity within the sector. It is important to consider improvements in transportation, storage infrastructure, and supply chain networks for aquaculture product in Maine, as innovative changes could allow product to flow more smoothly from farm to table. A development of in-state transportation hub(s), improved connections and transportation routes that connect

Downeast, Mid-coast, and Southern Maine, and a digitization of seafood supply chain are among the solutions suggested.

Need for Visioning

Interviews highlighted, either directly or indirectly, the potential value of future research and approaches to help progress efforts towards expanding and diversifying Maine's seafood economy and supply chains. Work undertaken by current initiatives to develop the Maine Aquaculture Roadmap and the SEAMaine Roadmap are important and significant efforts that have outlined goals and actions for future directions of the sector (Sadusky et al. 2022; Sea Maine, 2024). However, interviews highlighted that further understanding of overall future directions and aspirations for expanding the Maine seafood economy is needed. Undertaking research that include social sciences and futures thinking approaches to examine aspects such as values, needs, future scenarios, and trade-offs will be valuable to interrogate and inform the direction of these goals and the feasibility of potential actions. For example, emphasis on increasing and expanding production is present in both of these roadmaps, yet interviewees discussed the potential issues currently associated with the current reliance on smaller-scale 'boutique' or niche models of production in Maine. The 'Maine brand' and its value in the marketplace, often associated with its boutique or niche production models, may offer benefits such as a strong quality reputation, heightened consumer demand, and a high price point. However, it may also pose barriers to scaling due to issues regarding distribution of products or price competitiveness against higher-volume products, even if the Maine product has a higher quality. Scaling up production may require the potential for comparatively, by Maine standards, medium or large-scale businesses who possess and provide logistics sufficient to help smaller producers grow their farms. However, this may go against peoples' values or perceptions regarding Maine's identity and/or current seafood marketing strategies that often emphasise individual and small-scale operations/businesses. Neither approach is 'correct' nor the only approach, but futures thinking and visioning can be a useful tool and step to progress these efforts.

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Appendix 1. Seafood Supply Chain Business Interview – Protocol (Detailed version)

Introduction statement

- Today's interview is conducted as part of NOAA and Sea Grant funded project *Expanding Maine's Blue Economy* project members:
    - U Maine: Caroline Noblet, Keith Evans;
    - Maine SeaGrant: Keri Kaczor
    - Maine Aquaculture Association: Christian Brayden;
    - Island Institute: Sam Belknap;
    - Gulf of Maine Research Institute: Kanae Tokunaga;
- Goal of the project: identify and understand **marketing needs, seafood supply chain bottlenecks and opportunities, and consumer preferences** to expand market for Maine harvested seafood products.
- I am conducting interviews with seafood wholesalers, processors, retailers, and restaurants to understand opportunities and bottlenecks to expand market for seafood products harvested in Maine.
- Please note that your participation to this interview is voluntary.
- At the end of the interview, I will ask you to suggest 2-5 individuals for the same interview and provide their contact information (email and/or phone number). If you agree, I will mention your name when I contact these individuals. If you prefer not to suggest any individuals for the interview, you will not have to provide any names and/or contacts.
- If you agree, I would like to record this conversation for note-taking purposes. I will save the recordings in a secure location and will delete the digital files upon transcribing the interviews. Is it ok for me to record this conversation? (If yes, record, if no, do not record and take notes by hand)
- Do you have any questions before I begin?

Guide Questions

Interviewee ID:
Date:

1. Could you describe your business? What products do you sell? Who do you serve?

Types of products	Notes

2. Could you also tell me the size of the business in terms of volume of fish traded?
    - How and where do you currently source products?
        - Ask for % from Maine (in volume), Ask for % for each source from Maine

Sources	%	Note

3. Could you describe your market? Geographical location? Who do you sell to?
    - Types of business you sell to (restaurants, retail, direct)?
    - Any difference in terms of species?

Types of business	Total %	In-state %	Out-of-state %
Restaurants			
Retail			
Direct			
Other			

4. How did your industry change before and after the COVID pandemic and in the past 3 years? How did the prices or traded volumes change? Have you introduced any new products or species?

5. What do you see as important market opportunities for Maine harvested seafood products?

6. Do you see any supply chain bottlenecks that prevent Maine harvesters take advantage of these opportunities?

At the end of the interview

Ask the interviewee to suggest 2-5 individuals for the same interview and ask for their contact information (email and/or phone number). Also ask for consent to mention the interviewee's name in the invitation emails to the suggested individuals.

Name, business	Contact