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Adding Value Through Sustainability: Incentivizing An Ecosystem Approach To Oyster Aquaculture In Maine

Samuel Feldman

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**Adding value through sustainability:
Incentivizing an ecosystem approach to oyster aquaculture in Maine**

Samuel Feldman

Submitted in Partial Fulfilment of the
Professional Science Master's Degree
in Ocean Food Systems
School of Marine Programs
College of Arts and Sciences

University of New England

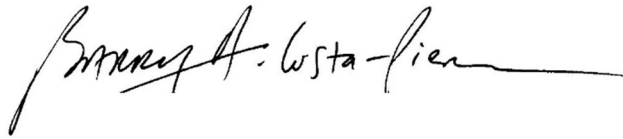
Advisors

Adam St. Gelais (University of New England)
Barry Costa-Pierce (University of New England)
Susie Arnold (Island Institute)
Dan Devereaux (Mere Point Oyster Company)

This thesis has been examined and approved.



Adam St. Gelais Assistant Lecturer for School of
Marine Programs, University of New England



Barry Antonio Costa-Pierce Henry L & Grace
Doherty Professor of Ocean Food Systems,
University of New England



Susie Arnold, Ph.D.
Marine Scientist
Island Institute



Dan Devereaux
Co-Owner
Mere Point Oyster Company

Date: July 7, 2021

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“The power of the concept of sustainable development is that it both reflects and evokes a latent shift in our vision of how the economic activities of human beings are related to the natural world – an ecosystem which is finite, non-growing, and materially closed.”

Herman Daly in “Beyond Growth” 1996

Abstract

This study identified oyster farming practices that have the potential to increase the sustainability of Maine’s oyster industry while increasing its value. Practices aligned with the principles of the ecosystem approach to aquaculture were gleaned from semi-structured interviews and surveys of oyster farmers and their buyers. Themes from interview transcripts were developed using thematic analysis. Survey data was used to triangulate interview transcript data. As a result, sustainable oyster farming practices were identified that had direct and indirect connections to the value of Maine’s oysters. Practices with direct connections to increased oyster value included conducting and advertising actions of increased stewardship in the coastal areas around farms. Practices with indirect connections to increased oyster value included 1) monitoring water quality to prevent exceeding production carrying capacity, and 2) involving a broader spectrum of community members as stakeholders in planning oyster aquaculture development at all scales.

1. Project Objectives and Significance

Maine's shellfish aquaculture industry consists predominantly of small-scale oyster farms.

While oyster aquaculture shows promise as a sustainable protein source and significant portion of Maine's marine economy, there is room for improvements in terms of an ecosystem approach to aquaculture (EAA). Some organizations have developed certification schemes for aquaculture. However, these tend to have a narrow focus on environmental sustainability, and often act as unattainable gateways to profitability for smaller aquaculture operations.

Adding value to farmed Maine oysters by practicing and marketing various forms of sustainability could be a solution. Frameworks such as an EAA help define sustainability within academia. However, farmers and buyers of oysters have diverse working definitions of sustainability when making marketing and purchasing decisions. Learning where these definitions overlap is crucial to both the business success of Maine's oyster farms, as well as to the overall economic, environmental, and social sustainability of the industry. To increase both the overall sustainability and profitability of oyster farming in Maine, this project aimed to identify shared definitions of sustainability within the industry, assess buyers' related willingness-to-pay, and identify feasible production practices that can be implemented by oyster farms.

2. Background

2.1 Introduction

Oyster aquaculture has been practiced in Maine since the 1970s but did not become an economically significant industry until recently. While Maine has an extensive coastline, it is also home to many ocean users. The resulting competition for near-shore and intertidal ocean access, combined with previous examples of environmental degradation from intensified shellfish aquaculture industries served as the context for the following research thesis. To provide detailed background information, the subsequent sections, in their totality, discuss the potential of eastern oyster farming in Maine to continue growing as a profitable industry while attending to social wellbeing and ecological health. Sustainability, in any of its forms, is often viewed as antithetical to economic growth. The following study aims to identify which aspects of an ecosystem approach to aquaculture (EAA), if any, have the potential to guide sustainable industry growth and simultaneously increase the value of Maine oysters.

2.2 Global Nutrition and Aquaculture

Despite decades of declining hunger and malnutrition world-wide, the Food and Agriculture Organization of the United Nations (FAO) has recently cited data suggesting that this progress has been slowly reversing since 2014 (FAO, 2020). Within the same publication, the FAO noted that the number of people that experience severe food insecurity is almost one tenth of the global population (p. 13). Based on projected increases in global human population size within the current century and spatial constraints of terrestrial human activities, current terrestrial agricultural practices will not be able to keep up with growing demands for protein for human consumption (Costa-Pierce, 2016).

While still producing fewer pounds per year than terrestrial animal protein globally, aquaculture is the fastest growing production method for animal-based protein (Bailey, 2008; FAO, 2016). Bivalve aquaculture makes up 20 per cent of annual aquaculture landings and is potentially more environmentally sustainable than finfish aquaculture, which has a feed conversion ratio like that of poultry (FAO, 2016; 2018). In addition to being a high efficiency protein source, oysters contain essential vitamins and minerals for human consumption (Wright et al., 2018).

2.3 Defining Sustainability

The term “sustainability” is difficult to define within a given problem or issue (Daly, 1996). Sustainability, as used in the colloquial sense, is vague and has many applications. An action, process, or industry is considered sustainable if it meets current needs in a way that does not diminish access to said resource for future generations (Brundtland, 1987). In many instances, the significance of any given application of the term is weighted differently depending on the user’s professional lens. Ecologists are likely to think of sustainability within an environmental context, economists within a financial one, and anthropologists within a social

one (Hilborn et al., 2015). This siloed approach is problematic when attempting to assess or improve sustainability within industries because sustainability is intrinsically transdisciplinary. For the purposes of this research project, the following sustainability definitions were used as a guide:

- Environmental: meeting human needs without degrading the health of ecosystems (Morelli, 2011).
- Social: "...maintaining and enhancing the diverse histories, values, and relationships of contemporary populations." (Low, 2003).
- Economic: maintaining and increasing the resiliency and efficiency of businesses and economies (Goerner et al., 2009).

2.3.1 Sustainable Aquaculture

The various definitions of sustainability and the transdisciplinary nature of oyster aquaculture requires study within and across distinct categories of sustainability. Many publications that focus on the sustainability of aquaculture frame the concept within environmental, economic, and social (sometimes referred to as cultural) sustainability (Mallet et al., 2006; Soto et al., 2008; Bailey, 2008; Charles, 2012; Murphy, 2012; Axelsson et al., 2013; Needles et al., 2013; Lacoste et al., 2020). As many publications have stated, while these categories are often separated in theory, in practice they are inevitably intertwined (Murphy, 2012; Charles, 2012; Axelsson et al., 2013). In the context of aquaculture, the issue of sustainability requires all stakeholders to reframe their actions. Rather than producing, processing, delivering, or consuming commodities, participants in oyster aquaculture are making choices that impact a complex web of social, ecological, and economic issues (Benessia et al., 2012).

2.4 An Ecosystem Approach to Aquaculture (EAA)

A well-documented framework that encompasses all three categories of sustainability and acknowledges their interconnectedness is an ecosystem approach to aquaculture (EAA) as defined by Soto et al. (2008) (Figure 1). The lack of feed required in bivalve aquaculture makes it a potentially appropriate industry for the application of an EAA because of its potential social and economic benefits (Alleway et al., 2018; Grabowski et al., 2012; Hall et al, 2011; Petersen et al., 2016). An EAA incorporates environmental, social, and economic sustainability to create aquaculture development that promotes equity and the resilience of socioecological systems (Soto et al., 2008).

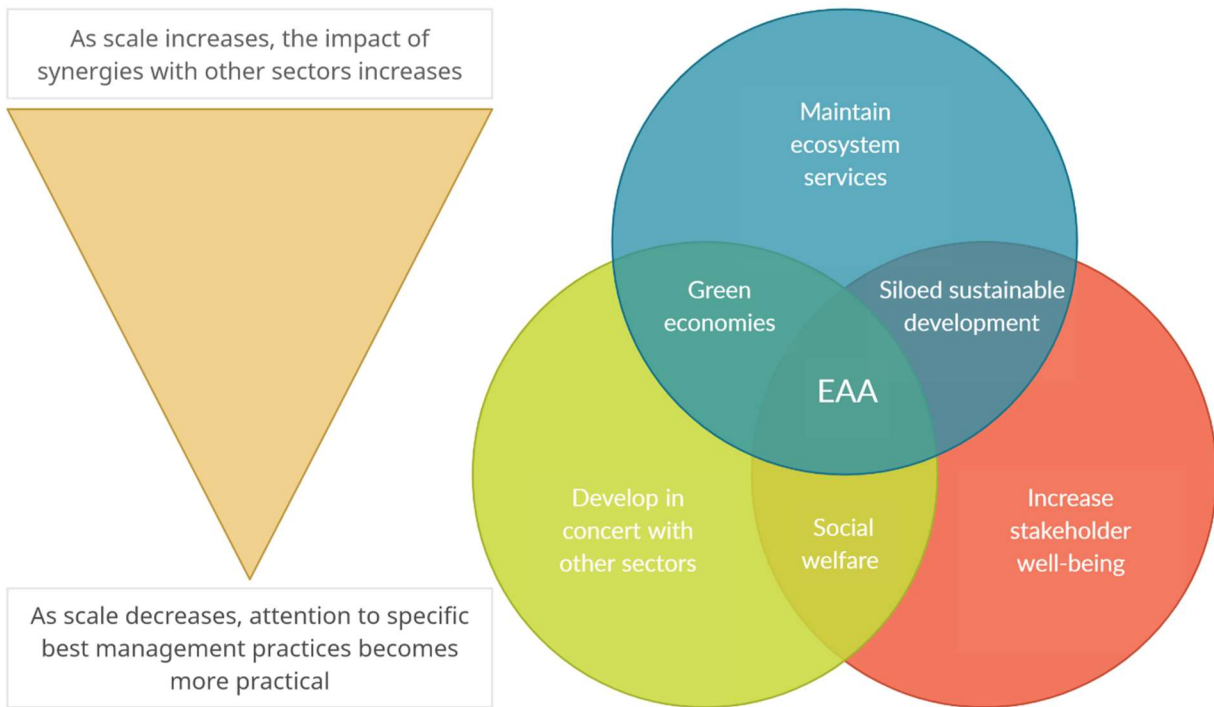


Figure 1. Venn diagram depicting the ecosystem approach to aquaculture (EAA) at the intersection of siloed sustainable development, green economies, and social welfare acting at multiple spatial scales. (Adapted from concepts in Soto et al., 2008).

2.4.1 Principles of an EAA

Governments, industries, and businesses that adopt an EAA frame their work around three main principles:

1. Aquaculture activities should not diminish the ability of the ecosystem to provide the services that communities rely on.
2. Aquaculture should increase the well-being and equity of all stakeholders.
3. Aquaculture development should not inhibit other human activities and should look for opportunities to work in concert with other producing industries.

By requiring environmental sustainability as it relates to humans, improving socioeconomic equity for entire communities, and acknowledging that aquaculture impacts and is impacted by all other sectors and goals of society, EAA requires policy development and planning to occur at all spatial scales, from individual water bodies to entire coastlines (Soto et al., 2008; Brugere et al., 2018; Willot et al., 2019).

Essentially, the three principles of EAA are centered around sustaining ecosystem services for all stakeholders through effective planning, monitoring, and management. Aquaculture systems benefit humans through enhancing the natural ecosystems' ability to

immediately provide food and other raw materials. This can disrupt other ecological processes unless managed properly. Social and ecological connections need to be acknowledged and understood to co-manage multiple uses from the same agricultural or aquacultural systems. These complex connections require diverse stakeholder groups to be represented throughout the planning and managing processes, and that the prioritized services reflect the unique characteristics of the aquaculture-ecosystem in question (Lescourret et al., 2015).

2.4.2 Implementation of EAA

The adoption and application of EAA globally has seen mixed results. In places where regulatory agencies are well funded and designed to be interdisciplinary, an EAA is particularly useful for spatial planning (Brugere et al., 2018). Europe has recently prioritized EAA based spatial planning using GIS software and cooperation from varied stakeholders (Aguilar-Manjarrez et al., 2016). However, awareness and understanding of EAA principles varies considerably, particularly outside of projects sponsored by the FAO. Effectively applying a framework as holistic and multi-scaled as an EAA requires updated, interdisciplinary, and enforceable regulatory frameworks that governments of all sizes often lack (Brugere et al., 2018).

To follow an EAA, the regulatory process must be participatory, meet multiple objectives, plan for interactions with other sectors, monitor impacts at multiple scales, be adaptive, include extended knowledge, guide action through incentives, and be transparent (Willot et al., 2019). Governments capable of accomplishing these goals are beginning to adopt modeling strategies to manage aquaculture's impacts in accordance to EAA. Most industrialized nations lack sufficient environmental regulatory standards and, like many other examples of industrial globalism, best environmental practices often increase costs of production, which then moves investment of aquaculture to regions of the world with fewer regulatory constraints, environmental and otherwise (Nunes et al., 2011; Vogt et al., 2019).

2.4.3 Governance and an EAA

Successful implementation of an EAA at larger scales over longer periods of time requires regulatory support. However, challenges exist. Due to the pressure to provide short-term economic growth for their citizens, states and nations often enact sustainability standards that are less stringent than voluntary standards (Vogt et al., 2019). Ecosystem-level regulations are difficult to regulate at larger scales because the different uses across diverse regions lead to varying socioecological carrying capacities. This is further complicated in rural coastal communities experiencing influxes of people who prioritize the aesthetics of pristine coastal areas over working waterfronts (Burbridge et al., 2001; Gurran et al., 2010). The resulting social conflict is exacerbated when expansion of the industry is rapid and local regulatory agencies lack sufficient funding to respond (Banta & Gibbs, 2010).

Rapid industry growth can lead to regulation drafted with incomplete information, which can inhibit stakeholder cooperation (Banta & Gibbs, 2010). In 2008, surveys of government employees at federal and state levels found that the largest barriers to implementing ecosystem-based management in the United States was political will. According to the survey responses, government employees felt that they were expected to prioritize management of one sector over the others. This was largely ascribed to a lack of resources or guidance on how to develop and apply ecosystem-scale planning and monitoring (Koontz & Bodine, 2008). While regulation can have the most wide-spread and lasting impacts on sustainability, these potential strengths also make it difficult to apply in a way that values all stakeholders and sustains the services provided by the ecosystem that is being regulated (Davies et al., 2019).

2.5 Ecosystem Services and Shellfish Aquaculture

When applied to aquaculture, ecosystem services are a concept used to describe and quantify the benefits that ecosystems bring to people (Alleway et al., 2018). These benefits include the categories:

- Provisioning (food, medicinal resources, etc)
- Regulating (carbon storage, water filtration, etc)
- Cultural (sense of place, employment, etc)
- Supporting (habitat, genetic diversity, etc)

By using these categories, wild shellfish ecosystem services have been compared with services provided by shellfish aquaculture. In doing so, it was found that, typically, wild shellfish ecosystems provide regulating and supporting services at a higher rate than provisioning or cultural services, while shellfish aquaculture tends to provide provisioning and cultural services at a higher rate than regulating or supporting services (Alleway et al., 2018). Shellfish aquaculture can present numerous social and economic services. Some of these include, but are not limited to, increased employment and deeper cultural connections, both of which are directly connected to the presence of locally harvested seafood (Alleway et al. 2018).

Table 1. Primary theoretical ecosystem services provided by shellfish aquaculture and shellfish ecosystems. (Adapted from Figure 1 in Alleway et al., 2018).

Category	Shellfish Aquaculture	Shellfish Ecosystems
Provisioning	Culture of seafood, harvest of seafood	Culture of seafood, harvest of seafood
Regulating	Wastewater filtration, Carbon sequestration, wave attenuation	Wastewater filtration, Carbon sequestration, wave attenuation
Cultural	Employment, ecotourism, recreational fishing	Ecotourism, recreational fishing
Supporting	Shelter for native organisms	Genetic diversity, shelter and food for native organisms

2.5.1 Ecosystem Service Benefits of Oyster Aquaculture

Bivalves are filter feeders and do not require feed. Instead, they are fully sustained by phytoplankton and heterotrophic microorganisms, as well as organic and inorganic particles (Hall et al., 2011). Excess nutrients in coastal waters generally come from human impacts, but filtration from shellfish aquaculture can reduce the likelihood of eutrophication while simultaneously acting as a source of overall carbon sequestration (Alleway et al., 2018; Petersen et al., 2016). For example, the hard-shell clam and eastern oyster aquaculture industries in Greenwich Bay, Connecticut were found to be a significant source of anthropogenic nitrogen removal (Dvarskas et al., 2020). Some researchers have begun to quantify the environmental benefits of shellfish aquaculture, and the benefits are significant enough to warrant direct payments to shellfish farmers. The current discussions of these payments largely involve nutrient removal of polluted or eutrophic coastal areas, particularly in cases where water quality is too poor to produce shellfish for human consumption (Ferreira & Bricker, 2015; Olivier et al., 2020). Additionally, the establishment of shellfish farms has the potential to remediate habitat loss and trawl fishing pressure, reduce the occurrence of harmful algal blooms, and absorb the impact of severe storms on coastal areas. (Grabowski et al., 2012; Gentry et al., 2019; Theuerkauf et al., 2019).

2.5.2 Ecosystem Service Challenges of Oyster Aquaculture

If cultured irresponsibly by overstocking, use of inappropriate gear, or insufficient biosecurity precautions, oyster aquaculture can negatively impact ecosystem services. Primary effects of these practices are limited access to nutrients for wild low trophic populations, excessive biodeposition under and around oyster cages, loss of benthic biodiversity, and potential spread of disease to other farms or wild populations (Onada & Ogunola, 2016).

Shellfish aquaculture's impacts on benthic conditions are particularly unclear. Research in eastern Canada investigated the benthic conditions under experimental oyster rafts and compared them to control sites. While modeling predicted that increased sedimentation of

organic matter would occur underneath the oyster rafts, the opposite was found (Mallet et al., 2006; Comeau et al., 2014). Conversely, blue mussel (*Mytilus edulis*) farming in Prince Edward Island, Canada, has been shown to increase deposition rates and resulting benthic loading enough to alter biogeochemical composition of marine substrate around shellfish farms (McKindsey et al., 2011). The complex interactions of biodeposition, substrate type, and hydrology still need further investigation. Additionally, most of the work to date on benthic changes due to shellfish aquaculture focus entirely on indices of macro-infauna. Little is known about overall changes in microscopic benthic community composition and how that may affect benthic conditions overall (Lacoste et al., 2020).

Disease outbreaks can also be a concern when shellfish farms operate at high densities. MSX (*Haplosporidium nelson*), a spore-forming protozoan, has been linked to large scale mortality events in oyster farms along much of the east coast of the United States (Virginia Institute of Marine Science, 2021). At the northern edge of its range, MSX has been found in Maine's Damariscotta River Estuary, where it has been linked to vectors from wild shellfish populations (Messerman & Bowden, 2016).

2.6 Carrying Capacity of Shellfish Aquaculture

Carrying capacity, or the maximum amount of life that a given socioecological system can sustain, has been modelled in various shellfish aquaculture settings (Byron & Costa-Pierce, 2013; Kluger et al., 2017). While discrete environmental factors such as available phytoplankton are typically used to calculate carrying capacity for shellfish aquaculture, it is also known that shellfish larvae consume a wide range of both autotrophic and heterotrophic organisms (Baldwin & Newell, 1991). Additionally, impacts of shellfish aquaculture on ecological communities are found to be density dependent (Kluger et al., 2017). However, these models tend to focus on the ecological capacity of a system, while leaving out social dynamics that are often unique to the area. Social concerns are often significantly more constraining for shellfish aquaculture than ecological constraints. Because social issues surrounding a body of water are often unique to that area, it is not feasible to predictively model social carrying capacity at large spatial scales.

2.6.1 Carrying Capacity and Social License

Social license is a set of stakeholder and community member expectations for the operations and behaviors of a business and is crucially important within oyster aquaculture. These concerns are often related to ocean front view-scapes, fears of potential sound pollution, environmental degradation, and others. Social license is not always grounded in demonstrable fact and often prescribe a more stringent set of guidelines than do local regulations (Gunningham et al., 2004). Many coastal waters already feel crowded to recreational and commercial users alike. The quantity of economic and recreational activities that occur in coastal waters that are attractive for oyster farms make social conflict difficult to avoid (Bailey, 2008; Silva et al., 2011). The presence and growth of aquaculture requires the preemptive building and maintaining

of social license to be successful (Krause et al., 2020). Lack of community support can act as a hidden barrier to sustainable aquaculture development, effectively lowering social carrying capacity as previously stated (Davies et al., 2019).

Ideally, regulatory structures provide procedures designed to aid collaboration between stakeholders (Costa-Pierce & Page, 2010). When aquaculture hearings take place, the most outspoken opponents are frequently NIMBY (Not In My Back Yard) voices, who often maintain conspicuous opposition even after approval is given to an aquaculture business (Davies et al., 2019). Unrefined regulatory structures often allow NIMBYism to have disproportionate influence on aquaculture development. Maine's Department of Marine Resources has procedures that both notify nearby landowners of aquaculture hearings. If a stakeholder believes that a proposed aquaculture lease will directly affect them, the stakeholder can apply to be granted "intervenor status". This allows them to testify at an aquaculture lease hearing and comment on the draft lease application decision if they are deemed to be substantially impacted by the proposed lease (Maine DMR, 2021).

2.7 Market Potential for Sustainable Seafood

Public attention on marine health potentially opens the door for an increased willingness to pay for further commitments to sustainable practices (O'Beirn et al., 2013). Additionally, there is evidence that consumers in industrialized nations are willing to pay a premium for seafood reared in healthy marine environments (Garza-Gil et al., 2016). This has been shown to be true for Irish consumers of farmed salmon (van Osch et al., 2017) and Vietnamese consumers of farmed shrimp (Xuan & Sandorf, 2020).

Current trends show that, among North American consumers, sustainability is an increasingly important issue when making seafood purchases. This is particularly true with younger consumers, who are eager for assurance that their purchases are either doing no harm or the least harm possible (Chase, 2011). Cathy Roheim, a prominent researcher in the field of seafood ecolabeling, thinks that, as these trends continue, they will lead to increased product value for seafood, both in terms of product price and volume sold (Roheim, 2008).

Integrating information about multiple benefits of seafood consumption has been shown to change consumer behavior to a greater degree than the pursuit of any single benefit (health, environmental sustainability, etc) (Jacobs et al., 2018). This suggests that consumers can and do absorb messaging that is complex. Seafood consumers are often frustrated by the lack of information on aquaculture product packaging (Risius et al., 2017). Research also found that seafood consumers tend to view simple labels or phrases regarding environmental or social sustainability with skepticism and want access to detailed information regarding wild harvest or aquaculture practices (Risius et al., 2017). Furthermore, consumers have diverse and varied foci when it comes to sustainable products, wanting to know about environmental and social issues linked to their purchases (Minkov et al., 2019). Marketing of farmed seafood that honestly advertises various environmental, social, and economic sustainability practices, both on water and on land, has the potential to attract consumers that prioritize any number of issues.

However, other studies have shown that consumers often lack awareness of seafood sustainability practices, and that they frequently choose seafood based on price, rather than sustainability practices. Research conducted on German seafood consumers has shown that individuals who value sustainability often do not understand wild or farmed seafood practices, and that attributes like taste and price often ranked higher in their decision making (Zander et al., 2017). Additionally, a consumer choice experiment conducted in the United States garnered similar findings. In this study, participants listed price and location as primary reasons for choosing seafood products, rather than certification status or wild versus farm raised (Brayden et al., 2018).

2.8 Certification Schemes

Increased willingness to pay for sustainable products and foods has resulted in the rapid expansion of certification schemes, which are advertised by ecolabeling. Using ecolabels as visual proof of the approval of popular certification schemes has become a central tool in marketing sustainability (Rex & Baumann, 2007). Certification schemes are programs designed to set various standards of sustainability, and then incentivize seafood producers to meet or exceed the programs' standards. This is generally done through coordinated efforts to assess seafood production and then conduct publicity campaigns outlining which types of seafood do or do not meet the program's environmental standards (Tlusty, 2012; Bush et al., 2013; Jonell et al., 2013). Products that do meet the standard are typically marked with an ecolabel, which have become increasingly recognizable to American consumers in recent years.

Certification scheme publicity campaigns need to contain or be accompanied by large scale educational campaigns to successfully influence decisions of consumers (Wessells et al., 1999). The mainstream thinking behind the effectiveness of certification schemes, that consumer preference is the main factor in pressuring corporations to add value to certified seafood, is an oversimplification. Instead, growing evidence suggests that behavior of seafood dealers, wholesalers, and restaurant owners has a much larger impact than direct consumers on the success of certification schemes (Barclay & Miller, 2018).

2.8.1 Certified Aquaculture

The Aquaculture Stewardship Council (ASC), which began certifying aquaculture farms in 2012 (ASC, 2020), functions today as an additional governance structure in regions and nations where it is in place. While there are several certification schemes that assess aquaculture practices, most of the emphasis is on finfish production. Few, such as Friends of the Sea (FOS) and Organics International (IFOAM Organic), certify oysters and other shellfish (Vogt et al., 2019). This can lead to confusion when consumers use ecolabels to pick between multiple alternatives. For example, a recent study has shown that, because farmed finfish in North America are more likely to carry an ecolabel than farmed bivalves, consumers often choose finfish thinking that they are making the more sustainable choice (Jonell, 2016). However, there

is little, if any, evidence that suggests any finfish aquaculture carries a smaller ecological footprint than that of its bivalve counterpart.

2.8.2 Limitations of Certification Schemes

Attempts at certifying seafood production often lack the financial incentives to motivate certified producers to continue to improve, or they have standards that are beyond the reach of the farmers or fishers that have the most harmful practices (Tlusty, 2012). As previously discussed, the definition of “sustainable” depends on who is defining it. This creates issues when access to various markets is reliant on multiple certifications with differing definitions or thresholds of what it means to be considered “certified sustainable”. Additionally, there is often criticism of certification schemes for being narrowly focused, unmeasurable, and priced beyond the means of small-scale production (Bush et al., 2013). They are also widely considered to be heavily weighted towards measurements of environmental sustainability, as opposed to economic or social sustainability (Jonell et al., 2013; Osmundsen et al., 2020). Because certification schemes tend to focus on the impacts of large-scale operations and more than the aggregate impacts of small-scale farms and fisheries, Jonell et al. suggest that certification schemes, if used, be one of several methods for improving sustainability (2013).

The link between certification schemes and consumers represents one of many interactions that drive sustainability in seafood. While consumers interact with seafood retailers, they also base purchasing actions on information from the media, seafood producers (including aquaculturists), and regulators (Barclay & Miller, 2018). The degree to which consumers are effectively able to access information regarding sustainable seafood is often the result of regulatory decisions.

Certification schemes have the potential to disrupt social practices and often ignore the need to develop and maintain social license (Vince & Haward, 2017). Additionally, certification schemes tend to exclude small-scale production from participation, either by overlooking their impact or by pricing their certification beyond the means of small or medium scaled producers (Vogt et al., 2019). When applied in tandem with regulation via hybrid governance, the likelihood of gaining social license increases, but is far from guaranteed (Vince & Haward, 2019). However, recent changes to some certifications allow flexibility when addressing dynamic issues of sustainability in culturally diverse regions. This flexibility has increased their ability to improve the regional environmental sustainability in instances where small farms are common (Amundsen & Osmundsen, 2020).

The narrow focus on ecolabels as a tool for communicating sustainability is also flawed (Vogt et al., 2019). By their very nature, ecolabels are simplistic. While easily noticed by consumers, consumers are often underinformed or confused about the meaning of any given ecolabel (Sharma & Kushawa, 2019). By using other green marketing strategies there is the potential to reach and more fully inform a broader consumer base than with ecolabels alone (Rex & Baumann, 2007).

2.9 Maine's Oyster Aquaculture Industry

As of 2019, shellfish aquaculture in Maine had grown by more than seven times its 2005 value (Maine DMR, 2020). The number of Limited Purpose Aquaculture licenses (LPAs) grew over 600 percent from 2010 to 2019 (Maine DMR, 2020). The strongest example of this growth is within Maine's eastern oyster (*Crassostrea virginica*) aquaculture industry. From 2005 to 2019, the value of Maine's farmed oyster harvest increased by more than a factor of ten (Maine DMR, 2020). Today, farmed oysters in Maine make up approximately 70 percent of the value of all shellfish aquaculture in the state. As of 2016, the acreage of Maine's oyster aquaculture takes up less than 0.2 percent of Maine's existing coastline (GMRI, 2016). Most of this is occurring on small scale farms operating on LPAs and small to medium scale farms run on Experimental or Standard Leases.

2.9.1 Localized Industry Growth

As of the writing of this report, approved Standard and Experimental Leases that are licensed to farm oysters in Maine totaled 619.04 acres of leases and 503 LPAs that are 400 square feet (0.009 acres) or less (Maine DMR, 2021). Oyster aquaculture is most dense in Casco Bay (105.20 leased acres and 141 LPAs) and the Damariscotta River Estuary (158 leased acres and 58 LPAs) (Maine DMR, 2021) (Figure 1). Combined, these two regions account for 42.5 percent of all oyster lease acreage and 39.6 percent of all oyster LPAs (Maine DMR, 2021).

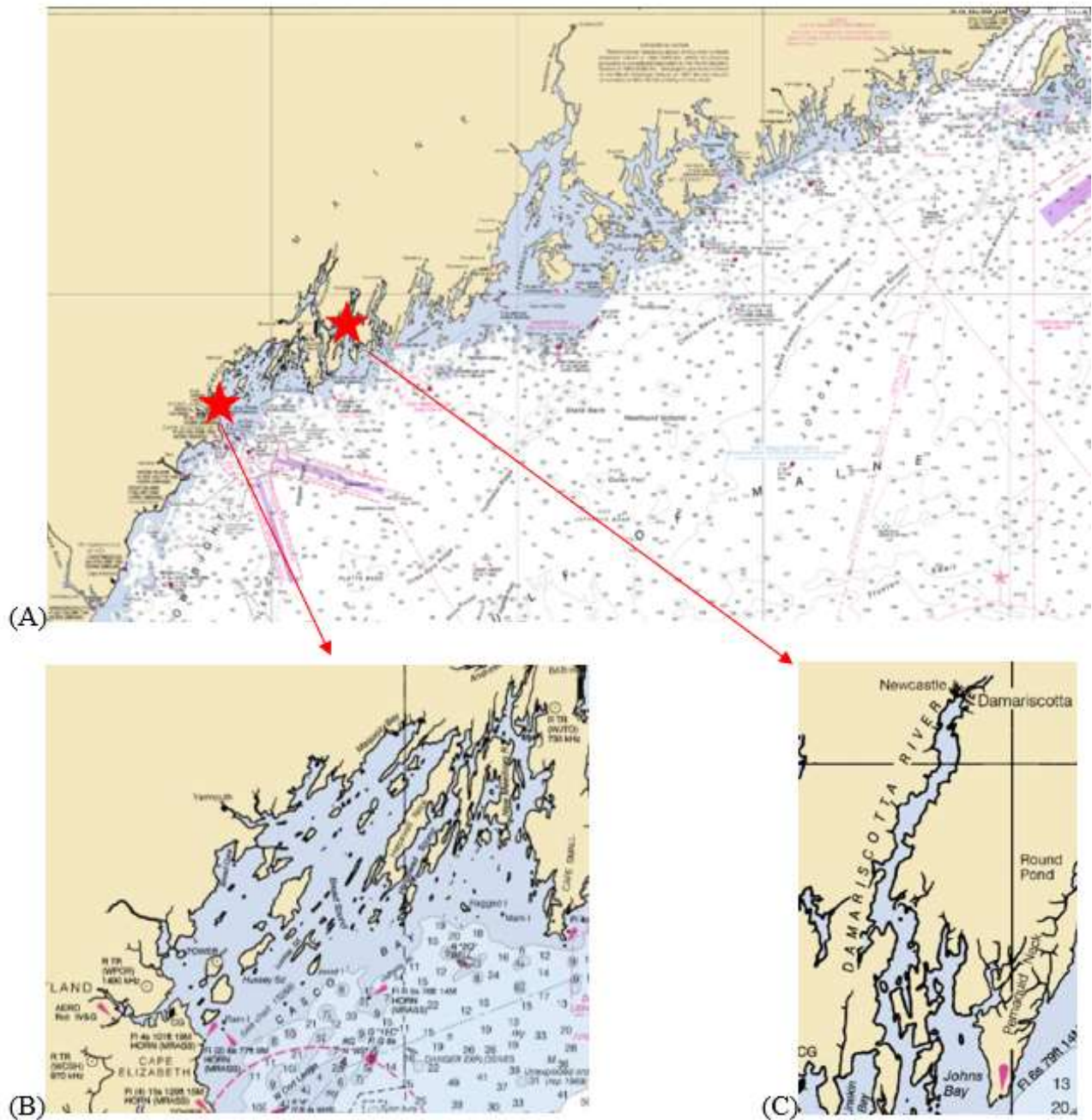


Figure 2. Coastal Maine (A), with expanded views of Casco Bay (B) and the Damariscotta River Estuary (C)

2.10 Maine's Oyster Market Potential

According to research done within Maine, the oyster industry in the state has at least several more years before the market begins to saturate (GMRI, 2016). However, there already exists a desire to further access the larger markets of Boston, New York, and beyond. In this,

Maine benefits from the broad perception that its coastal waters are pristine. This is particularly useful in the raw oyster market, as oyster buyers tend to have fastidious taste and preferences for oysters from specific locations (Kecinski et al., 2017; Brayden et al., 2018). Consumers' preference for oysters from Maine is reflected in the fact that Maine oysters frequently sell for close to 30 cents more per piece than the national average per piece (GMRI, 2016). Yet, some buyers believe that oysters from Maine are not worth the price premium when compared to lower priced oysters from further down the eastern seaboard (GMRI, 2016). If Maine oyster farmers want to compete in large markets beyond New England, the Maine name might not be sufficient to keep prices at where they have been historically.

3. Research Questions

To achieve the previously stated research goals, the following research questions were asked:

- Which buyers do Maine oyster farmers rely on most economically?
- How do definitions of “sustainability” compare among Maine oyster farmers and buyers?
- In what ways do Maine oyster farmers and buyers consider the industry to be sustainable?
- Which sustainability practices can be employed in Maine's aquaculture industry to increase their price and/or marketability?

4. Research Methods

4.1 Semi-structured Interviews

All interviews were recorded over Zoom. Interviews were recorded after obtaining permission from each subject and transcribed using Zoom's built-in software and edited manually for accuracy. Rather than directing or openly interpreting the subjects' responses, the researcher used the ‘talking back’ technique to ensure understanding and develop a dialogue that explores predetermined key themes (Griffin, 1990). Because this project was designated as Non-Human Subject Research from the UNE IRB Board, only verbal consent was required from interview subjects (Appendix 4).

Preparatory conversations indicated that these “influential buyers” were wholesale distributors and restaurant owners. Interviewing these groups allowed for data to be collected describing both how sustainability is defined within the industry as well as the degree to which sustainability is something that can improve an oyster farm's marketability.

Part of each interview included questions about additional farmers and buyers that should be included in the study. By doing this, both sample populations were able to help snowball the sample for either population. Snowball sampling is a method by which potential research subjects are identified by other research subjects (Frankfort-Nachmias et al., 2015). This also allowed interviews of both populations (farmers and buyers) to happen concurrently. Additional oyster farmers were identified and contacted using Maine's Department of Marine Resources

(DMR) databases. See Appendices 1-2 for copies of the semi-structured interview guides used in this study.

4.2 Surveys

An anonymous survey was emailed to Limited Purpose Aquaculture (LPA) holders in Maine. While the survey was sent to all Maine LPA holders, the data used to answer the research questions in this project was solely gathered from LPA holders who are licensed to commercially grow and sell oysters. This was accomplished by using skip logic with the survey development software. The survey was designed to yield similar data as the oyster farmer interviews. LPA holders were identified for survey by using DMR's databases. See Appendix 3 for a copy of the survey questions used in this study.

4.3 Data Analysis

Data analysis of all interview data followed the methods of thematic analysis (TA) as outlined by Braun & Clarke, 2006. This methodology was also used for qualitative responses from surveys (e.g., "if other, please explain). Trends and patterns from all interviews were assessed using the following theoretically derived themes:

- Buyer influence
- Farmer sustainability definitions
- Buyer sustainability definitions
- Potential changes to aquaculture/business practices
- Increased marketability/value added

These themes stem directly from the research questions outlined in section 3 of this report and were used to help guide follow up questions during the interview process. Themes were added or changed via the inductive approach to TA after the interviews as needed (Braun & Clarke, 2006). This was done to ensure that the research subjects' responses guide the analysis of the transcript data. All Likert scale data collected from surveys was analyzed quantitatively. The numbers 1-5 were assigned to various levels of agreement (strongly disagree = 1, strongly agree = 5). The survey data was used to triangulate the TA data analyzed from the semi-structured interview transcripts.

5. Results

5.1 Subject Descriptions

5.1.1 Interviewees

To identify leverage points within Maine's oyster aquaculture industry, it is critical to understand how priorities and definitions regarding sustainability compare across the industry. To accomplish this, twenty-one interviews were conducted with Maine oyster farmers and buyers of Maine oysters. Of these, 12 interviews were conducted with 13 farmers (one farm had both owners present), and nine interviews were conducted with buyers. Two farmers identified

themselves as having licenses to distribute or wholesale oysters. One buyer identified themselves as also having a small farm. All farms interviewed operate at least partially on aquaculture leases, rather than solely on LPAs.

Farms were categorized as either small (averaging fewer than 5,000 oysters sold per week) or medium-large (averaging more than 5,000 oysters sold per week). This number was based on research conducted for the Maine Aquaculture Association (C. Brayden, personal communication, November 12, 2020). Buyers were categorized based on the size of their distribution network. Buyers who distributed oysters within Maine only were categorized as local, while buyers who distributed oysters outside of Maine were categorized as regional or national.

5.1.2 Survey Respondents

Sixty-three survey respondents were licensed to grow oysters and were thus included in this study. Most of Maine's coastal regions were represented, with 27 respondents from Casco Bay, 15 from Penobscot Bay (not including the Bagaduce River), 10 from Hancock County, eight from the Damariscotta River, seven from the Midcoast Rivers (not including the Damariscotta River), three from Washington County, and two from between Kittery and Cape Elizabeth (Figure 3). Respondents could choose multiple locations, which explains why the total number of responses outnumbers the respondents.

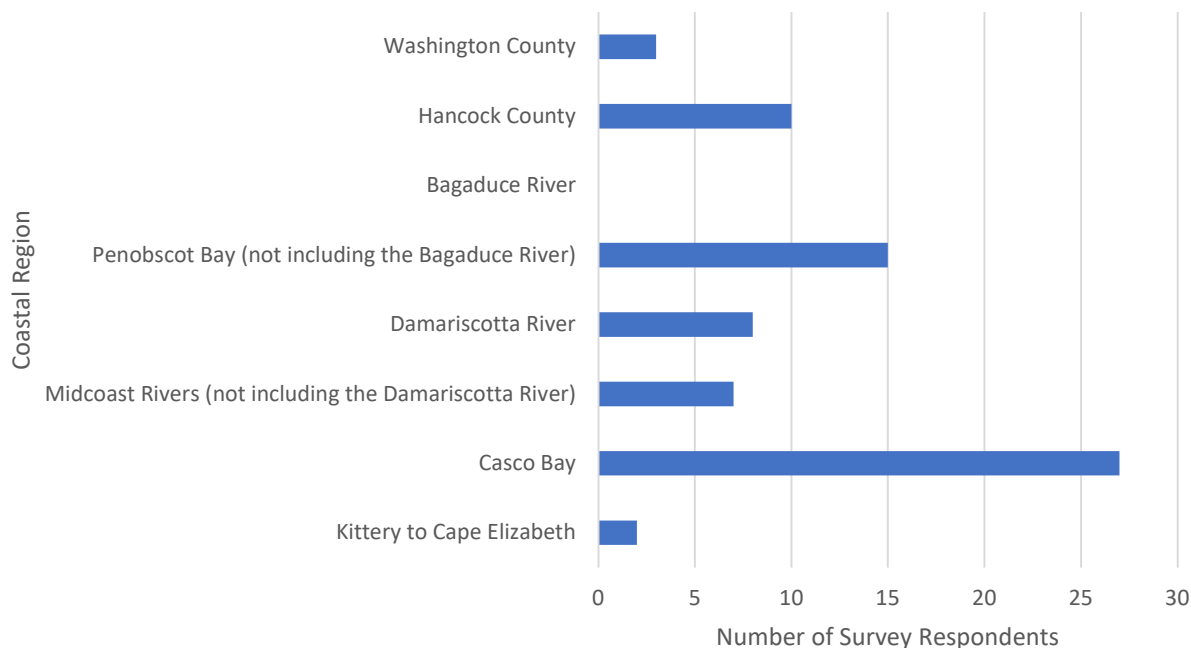


Figure 3. Coastal regions represented by oyster LPA survey respondents.

5.2 Which type of buyers do Maine oyster farmers rely on most economically?

Table 2. Themes, subthemes, and selected quotes relevant to the research question: “Which type of buyers do Maine oyster farmers rely on most economically?”

Theme: Primary buyers	
<ul style="list-style-type: none">• Restaurants• Wholesalers• Distributors	<ul style="list-style-type: none">• Farm is a dealer/distributor/wholesaler• End consumer
<p>“But we want to jealously guard and grow one-on-one relationships with farm to table situations...”</p> <p>“I enjoy working on the water too much to be driving around and calling people on the phone and shipping out packages, so I tend to concentrate on wholesalers.”</p>	

5.2.1 Primary Buyers

Identifying primary buyers of Maine oysters from the perspective of oyster farmer was a necessary starting point for later analysis of buyer willingness-to-pay (WTP) and marketability related to economic, environmental, and social sustainability. Interviewed farmers responded to the question, “Before the Covid-19 pandemic, which buyers most strongly influenced your marketing decisions?”. Restaurants were listed in seven interviews, wholesalers in five interviews, distributors in three, and end consumers in three (Table 2). When asked why wholesalers drove marketing decisions, one farmer replied, “My wholesalers understand what a chef’s point of views are for the most part, and what species they are interested in... I talked to my wholesalers about what species I'm thinking of putting on my farm.” Additionally, two farms identified themselves as dealers. These farms both included restaurants as significant marketing influencers. “I’m a dealer and I have a dealer license and retail license... I sell to wholesale to restaurants... I just ordered more seed, because the restaurants... told me that they want double or triple what they're buying from me last summer... the restaurant market drives some of that retail.”

For some farmers, there was a shift toward direct sales during the Covid-19 pandemic. This is illustrated by the quote, “...what we learned through Covid is... if we can put three dozen in a box and send it to someone in New York or Miami or something, then we can put 200 in a bigger box and send it to a restaurant.” Some farmers were already selling directly to restaurants instead of using distributors or wholesalers. These farmers also frequently began to use similar shipping methods to sell directly to end consumers.

LPA Survey Responses

LPA survey respondents were asked to answer a similar question by selecting their level of agreement with the statement “Before the COVID-19 pandemic, the following buyers most

influenced your marketing strategies and decisions” (Figure 4). The number of respondents varied slightly, with 36 responding regarding wholesalers, 33 regarding dealers, 35 regarding restaurants, and 35 regarding end consumers. Buyer categories were asked separately to make responses non-exclusive. Survey respondents responded the most positively (either strongly agree or agree) to the restaurant category (80%), followed by wholesalers (75%), end consumers (71%), and dealers (70%). Survey respondents responded the most negatively (either strongly disagree or disagree) to the dealer and wholesaler categories (9%), followed by restaurants (3%). No respondents had a negative response to the end consumer category.

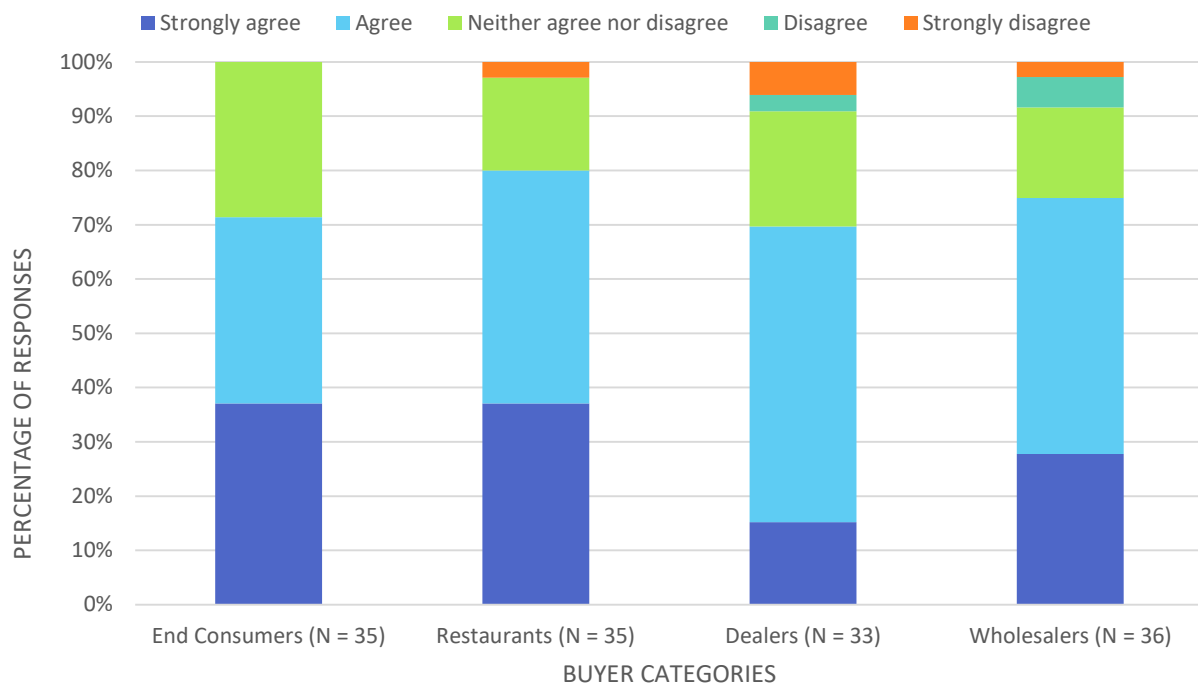


Figure 4. Survey respondents’ level of agreement to the statement “Before the COVID-19 pandemic, the following buyers most influenced your marketing strategies and decisions” for end consumers, restaurants, dealers, and wholesalers.

5.3 How do definitions of sustainability compare among Maine oyster farmers and buyers?

Table 3. Themes, subthemes, and selected quotes relevant to the research question: “How do definitions of sustainability compare among Maine oyster farmers and buyers?”

Theme: Buyer sustainability definitions		Theme: Farmer sustainability definitions	
<ul style="list-style-type: none"> Business viability Balanced priorities 	<ul style="list-style-type: none"> Ecosystem health Social benefit 	<ul style="list-style-type: none"> Ecosystem health Business viability 	<ul style="list-style-type: none"> Social benefit Balanced priorities

<p>“It’s about a long-term view. It’s about healthy fish, healthy stocks, responsible farms. You’ve got to be able to continue using a resource in a way that doesn’t keep it from existing down the road...”</p>	<p>“Sustainability is something that's regenerative. That's the first word that I think of that comes to mind when I start to try to define it, but it's being able to continue to produce something without taking away, I guess... it's about asking the least amount of planet earth while getting something in return. I don't know if something's ever going to be truly 100 percent sustainable, right?”</p>
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5.3.1 Buyer Sustainability Definitions

Buyers were asked the question, “What comes to mind when you hear the word “sustainability”? Six out of nine interviews included the subtheme business viability, five included balanced priorities, five included ecosystem health, and one included social benefit (Table 3).

Business Viability

Buyers concerned with business viability described it in different contexts. Functioning seafood supply chains, whether farmed or wild, was mentioned in four interviews. One buyer stated, “It also comes down to being self-sufficient... one of the big things in sustainability is self-sufficient farms.” Business viability was also brought up in the context of economic efficiency, “...some are more sustainable than others, as far as their infrastructure and their placement. And just their distribution lines, again coming down to efficiencies I think is really what makes things more sustainable...”

Ecosystem Health

Ecosystem health was included in various contexts as well. For oyster buyers, ecosystem health often goes beyond the necessities of their businesses. This sentiment was expressed by local, regional, and national buyers. However, local buyers were more focused on general ecosystem health, “Being environmentally conscious in terms of thinking long term for not just our generation but next generation when it comes to stewardship. Stewardship certainly comes to mind.”, while regional and national buyers focused more frequently on reducing the negative environmental impacts associated with seafood production, “...something that you can continue to produce reproduce with minimal impact to the environment.”

5.3.2 Farmer Sustainability Definitions

Farmers were also asked the question, “What comes to mind when you hear the word “sustainability”? Ecosystem health came up in 10 out of 12 interviews with oyster farmers, followed by business viability (5), social benefit (3), and balanced priorities (1) (Table 3).

Ecosystem Health

Oyster farmers consistently defined sustainability in relation to ecosystem health. Small scale farmers tended to have a broad focus on limiting negative environmental impacts, "...it works... for the environment that it's something that can sustain itself... it doesn't take too much from one part of the environment." When providing specific impacts, small farmers repeatedly expressed concern about their reliance on plastics, "The word sustainability means to me producing food and shelter in a way that has a net neutral or positive impact on the ecosystem... So, when it comes oysters for us that translates into 'How do we avoid leaving plastic even in its micro form in the ocean?'"

In contrast, large scale farmers focused on reliance on fossil fuels, "The first thing that comes to mind is... the environmental footprint that you have and... are you using renewable resources? ...over a period of time... it's that use of non-renewable resources." One large scale farmer who has been operating a farm for multiple decades described climate related changes that he noticed in recent years, "I mean, in the past 20 years I've seen a lot of changes happening environmentally. Warmer winters, warmer summers. Especially this year. It seemed like the growth for the oysters was a lot longer than it normally is. We had growth in November, which you don't usually see, and it was pretty substantial growth, too. I think this is one of the one of the warmest years in a while. When I first started doing aquaculture here we had to worry about freezing in on the river just about every year and now it's every four or five years."

Business Viability

Like buyers, farmers who defined sustainability in part as business viability did so in varying contexts including growing their business at a manageable rate, maintaining supply chains, and depending on their farm for their livelihood. This last context is well represented by a small-scale farmer who said, "Environmental sustainability was never an intention of mine, and the social sustainability came later, after seeing the need. The primary concern is economic sustainability. To create a livelihood for myself and run a viable business long term." Small scale farmers consistently defined sustainability in terms of ecosystem health but described their day-to-day focus as maintaining a viable business.

LPA Survey Responses

To gather similar data through the LPA survey, respondents were asked to select their level of agreement with the statements "Sustainability has to do with the environment", "Sustainability has to do with the economy", and "Sustainability has to do with society/culture" (Figure 5). Sustainability categories were listed separately to make responses non-exclusive. Survey respondents responded the most positively (strongly agree or agree) to the environment category (93%), followed by the economy (88%), and society/culture (84%). Survey respondents rarely responded negatively (strongly disagree or disagree) to any of the statements.

Five percent responded negatively to the economy, 3.6% to society/culture, and 1.8% to the environment.

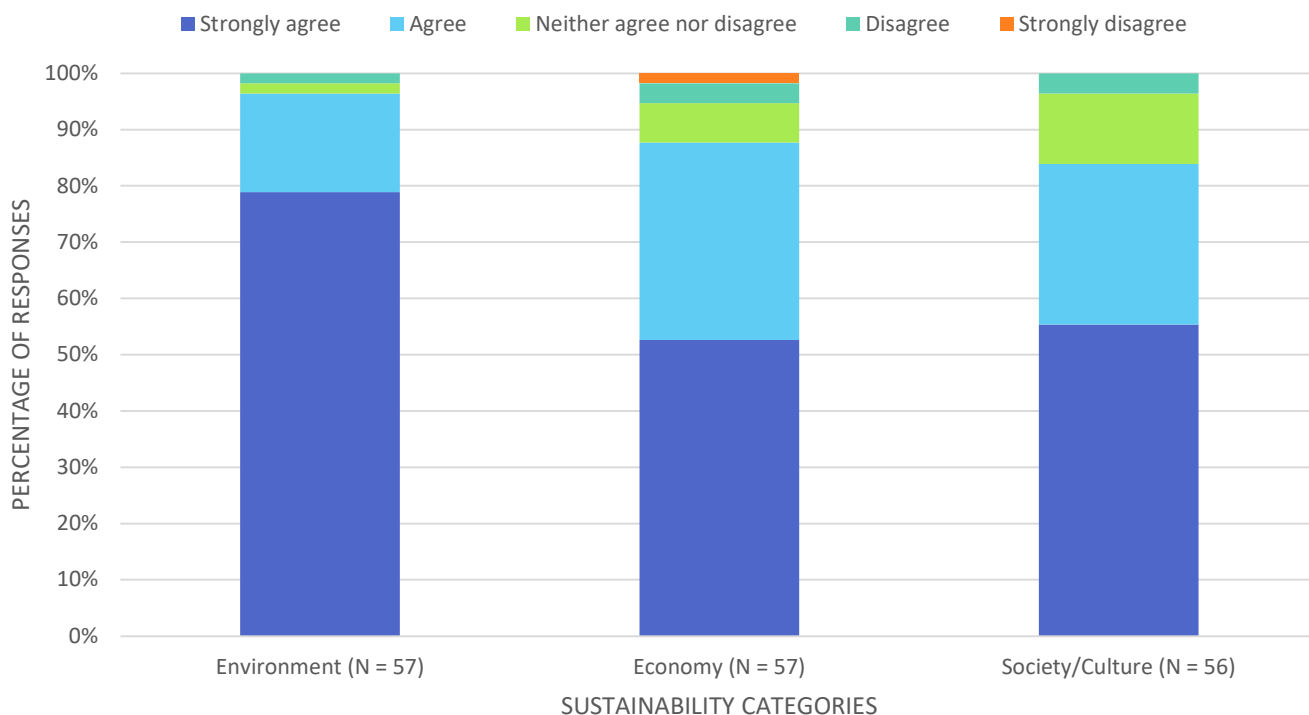


Figure 5. LPA survey respondents' level of agreement to the statement "Sustainability has to do with..." for the environment, the economy, and society/culture.

5.4 In what ways do Maine oyster farmers and buyers consider the industry to be sustainable?

To identify the ways in which they consider the oyster aquaculture industry to be sustainable or unsustainable, interviewed farmers and buyers were both asked a series of questions (Appendices 1 and 2). After analyzing the interview transcripts, six themes were identified (Table 4).

Table 4. Themes, subthemes, and selected quotes relevant to the research question: "In what ways do Maine oyster farmers and buyers consider the industry to be sustainable?" Subthemes are categorized as either positive (+) or negative (-).

Theme: Buyers on economic sustainability		Theme: Farmers on economic sustainability	
<ul style="list-style-type: none"> Farming costs too high (-) Not enough market expansion (-) 	<ul style="list-style-type: none"> Distribution channel barriers (-) 	<ul style="list-style-type: none"> Market saturation concerns (-) Barriers to entry (-) 	<ul style="list-style-type: none"> Labor costs (-) High oyster quality (+) Dependable local distribution (+)

<ul style="list-style-type: none"> Income predictability (+) <p>“Those farms that really want to make a goal, particularly the farms I'm working with right that want to scale outside of Maine... need to get bigger and get more efficient.”</p>	<ul style="list-style-type: none"> Financial costs of climate change (-) Price staying up (+) Stability through diverse accounts (+) <p>“The least sustainable... is probably the manual part of it... we're fortunate to have a bunch of young adults working on the farm that have great backs... can we sustain that? I don't know. So that's why... we need new equipment modernization.”</p>
Theme: Buyers on environmental sustainability	Theme: Farmers on environmental sustainability
<ul style="list-style-type: none"> Restorative (+) Already sustainable (+) Potential for greenwashing (-) Not enough crop/culture ingenuity (-) Increased sustainable tech investment (+) Processing/distribution impacts (-) <p>“Oysters are the best thing there is for the environment, I mean they filter everything out...I can't see where there's a downside.”</p>	<ul style="list-style-type: none"> Marine specific impacts (-) Restorative (+) Gear innovation (+) Renewable energy increasing (+) Processing/distribution impacts (-) Crop/culture ingenuity (+) Better than agriculture (+) Not currently sustainable (-) Unknown impacts (-) Packaging innovation (+) <p>“...plastic mesh, again, because I have not yet... managed to find a biodegradable or recyclable option that is, you know, cost effective and easy to get my hands on. And then I think the other sustainability piece for the larger industry is... shipping and packing.”</p>
Theme: Buyers on social sustainability	Theme: Farmers on social sustainability
<ul style="list-style-type: none"> Community stability (+) Not enough community engagement (-) Stakeholder density (-) Not currently feeding rural communities (-) Fragile industry image (-) Maintaining coastal culture (+) 	<ul style="list-style-type: none"> Ineffective regulations (-) Maintain coastal culture (+) Community engagement (+) Building community of knowledge (+) Community stability (+) Stakeholder conflict (-) Shared infrastructure/gear (+) Small farms connected to community (+) No marine spatial planning (-) Potential gender equity (+)

<p>“People are fine seeing a lobster buoy, people are fine, you know that's part of Maine now. But that wasn't liking happening overnight, they took probably hundreds of years to get there.”</p>	<p>“In the leasing process you need to basically outline how every little like piece of gear is going to be laid out, what that gear is, how many oysters it's going to hold. It's like a full plan for your full-scale farm and that lease goes 20 years right, like how are we supposed to evolve as a business and lay out every little piece in our application 20 years down the line...? And if we do that and we plan for all possibilities the public freaks out because they see this insane business that [they think] is going to be plopped in the water next year.”</p>
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5.4.1 Buyers on Economic Sustainability

Among buyers, three out of four subthemes expressed doubt on the current economic sustainability of oyster aquaculture in Maine. Of these, five out of nine interviews included the subtheme farming costs too high, five included not enough market expansion, and one included distribution barriers. The positive subtheme income predictability was discussed in two interviews (Table 4).

Farming Costs Too High

Oyster farms in Maine, particularly small farms, are associated with small profit margins and exhaustive labor. This labor is time consuming to the point where operations do not increase in efficiency quickly. One buyer described this by saying, “... economically... they're going to have to figure out how to make themselves more efficient to sustain the volume that's going to be coming down the road.” Small farms often have a difficult time offsetting this through hired labor due to cost, “That's really one of the most expensive things in farming is the labor. So that makes sense as especially as your baseline, your minimum wage is always increasing.” With labor costs cutting into small profit margins on many farms, one buyer expressed concern regarding efficiencies of scale, “The farms I'm working with, right, that want to scale outside of Maine, you know, need to get bigger and get more efficient.”

Not Enough Market Expansion

The need for more market expansion was mentioned in all the regional and national buyer interviews. This was presented in two different contexts. One was that farmers need to have a larger out of state market base to balance the seasonality of tourism in Maine, “I think that in order to be a sustainable oyster industry Maine has to sell at least half of their oysters out of state. I mean, we have a great tourist industry here, but that only gets you so far. You got places like... Atlanta Los Angeles Portland, Oregon, Seattle Austin, Texas. Those guys all hit oysters

extremely hard... you do need that competition, you do need healthy distribution.” The other reasoning was that the recent increase in Maine oyster farms may be beginning to cause market saturation within the state, “I don't know how it's viable at times for these farms to like maintain unless they are actually exporting out because... Mainers love their oysters but Maine is, in my eyes looked as that kind of epicenter of of the oyster aquaculture zone currently so...according to some farmers and good buddies they really kind of need to be moving product out of state essentially.”

Income Predictability

Two of four local buyer interviews mentioned the positive effect oyster farming has on income predictability for the farmers themselves. Both interviews mentioned it in comparison to wild capture fisheries in Maine. This contrast in business models lead one buyer to say, “I mean, I know just from a lot of people we work with a lot of people are either dually doing fishing and some aquaculture, or have straight up left fishing and moved to aquaculture...It's just a definitely a little more of a business plan that you can actually like strategize.”

5.4.2 Buyers on Environmental Sustainability

Seven interviews mentioned the subtheme restorative, followed by oyster aquaculture is already sustainable (3), greenwashing (2), not enough crop/culture ingenuity (2), sustainable tech investment (2), and processing and distribution impacts (1) (Table 4).

Restorative

Most interviewed buyers were quick to share the restorative qualities of oysters. In some cases, this was brought up in the context of climate change, “Yeah, the overall sustainability of whether... it's depleting oceans, or acid the acidity kind of raising up. There's so many... wonderful attributes that oyster and, specifically, oyster aquaculture has... to change the way people see sustainability. and interact with it, you know?” In other instances, it was discussed more generally, with emphasis on the idea that the restorative aspects oyster farming go beyond sustainability, “...it's one of the more unique practices where it's not just considered sustainable, but really it has restorative properties as well.” In many of these instances, the focus was on the biology of filter feeding bivalves, and not on specific farming practices.

Sustainable tech investment

Buyers consistently expressed excitement about innovation and environmentally sustainable technologies. Local buyers highlighted some of the benefits of all scales of oyster farming in Maine. For example, one local buyer stated, “I think people are really pushing the envelope... there's a lot of small farmers that are...not using a lot of plastic equipment or a lot of transit or a lot of you know? And then on the flip side, you have some of the larger players in the state that are like really cutting edge from using solar...”

In contrast, regional and national buyers were consistently focused on the vertically integrated technologies that larger farms often use. One such buyer expressed this by saying, “I guess what else makes it sustainable is people using new technologies to be more efficient. Such, as you know, using less electricity, you see some people using these like solar upweller systems now, too, for growing their juvenile seed.” In either case, the value of small farms was expressed in terms of having smaller environmental footprints, while large farms have the benefit of being able to invest in technology that offsets the size of their environmental footprint.

5.4.3 Buyers on Social Sustainability

Six interviewed buyers mentioned the benefit community stability, followed by not enough community engagement (3), oyster farming currently does not feed rural communities (3), fragile industry image (3), helps to maintain coastal culture (3), and stakeholder density (2) (Table 4).

Community stability

Local, regional, and national buyers discussed community stability, which was characterized by an inherent link between the social and economic needs that are specific to coastal communities. Specific issues that arose in conversation were economic value outside of coastal real-estate, access to working waterfronts, and working with seasonal tourism. One local buyer said, “Well... I think it's incredibly important to preserve the land rights of the generational inhabitants of our waterfront and by leasing land to grow oysters. And... to create economic value of protecting the waterfront of those communities, it preserves the roots of those communities, so that economic value doesn't come from other industry or development.” One buyer with national distribution expressed, “You have people kind of running out and getting back to something that hopefully they love and believe in and creating an economy around it that, you know, then fuels tourist industry and... really draws people into I think within the overall practice and community sustainability...” The ability to provide stability to coastal communities is a valued benefit for some buyers.

Not enough community engagement

A concern that buyers had regarding the social sustainability of oyster farming was community engagement. Buyers were concerned that, while some efforts were being made by farmers to connect with the community, more needed to be done. An interview with one regional buyer illustrated this by saying, “Yeah, I think aquaculture has a pretty uphill battle. It really had a pretty bad rap and really shaped the whole world of aquaculture. In Maine, most people don't even know what aquaculture means... It's like there are different silos and investors really. We need... shellfish aquaculture if they can kind of get education around it.” While aquaculture is a term that encapsulates many practices, species, and associated impacts, this

buyer was concerned that communities in proximity to oyster farming do not receive enough information directly from the farms.

Another buyer discussed these concerns in the historical context of Maine's working waterfront and how relatively young the oyster farming industry is in the Maine. "Probably the number one way I think the negative could really be because people are fine seeing a lobster buoy, people are fine, you know that's part of Maine now, but that wasn't liking happening overnight. They took probably hundreds of years to get there. So it's like aquaculture has... only been in the Damariscotta 30 years old, but that's 30 years... the lion's share of aquaculture is really common the last like five years" According to this buyer, habitual exposure to oyster farming may, over time, change how communities respond to it.

5.4.4 Farmers on Economic Sustainability

When asked about the current economic sustainability of oyster farming, all farmer interviews expressed concerns. Eight farmer interviews expressed market saturation concerns, followed by farm labor (6), climate change (4), and barriers to entry (3) (Table 4).

Farm labor is limiting factor

For those farmers who expressed farm labor as a limiting factor of their economic sustainability, they were often focused on the labor associated with farming, rather than processing, marketing, or distribution. "It's the production process it's the business aspect of the farmers, the labor required to control for biofouling, the labor required to get into a cage pull, out a bag, empty the bag, break it up into two or three bags, put them out into two or three cages. Now I've got two or three times more cages to flip for biofouling and it's just that labor that's the least sustainable part of this business." As oyster farms improve their practices and fill out LPA or lease spaces by lowering grow-out densities, they inherently increase the labor associated with most aspects of growing marketable oysters.

Barriers to entry

Additionally, farmers expressed frustration at the difficulty they had experienced, or were currently experiencing, as a new business. The combination of labor costs, lack of investment, and delayed income act as financial barriers for most farms. One farmer illustrated this by saying, "Especially at the state level here in Maine...it's really hard to innovate in this space and to grow these businesses. The bivalves slow you down. It takes a year, two years, but then all the red tape slows you down quite a bit as well. We're learning like for investors it's just too long. It's too risky. So, you get all these part timers out there trying to make the switch from the security of a job they don't like to something they really love but just economically is not sustainable...I just see these businesses needing help from all ends right now help getting started." Without

outside investment or immediate revenue, many new or potential oyster farmers have a difficult time foreseeing economic sustainability.

All farmer interviews also expressed optimism regarding economic sustainability. Five expressed relief that they have been able to maintain price, followed by high oyster quality (4), local distribution (3), diverse buyers (3), and room for more farms in the market (2) (Table 4).

Have been able to maintain price

Some farms that have been able to maintain their price points as the supply of oysters has increased have done so by either delaying the sale of their oysters to increase the size of their cull, outcompeting other farms based on high quality and low quantity oysters, or selling directly to restaurants or end consumers. One farmer expressed this last tactic by saying, “Our price has not changed, but our vision for our price has changed. So, there was a time where we were going to substantially drop our price and grow a lot more and like wholesale and all that stuff was always really in our vision... we've stepped away from that and want to try and pursue growing at our higher price and taking on some of that, the more responsibility that we would have passed off to a wholesaler.” While oyster farms experienced many economic hardships during the COVID-19 pandemic, in this case learning to efficiently sell directly to consumers and restaurants has benefited the farm.

LPA Survey Responses

Some LPA survey respondents were concerned that they were inherently at a disadvantage in comparison with larger farms. One such respondent stated, “Much like other agri-business industries and food systems, the stage has been set for consolidation and favors large-scale, "efficient" producers. It is never advisable to only grow one species, particularly in such a volatile market.” By incentivizing reduced costs through increased efficiency and monoculture, some small farms operating on LPAs are concerned not only for their own economic sustainability, but that of the whole industry as well.

While eight of the 12 farmer interviews mentioned market saturation concerns, the results were more mixed among LPA survey responses (Figure 6). Of 55 respondents, 38 percent expressed concern with market saturation for their LPA products, and an equal number were not concerned with market saturation.

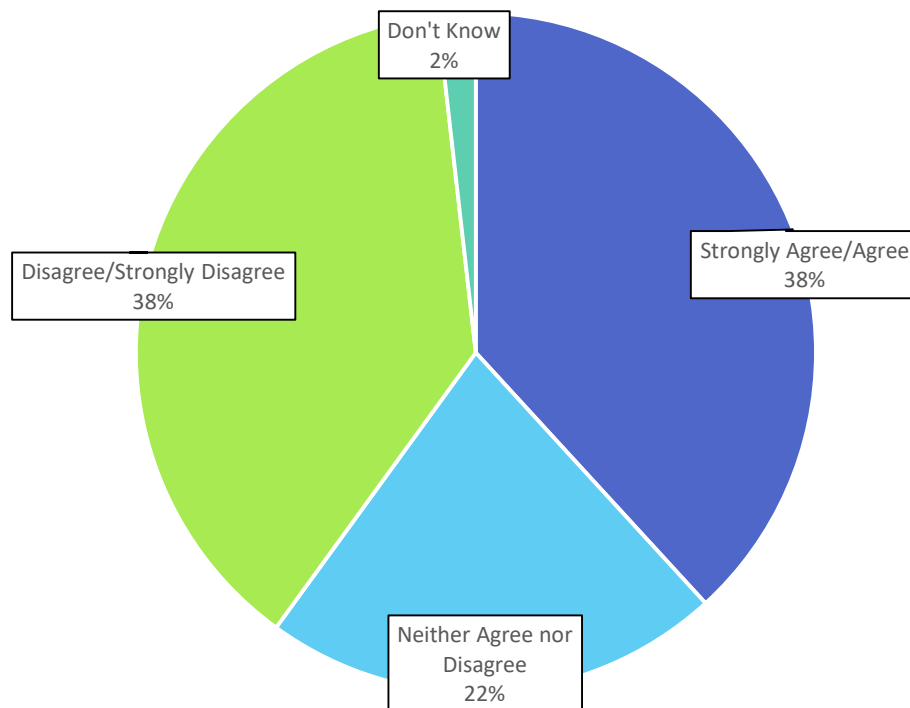


Figure 6. LPA survey respondents' level of agreement with the statement "I am concerned with market saturation for the product(s) of my LPA(s)." (N = 55).

5.4.5 Farmers on Environmental Sustainability

When asked about the environmental sustainability of oyster farming, all farmer interviews included positive subthemes. Nine interviews mentioned the restorative properties of oyster aquaculture, followed by gear innovations (7), comparatively better than land based animal agriculture (7), growing access to renewable energy (6), crop culture ingenuity (6), and packaging innovations (3) (Table 4).

Renewable energy access

Three out of the four large farms that were interviewed expressed interest in accessing more renewable energy, mainly in the form of solar power. "We could put more solar capacity on our property. And I think at some point will probably want to do that. I think we're producing enough that it covers maybe 25 percent or so of our use which is a start." When solar power is used by oyster farms, it is often used to offset land-based processing costs. However, some farms, described how they are, or are planning to, use solar power on the water, "I think I'll probably have a little solar powered pump for the water pump that I hope to have out my float this season." Additionally, four farmers were hopeful about using electric outboard motors once they felt the technology was reliable enough for commercial use. This is illustrated by the quote

from on farmer, “We’ve looked at turning to an electric fleet, but the technology really isn’t there yet. We are doing a big solar installation to offset our electricity use for refrigeration... so we will be solar powered on shore, but not on the water yet.”

Packaging innovations

While small scale farmers expressed increased direct-to-consumer sales, they also expressed concern with the environmental impact associated with increased reliance on shipping. However, some farms are finding innovation in their packaging to insulate their oysters during shipment. “But all the shipping that we do...we don't use any Styrofoam. It's all either like corrugated cardboard insulation for boxes or a wool insulation, which is really cool.” While the use of cardboard or wool for insulation does not neutralize the potential impact of shipping direct-to-consumers, it is likely to mitigate it to some extent.

All farmer interviews also included negative subthemes regarding the environmental sustainability of oyster farming. Eleven mentioned plastics and ocean pollution, followed by processing and distribution (7), unknown impacts (4), and oyster farming is not currently environmentally sustainable (2) (Table 4).

Plastics/ocean pollution

Farmers’ concern with plastics and ocean pollution were the most frequently discussed of all the subthemes identified in farmer interview transcripts, coming up in 11 of 12 interviews. Small scale farmers were frequently focused on the tangible impacts of their individual farms. One farmer illustrated this by stating, “And every time I bail out the boat and I see those little bits of Styrofoam peanut coming off it drives me freaking crazy. I have not yet ripped the seats out in order to get rid of the Styrofoam, but I feel guilty about it every time I bail the damn boat out.”

Farmers from medium and large-scale farms were similarly focused on plastics and ocean pollution, but this was typically in the context of the entire Maine oyster aquaculture industry. “All of us are heavily dependent on plastics.” Farmers of different scales often expressed a desire to access effective alternatives to plastics on their farms. “I have not yet... managed to find a biodegradable or recyclable option that is... cost effective.”

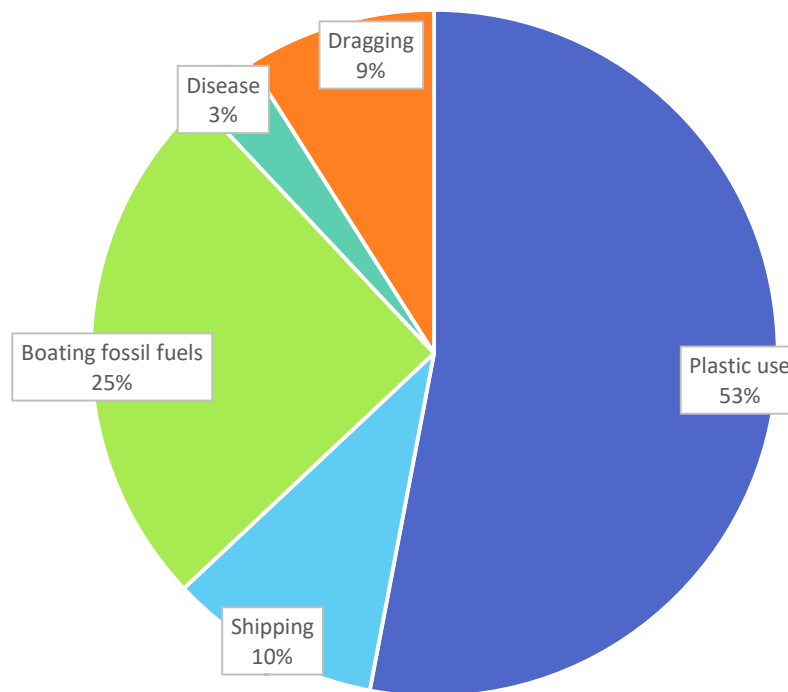


Figure 7. LPA survey respondents' views of the least environmentally sustainable practices in Maine oyster aquaculture (N = 36).

LPA Survey Responses

The concerns that lease operating farmers expressed regarding environmental impacts of oyster aquaculture were reflected in the most common survey responses as well. LPA holders were most concerned about plastic use, followed by boating fossil fuels, shipping, dragging to harvest, and potential disease outbreaks (Figure 7).

Additionally, multiple LPA survey respondents were conflicted about the role that small and large oyster farms play in the overall sustainability of the Maine oyster aquaculture industry. This is encapsulated by the quote from one LPA holder, “The many small farms in Maine yield higher social sustainability, but the inefficiencies of a many small farm sector negatively effects the environmental sustainability of the sector as a whole: more boats, more fuel, redundant equipment, less efficient supply chains and product distribution. This is why an industry with farms of all sizes is stronger and more sustainable as the small farms can rely on the larger and more efficient infrastructure established by the larger operators.” According to this farmer, a healthy industry will foster the success of farms of all sizes.

5.4.6 Farmers on Social Sustainability

Farmer interviews included the following positive subthemes when asked about social sustainability: Maintaining coastal culture (10), community engagement (6), building community of knowledge (5), community stability (3), share infrastructure and gear (3), smaller farms connected to community (3), potential gender equity (2) (Table 4).

Maintain coastal culture

Several oyster farmers thought of oyster aquaculture as a way to maintain the coastal culture of Maine as environmental conditions shift in the future. To illustrate this, one large-scale farmer said, “Here on the Maine coast is that there is this, you know, centuries old heritage of our use of our marine resources that go and that's changed over time. But it has gotten... to a point where the working waterfront is really dependent on you know, people being able to earn their living from the sea in Maine... We're going to have to adapt. We're going to have to adapt to climate change. We're going to have to... evolve in a way that makes more environmentally sustainable in order to sustain the cultural part of it.” By providing additional sources of income on the Maine coast, this farmer hopes to keep a distinct part of Maine culture thriving.

Community stability

Three farmer interviews also included broader community stability as a benefit that oyster aquaculture has the potential to provide. One small-scale farmer described this by saying, “...social economic stability for the community is why we started this thing. Our area is like a lot of coastal or island communities under increasing pressure as income stratification increases dramatically. And there's a whole series of social and economic pressures that keep young families from being able to live on the water. Our focus... is, how do we help small family owned family operated aquaculture businesses find a way to thrive?” By providing sources of income for individuals and families that live on the coast, some farmers hope that more people working on Maine’s coast can afford to live there, too.

All farmer interviews also included negative subthemes regarding the social sustainability of oyster farming. Eight of twelve interviews included ineffective regulations, followed by stakeholder conflict (3) and lack of marine spatial planning (2) (Table 4).

Ineffective regulations

A common subtheme among farmers at all scales was the regulatory process involved with obtaining a Standard Lease. While there was general agreement that public involvement was necessary and appropriate, there were frustrations with how the process relied on detailed, long – term plans. As one large-scale farmer put it, “But you know, that's one of the challenges I think with the, the whole Department of Marine Resources application process to get into this is

you really have to be very descriptive on what you're going to do, and your leases for a 20-year period. And who knows what's going to happen three years from now, let alone 20 years from now?" In an industry that is relatively young and growing, farmers often lack the detailed information about what their expansion will look like in the medium to long term future.

Stakeholder conflict

Three farmer interviews also expressed concern with stakeholder conflict. One interviewee believed that a solution to the problem is to involve the broader community more specifically. "Social sustainability ultimately is going to...depend on people, other than just landowners and fishermen weighing in on it. In other words, if you think about marine resources, they're the commons so everybody in the state of Maine is entitled to... its resources right? Most of the conversation is... from the immediate stakeholders...The industry needs to bring in more people you know who aren't necessarily directly connected but see and care about the economic impacts positive economic impacts as well as being careful about how Maine's public sources are being used..." The current stakeholder interactions typically involve those directly involved. According to the farmer quoted above, the oyster aquaculture industry would benefit from actively involving the broader community.

LPA Survey Responses

When asked about the least sustainable aspects of oyster aquaculture in Maine, several LPA survey respondents pointed to social issues, including problems with regulatory factors. For one respondent, the geographic distribution of LPAs was causing outsized impact to other stakeholders. "LPAs are forced to be spread out rather than clustered which results in more impact to other stakeholders." Another respondent described the issues they experienced as, "Understaffing at the DMR and landowner tension."

LPA survey respondents were also asked to provide their level of agreement with three statements regarding oyster aquaculture and social sustainability (Appendix 3). Of the three statements, respondents agreed most frequently regarding support for working waterfronts (91 percent either strongly agreed or agreed), followed by support for society and culture more broadly (84 percent), and support for gender and racial equity (37.5 percent). No respondents strongly agreed that oyster aquaculture should promote gender and racial equity (Figure 8).

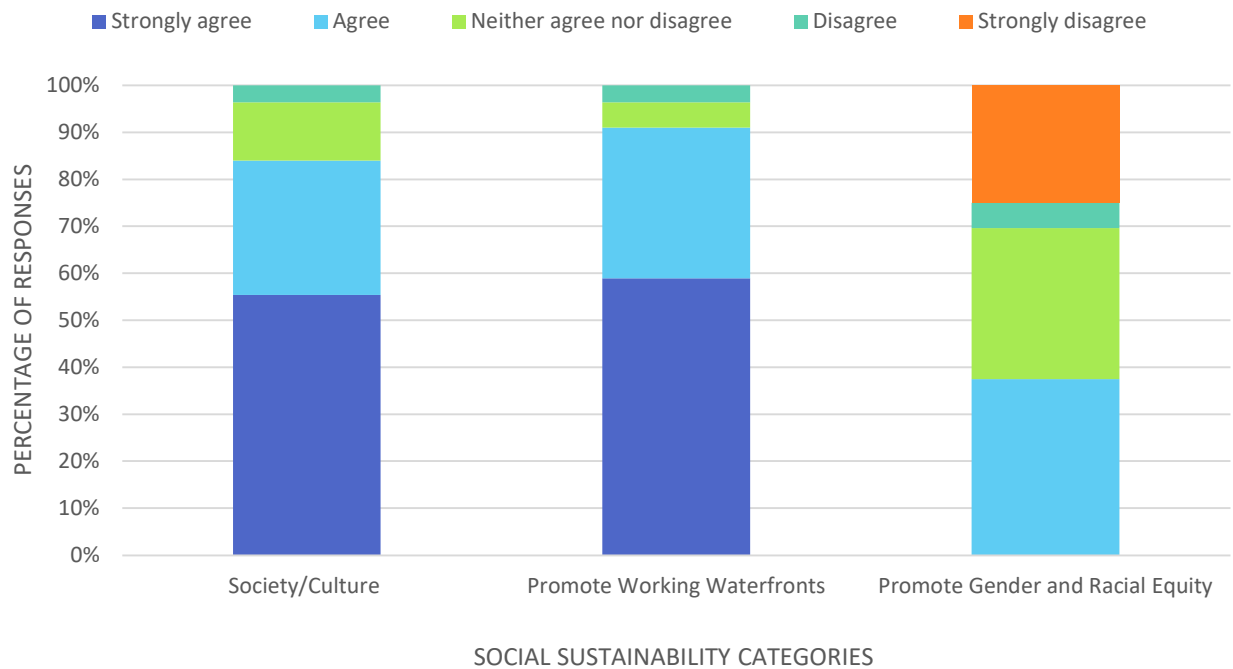


Figure 8. Survey respondents' level of agreement to statements regarding Maine oyster aquaculture's responsibility to various social issues (Appendix 3) (N = 56).

5.5 Which sustainability practices can be used to increase Maine oyster price and marketability?

To identify which sustainability practices, if any, could help increase Maine oyster price and marketability, interviewed farmers and buyers were both asked a series of questions (Appendices 1 and 2). After analyzing the interview transcripts, six themes were identified (Table 5).

Table 5. Themes, subthemes, and selected quotes relevant to the research question: "Which sustainability practices can be employed in Maine's oyster aquaculture industry to increase their price and/or marketability?" Subthemes are categorized as either positive (+) or negative (-) where applicable.

Theme: Willingness-to-pay (WTP)		Theme: Buyer perceptions of consumers	
<ul style="list-style-type: none"> • Extra environmental steps • Price pass-through • Maine at maximum price already 	<ul style="list-style-type: none"> • Quality • Consumer WTP still increasing • WTP is equal for all Maine oysters • Social sustainability 	<ul style="list-style-type: none"> • Lack information • Won't differentiate between Maine farms 	<ul style="list-style-type: none"> • Prefer either wild or farmed • Want help purchasing sustainably

<p>Not WTP for any sustainability</p> <p>“...I make my money on selling oysters, I need oysters to be sustainable. And, you know, it can't be a dying resource.”</p>		<p>“...the six grams or the 20 grams of protein you got from that burger you ate consumed X amount of water whereas this oyster just consumed literally a 20th of the amount of energy to create that amount of protein. I think that resonates and makes people feel better about it.”</p>	
<p>Theme: Buyer purchase priorities</p> <ul style="list-style-type: none"> • Quality • Carbon footprint • Reliable supply • Gear innovation <p>“It’s easy to grow an oyster. It’s hard to grow high quality oysters at a high enough volume over a long enough time to consistently be on restaurant menus and to create reliable customers.”</p>		<p>Theme: Marketing</p> <ul style="list-style-type: none"> • Story/people • Ecosystem services • Small farm practices • Maine oyster quality • Transparent practices <p>“We market what sells. Maine. Fresh. Merroir. Our story. Connection to place. That's the kind of things that people are buying right now, not even sustainability and we need to change that.”</p>	
<p>Theme: Buyer certification views</p> <ul style="list-style-type: none"> • Unequal benefit (-) • If tied to broader industry benefit (+) • Biased incentive structures (-) • Can inform consumers (+) 		<p>Theme: Farmer certification views:</p> <ul style="list-style-type: none"> • Unnecessary (-) • Biased incentive structures (-) • Unequal benefit (-) 	
<p>“Sometimes it makes sense, sometimes it doesn’t. If they red list you, regardless, the market can dry up overnight. Happened here with the Jonah Crab fishery. I would say if you’re going to get MSC or ASC certified you’d be better off using that money to spend on marketing and as long as you’ve got good product and a good story to tell, you can get to the consumer.”</p>		<p>“So... my initial impression based on certification programs for fisheries and then also organic vegetable production is that they typically disadvantage small farms. And more socioeconomically disadvantage individuals. So, I would be wary of the idea of certification.”</p>	

5.5.1 Willingness-to-pay

Buyer interviews resulted in the following subthemes when asked about their willingness-to-pay for sustainable oyster farming practices: extra environmental steps (5), price pass through (4), Maine oysters already at maximum price (4), quality (3), consumer WTP still is increasing (3), WTP for social sustainability (3), all Maine oysters are equal (2), and not WTP for sustainability (2) (Table 5).

Extra environmental steps

Oyster buyers, whether local, regional, or national, provided varied responses that referred to extra environmental steps. One local buyer referred to issues that may influence the inconsistencies that were identified by saying, “I mean it depends... you don't really know how much of a change it's really impacting your own business.” If buyers are not sure how much of an impact a given farming practice has on social, environmental, or economic sustainability, it is difficult to predict how much of an impact the practice may have on consumer WTP. Conversely, some buyers expressed the interconnectivity between environmental sustainability and their own business viability. For example, one buyer with national distribution stated, “I want to sell a product that I can keep selling... I make my money on selling oysters, I need oysters to be sustainable. And, you know, it can't be a dying resource.” By promoting environmental health, this buyer believes they are promoting their future business success.

Quality

When asked about their WTP for sustainability practices, some buyers maintained that they make purchasing decisions only based on product quality. “People, when they start eating oysters... they may come back and say ‘Oh, I want this farm or I want another one because they've had it before they like the flavor. So the public will determine what they want... I'll buy more of that product because that's what the public wants.” Similarly, one local buyer referred to consumer choices regarding sustainability as choices based in wanting fresh food. “We are seeing a huge foodie movement right? We know it's not happening because of sustainable sustainability choices. It's happening because people want fresher food.” While consumer choices may support environmental sustainability, this buyer argued that it is in order to ensure the quality of what they are eating, rather than to benefit the broader environment.

5.5.2 Buyer perceptions of consumers

Buyer interviews resulted in the following subthemes regarding their perceptions of oyster consumers: Three interviews described a lack of consumer understanding of low trophic aquaculture, followed by a general lack of information (2), want help acting on sustainability (2), won't differentiate between Maine farms (2), and only look for wild versus farmed (2) (Table 5).

Lack information

Some buyers were focused on the lack of information that consumers often have about oyster aquaculture and different farming practices. As a result, one local buyer expressed this as an opportunity by saying, “I would say that people know two things about oysters and that's whether they like them when they don't like them and then after that they don't know damn thing about oysters. Any information you're giving them is going to be powerful.” According to this buyer, because consumers tend to lack information, any information a farm provides about their practices and how they improve an aspect of sustainability will have a large impact.

Want help acting on sustainability

Another local buyer expressed confidence in consumers' desire to participate in sustainable solutions. He described this as being particularly true when it comes to local community sustainability by stating, “...I think one is giving back to a community because they want to see this having a larger impact. I think they will really like that, because kind of the trickle down effect of this consumption. They like supporting... mom and pops.” By making sustainable choices easier for consumers, this buyer thinks they will be happy to support small community-based businesses.

Separately, one buyer with regional distribution was confident that, given a choice, consumers will choose products that are more environmentally sustainable. “...between two oysters that someone hasn't had before and that they're curious about and one is packaged that way and it's advertised in that manner and the other one is packaged in a plastic bag they would definitely be buying... the new biodegradable products. But it comes down to advertising and letting the consumer know that.” By accurately advertizing commitments to improving environmental sustainability, oyster farms may improve their relative marketability.

5.5.3 Buyer purchase priorities

Buyer interviews resulted in the following subthemes regarding their priorities when purchasing oysters: Six interviews referred to quality, followed by reliable supply (5), gear innovation (3), carbon footprint (3), and consumer demand (1) (Table 5).

Quality

Quality was the most frequently mentioned purchasing priority for oyster buyers, regardless of whether they had local, regional, or national distribution. Some buyers noted that, in Maine, oyster farming practices and environmental conditions (“merroir”) were not uniform from farm to farm, and that the resulting quality is what differentiate farms from each other. “So, you need the merroir for them to taste good, and there's lots of that in Maine, but you also need to handle them right. I have my favorite oyster shell in my hand... If you can grow them in Maine to look like this, we can sell a lot of them. How's the flavor, how's the grading? If they can't get the grading, it's hard to work with them. That's how you make a business sustainable.

Reliable, dependable, good product.” This quote is illustrative of a common view among buyers that having consistent quality over the long-term leads to the success of an oyster farm.

This differentiation results in buyers choosing farms to conduct business with, thereby increasing the marketability and overall distribution and economic success of the farm. This was encapsulated by a regional buyer who said, “You have the stuff that you know is an art and a lot of these oysters that... grow out in six months. So that's great. But it's going to fall apart in your hand when you try to open it. And we all know there are oysters in Maine that grow fast and are horrible to open in a restaurant... as a buyer, you just make your choices to work with those farms or don't work with those farms.” According to this buyer, shells that are easy for restaurants and consumers to work with is a central aspect of their quality.

Reliable supply

Reliable supply was also a priority for buyers. Buyers expressed a desire to work with farms that can maintain consistent harvest numbers, regardless of the time of year. According to one local buyer, “Trying to maintain that consistency over a twelve month period, that's where a really refined farm and practice comes into place.” Having these “refined” farming practices in place can help ensure that buyers, and thus end consumers, have access to that farm's oysters long enough to create consistent consumer demand. As stated by a national buyer, “If we are looking at economics of a single farm or business, it's all about consistent product. It's easy to grow an oyster. It's hard to grow high quality oysters at a high enough volume over a long enough time to consistently be on restaurant menus and to create reliable customers.”

5.5.4 Marketing

Farmer and buyer interviews resulted in the following subthemes describing marketing techniques or topics that they view as impactful: Ten interviews mentioned marketing a story or people, followed by ecosystem services of oysters (8), small farm practices (6), Maine's oyster quality (5), and transparent practices (3) (Table 5).

Market story/people

Ten interviews mentioned the need to market a story about the people connected to the oyster farm. According to one local buyer, using such stories evokes sentimentality in consumers that convinces them to choose a particular product over other options: “I think, oyster farming is all about the person and the people. Yes, environmental environmental sustainability is something I think that is assumed and doesn't necessarily need to be highlighted. It's the person, it's a Abigail the oyster lady. It is Bill Mook, it's his name. It's a picture of Dana Morse standing on his boat. It's a family from Moshier Island who has a kid who's in a couple sitting there sorting out oysters. That sentimentality, I think, is the best marketing tool for oysters there is.” This is also reflected in how a different local buyer communicates with oyster farms about how he plans to market their oysters: “Typically... we send out a little grower questionnaire for

advertising and it has just like the questions of, like, what's the area like that you grow in? How long have you been there? How many oysters? How many people do you, how many people on your team to do it?" Providing a face, name, and specific details about how oysters are grown and brought to a consumers plate is a powerful way to get the attention and loyalty of consumers.

Ecosystem services of oysters

The ecosystem services provided by oysters is a topic that farmers expressed reliance on, particularly when conducting direct-to-consumer sales. In some cases this information is provided on a website that supports e-commerce. As one small-scale farmer put it, "There's definitely some talking points on the website that talks about you know the beneficial effects of oysters and cleaning the waters and how sort of our relationship with the ocean and being stewards of that and how this is tied in with that." Additionally, some farmer interviews mentioned teaching ecosystem services when talking face-to-face with consumers. One large-scale farmer described a typical farmers' market talking point as, "... we've always talked about how we're... not depleting and the water quality and stuff. So I guess, you know, as part of the pitch." It is noteworthy that, while eight of 12 interviewed farmers mentioned ecosystem services as part of their marketing strategy, no buyers mentioned the topic as a key part of their marketing strategy.

LPA Survey Responses

LPA survey respondents were asked if their oysters had changed in marketability in recent years and, if so, what factors they attributed it to (Appendix 3). Fifty five percent either strongly agreed or agreed with the statement, 25 percent neither agreed nor disagreed, and 20 percent either disagreed or strongly disagreed (Figure 9). Three representative quotes were selected from the 55 percent who had experienced changes in the marketability of their oysters. Of these, two represent positive changes in marketability: effectively using the Maine name as a marketing tool, and improved farming practices leading to a more marketable oyster. One quote includes this later improvement while also pointing to increased competition as source of reduced marketability (Table 6).

Table 6. Quotes from LPA survey respondents describing why they believe the marketability of their oysters has changed in recent years.

“The quality of a MAINE product. The Maine label in seafood is very strong due to the vast history of lobstering and fishing, we now are latching on to that label and using it for aquaculture.”
“I am new. My farming process is improving.”
“Positive: I have learned to grow a more marketable oyster. Negative: There are far more oyster coming to market leading to increased competition.”

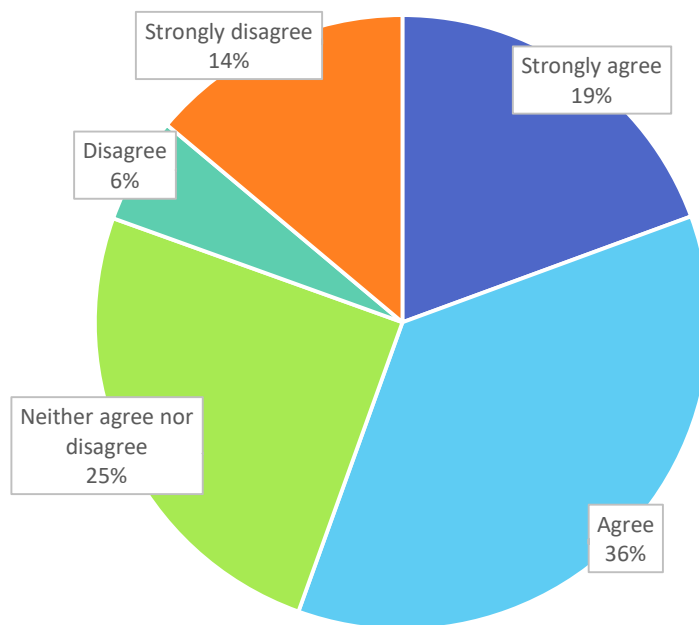


Figure 9. LPA survey respondents' level of agreement with the statement “The marketability of my oysters has changed in recent years” (N = 36).

5.5.5 Buyer certification views

Buyer certification views are represented by the following subthemes: Three buyers thought they provided unequal benefit, followed by the fact that they can inform consumers (2), should be tied to broader industry improvements, and biased incentive structures. While the last

two subthemes were only mentioned in one interview, they were each mentioned three times within the interview.

Unequal benefit

The most common view of certification schemes among buyers was that they unequally benefit larger farms and businesses. For example, one local buyer stated, “If you're a company a large company with a lot of money behind you certifications will come quickly and easily for you.” Another local buyer expressed a similar sentiment, and added that they wanted certification to stay out of Maine’s oyster industry: “There are a lot of farmers out there who farm organically, but you don't have the sticker on their products because they can't afford the you know the certification process... it's one of those weird capitalist things that I would like it if that stayed away from our industry”

If tied to broader industry improvements

One local buyer expressed interest in certification schemes in Maine oyster aquaculture, but it was contingent on them being used to help fund broader improvements across the industry. This was both in the context of equipment to help farms become more economically sustainable, “I guess if it would go towards some kind of subsidy for new equipment like expensive equipment... Whether it's agovernment fund that is paying for a shared piece of equipment on a certain body of river, maybe like you know there's now this brand new oyster tumbler or that brand new sorter.”, as well as in the context of promoting aquaculture education and research and development: “Or it could go towards um, you know, a scholarship to promote more aquaculture or to go to an R and D thing where there you know, how that money split up could be dictated but if there was a fund that could go to it, I think I would feel more comfortable paying said price increase.” As previously stated, this subtheme is only represented in one interview. However, the frequency of its appearance within the interview justifies its representation here.

5.5.6 Farmer certification views

Farmer certification views are represented by the following subthemes: Eight farmers viewed certification schemes as unnecessary in Maine oyster aquaculture, seven expressed concern that they would unequally benefit larger farms, and four believed certification schemes operated with biased incentives (Table 5).

Unnecessary

Eight of 12 interviewed farmers believed certification schemes to be unnecessary in Maine oyster aquaculture. This was generally articulated in the view of oyster farming already being considered sustainable by farmers, as well as the fact that Maine’s oyster aquaculture industry is made up of mainly small farms that do not access big enough sales accounts to necessitate

certification. Both of these views are represented by the following quote from an interview with a large-scale farmer with broad distribution, both within Maine and nationally: “I think the sustainability is inherent in the practice. I know they are expensive. For small farms it probably doesn’t make sense. On the shellfish side there probably aren’t any farms big enough to make the certification a strong benefit. It depends on where they’re marketing the product. If you are going to Whole Foods, they are more and more requiring some sort of certification. On the shellfish side, we just aren’t there yet in Maine.” According to this farmer, certification may be relevant to discuss as a possibility in the future if Maine’s oyster aquaculture industry grows enough.

Unequal benefit

Multiple small-scale farmers that were interviewed expressed concern that certification schemes would be available to larger farms with more access to capital, and thus further advantage such farms. One small-scale farmer articulated this by saying, “... shellfish aquaculture is so inherently sustainable that it might just be a matter of who can afford something like that and who can’t. Which is problematic.” This was also represented by another small-scale farmer who stated, “My initial my initial impression... is that they typically disadvantage small farms and more socioeconomically disadvantaged individuals. So I would be wary of the idea of certification.”

5.6 Additional information gleaned from interview and survey data

In addition to themes relevant to predetermined research questions, three themes were identified within buyer and farmer interview transcripts that appeared relevant to this research. (Table 7).

Table 7. Relevant themes identified within interview transcripts that were not relevant to any predetermined research questions.

Theme: Distribution opportunities		Theme: Distribution barriers	
<ul style="list-style-type: none"> • Marketing Maine name (+) • Market base expansion (+) 	<ul style="list-style-type: none"> • Direct to consumer sales (+) • Exporting abroad (+) 	<ul style="list-style-type: none"> • Consistent supply/ quality (-) • Price (-) • Expensive shipping (-) • Environmental impacts of distribution (-) 	<ul style="list-style-type: none"> • Licensed dealer cost (-) • Farmer time and energy (-) • Farmer trust (-)
“...we’re lucky here in Maine to have such cold water, which is synonymous with clean.”		“I think the cost of licensing... is also a huge barrier. The only reason I was able to get my wholesale dealer certification was... through	

	finding a grant... I think that's a massive barrier for anyone who wants to build a business that isn't just going straight to wholesalers to get rid of product.”
Theme: Farmer/buyer relationships	
<ul style="list-style-type: none"> • Farmers lack trust in larger buyers (-) 	<ul style="list-style-type: none"> • Trust is essential • Farmers trust local distributors (+)
<p>“I just think they have a finger on the pulse of the restaurants, they know them better than me. I'm not going to try to go learn an entirely new industry. You know, they understand.”</p>	

5.6.1 Distribution factors

Distribution factors within Maine’s oyster aquaculture industry were organized into the following four opportunities and seven barriers (figure 10).

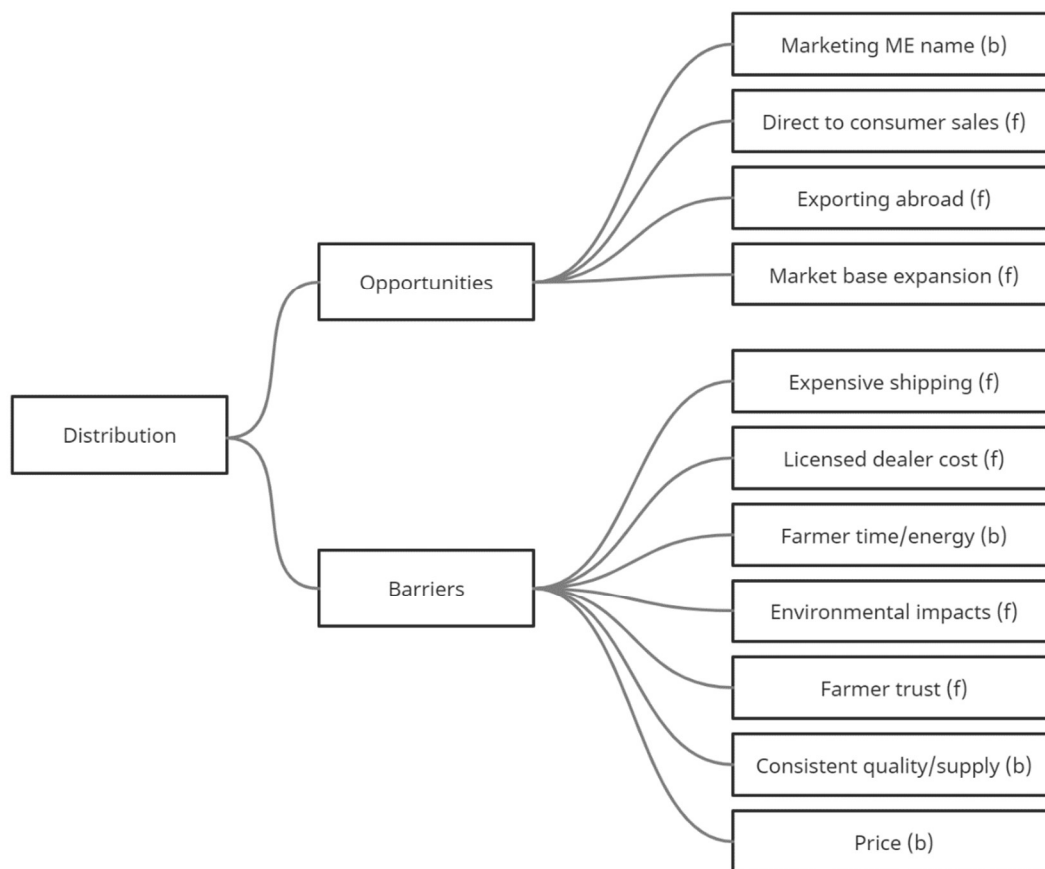


Figure 10. Subthemes representing farmer (f) and buyer (b) perceptions on distribution opportunities and barriers.

Distribution Opportunities

The theme distribution opportunities include the following subthemes: Four buyers mentioned the Maine name, four farmers listed direct-to-consumer sales, three farmers mentioned exporting abroad in the future, one farmer listed market base expansion, and one listed market buy-in (Figure 10).

Marketing ME name

While phrased as a potential marketing strategy, the Marketing ME name subtheme is categorized as a distribution opportunity because it was consistently brought up as a method to distribute Maine oysters further within the United States. Marketing the Maine name was the only distribution opportunity listed by buyers. Four out of nine buyer interviews (44%) mentioned the word “Maine” as a potential opportunity to expand distribution of Maine oysters nationally. However, three of the buyers who mentioned this do not distribute oysters beyond Maine. This perception within local buyers is represented by the following quote, “You know, we’re lucky here in Maine to have such cold water, which is synonymous with clean.” The regional/national buyer who mentioned the word “Maine” to expand distribution said, “...it's been a lot tougher over the past year with people not traveling as much but... I think Maine really benefits from being a tourism state. People really romanticize their memories from Maine.”

Direct to consumer sales

During the Covid-19 pandemic direct to consumer sales increased across the seafood industry (Bever, 2021). This subtheme included any mention of either shipping or delivering oysters directly to consumers. Four out of twelve farmer interviews mentioned direct to consumer sales as a strategy that they had pivoted to during the pandemic but planned to continue using to increase their distribution channels. All four farmers that mentioned direct to consumer sales as a long-term strategy were from the small farm category (selling fewer than 5,000 oysters per week). Small farms have the incentive to distribute their own oysters and receive all of the potential profit. “...And we don't necessarily need to pass it off to other people at the scale that we've planned... we can figure out how to ship 40 boxes a week...” Other small farms mentioned direct to consumer sales as an option but expressed hesitancy due to the time and logistics required to distribute their own oysters, particularly if shipped.

Distribution Barriers

The theme distribution barriers included the following subthemes: Five farmers listed expensive shipping, five farmers included the cost of accessing licensed dealers, four buyers referred to farmers’ lack of time and energy, three buyers included a lack of consistent quality and supply, three farmers mentioned concerns about environmental impacts, two buyers listed farmers’ lack of trust in larger-scale buyers, and two buyers indicated that price limited the distribution of Maine oysters (Table 7).

Consistent supply/quality

Consistent supply of high-quality oysters was a barrier brought up by buyers with local, regional, and national distribution. While Maine oysters are considered to be of good quality, many smaller Maine farms do not yet have the capability to consistently supply those oysters year-round. According to one buyer with national distribution, “It’s not just having good product, you’ve got to keep it on the menu long enough to get customers used to it... the goal is have your oysters available year round.” Once distribution chains are stopped or put on hold, it is difficult to get them going once oysters are available again.

Licensed dealer cost

The cost associated with obtaining a shellfish dealer’s license was included in five of eight interviews with small-scale farmers. This was generally characterized as a lack of access to property near working waterfronts. “Since I don’t own property, I really can’t affordably...get a dealer’s license because I don’t have a physical building where I can meet those requirements.” This barrier exists for many small farms in the state, and presents additional hurdles to farm growth and business success.

5.6.2 Farmer/buyer relationships

The theme farmer/buyer relationships is characterized by the subthemes trust is essential (listed by three farmers), farmers feel they can trust distributors (included by two farmers), and farmers lack trust in larger buyers (listed by one farmer and one buyer) (Table 7).

Trust is essential

Trust between farmers and their buyers often comes down to delivering on promises and honoring business relationships. One small-scale farmer commented on the former by saying, “...too often, people just can’t deliver on what they say they’re gonna do. If we say we have oysters around and these are the quantities...we have to deliver on that.” The need to honor business relationships was also articulated by a small-scale farmer, who said, “...if we’re working with a wholesaler, they know that we’re never going to poach business from them...” Small-scale farmers have many barriers to their distribution. This necessitates functional working relationships with their buyers.

Farmers lack trust in regional/national buyers

One small scale farmer lamented the loss of trust he has experienced. “As a farmer, you don’t have you don’t have a lot of any sort of control over economic issues anymore... you’re told by the people who have a lot of money how much money you’re going to be paid and how many oysters they want...” According to this farmer, the added competition and increased supply of oysters has eroded his ability to control the price of his oysters.

6. Discussion

The research goals guiding this research project were to identify shared definitions of sustainability within the industry, assess buyers' related willingness-to-pay, and identify feasible production practices that can be implemented by oyster farms. These goals are now returned to with insights from the data collected, in combination with relevant information from existing literature. In addition, the identified themes and subthemes are categorized based on their level of relevance within the EAA framework.

6.1 Opportunities for adding value to Maine's oyster aquaculture industry using an EAA

While significant growth in Maine's oyster aquaculture industry is largely due to increased numbers of small-scale operations, examples from around the globe stress that sustainability within aquaculture industries is most achievable prior to and at the beginning stages of intensification (Lebel et al., 2002; Bostock et al., 2010). This is thought to be due to the flexibility and increased innovation that is typical of younger industries. Thailand's shrimp aquaculture industry, Bangladesh's fish aquaculture industry, and France's oyster aquaculture industry illustrate the need for developed regulatory, environmental monitoring, and biosecurity infrastructure prior to surges in production (Lebel et al., 2002; Henriksson et al., 2018; You & Hedgecock, 2018). Considering this, now may be the time to explore ways to make strides toward environmental, social, and economic sustainability in Maine's oyster industry.

The strongest evidence that suggests applying practices in line with the EAA framework could lead to a direct increase in the value of Maine's oyster aquaculture industry comes from the WTP and marketing themes. When discussing WTP, one local wholesale buyer expressed interest in paying more for those farms who go "above and beyond" with their interactions with the coastal environment by participating in ecosystem restoration projects. However, this same buyer was unsure that they would be willing to pay significantly more to a farm for these practices. While there may be some buyers who are willing to increase their WTP for significant and specific environmental sustainability steps, even those buyers have a limit on how much more they are willing to pay. Recent work by Hilger et al. investigated seafood purchase records and concluded that consumers frequently valued sustainability positively (2018). By going "above and beyond," this trend of both wholesale buyers and end consumers showing a WTP for environmental sustainability could be capitalized on by Maine oyster farmers if practiced honestly and marketed effectively.

Marketing the ecosystem services of oysters came up frequently in farmer interviews, but was not mentioned by any buyers as a marketing strategy that they employ. Farmers at all scales mentioned their belief that ecosystem services are a successful marketing topic. This was consistently described as a central part of their social media strategy. Farmer interviews revealed their belief that, if marketed consistently and clearly, the marketability of Maine oysters would increase because consumers want to support environmental sustainability. This would be consistent with findings of other studies of the sustainable seafood movement (Chase, 2011;

Risius et al., 2017; Minkov et al., 2019). However, it is difficult to compare the general findings of this study regarding marketing strategies of individual farms, with that of larger certification and ecolabel studies like those referenced above.

Common subthemes tied to marketability, buyer purchase priority, and WTP are indirectly tied to the continuation or adoption of EAA aligned practices. A reliable supply of high quality oysters was the most consistent priority expressed by Maine oyster buyers, regardless of the extent of their distribution. While this is not directly tied to social or environmental sustainability, introducing practices that are aligned with EAA principles can help support both the quality and supply of oyster from Maine aquaculture.

Effectively monitoring and managing oyster densities at the bay or watershed level is one way to prevent the decrease in quality that shellfish farms in other parts of the world have experienced. At high densities, shellfish farms are at risk of overgrazing the available phytoplankton on which they depend. This occurred in Tacadie Bay, Prince Edward Island, Canada in the late 1990s and early 2000s (Newell, 2004). Mussels grown in the inner portion of the bay grew at slower rates and yielded less meat per animal. Research at the time suggested that this was due to farming at densities beyond production carrying capacity (Waite et al., 2005). Expanded water quality monitoring and cooperation among oyster farmers could help prevent this from happening in Maine. Any such management would benefit from being site specific because of varying hydrodynamics and phytoplankton turnover time from bay to bay (Dame & Prins, 1997; Mallet et al., 2006).

Another opportunity may exist if farmers increase stakeholder interaction and broaden their working definition of who they consider to be stakeholders. Lack of social license has the potential to be a limiting factor for aquaculture expansion (Davies et al., 2019). However, stakeholders generally do not fully oppose or support shellfish aquaculture. Rather, everyone has their own views on the acceptable types of gear and acceptable densities of aquaculture (Dalton et al., 2017). By bringing in a diverse group of community members into aquaculture development and expansion conversations early on and making good faith efforts to address concerns when appropriate, shellfish farmers can potentially make inroads to the community in multiple sectors. The benefits of more social cohesion, local employment and related population retention, and community pride may also be felt by the broader community if community relations are done by farmers with long-standing connections to the community (Pierce & Robinson, 2013).

6.2 Barriers to adding value to Maine's oyster aquaculture industry using an EAA

One barrier that existed throughout many of the farmer and buyer interviews was the perception that oyster farming is already sustainable. This may make farmers hesitant to invest meaningfully into either finding alternatives to plastic gear, monitoring water quality in and around farm sites, or working with local stakeholders to attempt to find areas of compromise.

Another barrier to applying the EAA framework to Maine oyster aquaculture is the growing reliance on direct-to-consumer sales. The environmental impacts of seafood processing and distribution are gaining more consideration in recent years (Zeigler et al., 2012; McKuin et al., 2021; Jacob et al., 2021). This was a concern among interviewees in this study as well, with some small farms limiting their distribution to reduce their carbon footprint and some large farms increasing their reliance on solar power for land-based operations. However, many oyster farmers were increasing their direct-to-consumer distribution. In most cases this had begun as a survival strategy during the Covid-19 pandemic and has now become part of a long-term plan to increase profit margins by reducing reliance on distributors. As these practices continue and potentially expand, the carbon cost of each shipped oyster will remain high.

Results from some farmer interviews suggest that, from the perspective of the farmer, another barrier may be stakeholder resistance to any increase in oyster aquaculture because they are afraid of a potential ubiquity of oyster farms. Having extensive marine spatial planning that involves a broad spectrum of community members may help to reduce stakeholder pushback against oyster aquaculture in Maine.

This is aligned with previous research on marine spatial planning and related social impacts of aquaculture (Bailey, 2008; Soto et al., 2008; Craig, 2019). Governments overseeing coastal areas should have marine spatial planning to be able to practice adaptive management. Ideally, such regulations improve over time due to iterative work to solicit increased public participation and promote experimentation within the industries using the coastal waters in question (Craig, 2019).

6.3 Limitations

One issue that arose when interviewing oyster farmers was confusion about the difference between wholesalers and dealers. For the purposes of this study, value chain definitions were based on a recent Maine farmed shellfish market analysis in which dealers were defined as “A person or business to who certification is issued for the activities of the shellstock shipper, shuckerpacker, repacker, reshipper, or depuration processor.” Wholesalers are defined in this case as a “Business entity that purchases and distributes shellfish from dealers either to distributors for further transportation or directly to retail and foodservice customers” (GMRI, 2016). However, because most of the analysis was based in the difference between 1) sales to restaurants and end consumers and 2) sales to dealers and wholesalers, confusion among interviewees between members of the latter group is not considered a significant concern.

Another limitation was that this study did not employ a survey for additional oyster buyers. Data triangulation and valuable results came from the Oyster LPA Survey, but there was no such survey for oyster buyers for similar triangulation. A subsequent study may find value in distributing such a survey regionally or nationally to oyster buyers.

6.4 Future research recommendations

The findings of this study provide a useful starting point for subsequent research. For example, understanding specific WTP metrics for wholesalers, distributors, restaurants, and end consumers of Maine oysters may provide a path toward tangible incentives for oyster farmers to increase their adherence to EAA principles. Another next step could be a study that uses interviews with stakeholders to measure interest in marine spatial planning for Maine. This would ideally include aquaculture farmers from different sectors within Maine aquaculture (kelp, shellfish, and finfish), commercial fishermen, recreational users, landowners, other community members, and regulators at the municipal and state level. Lastly, if marine spatial planning is to be adopted in Maine, extensive case studies of other countries and states that have implemented marine spatial planning and include aquaculture would be a responsible first step.

7. Impact Statement

Maine's oyster aquaculture industry is growing into a significant portion of the state's seafood economy. This growth has already led to concerns of potential economic, social, and environmental impacts voiced by commercial fishermen, coastal landowners, and other stakeholders. The focus of this research project was on economically, environmentally, and socially sustainable growth of the industry. The goal of this research was to investigate the potential of natural economic market incentives to guide this sustainable growth, using principles from an ecosystem approach to aquaculture (EAA) as a guide.

This study interviewed oyster farmers operating on aquaculture leases and their buyers, and surveyed oyster farmers operating on Limited Purpose Aquaculture licenses (LPAs). By doing so, oyster aquaculture practices were identified that have the potential to either directly or indirectly increase the value of Maine's oysters both within the state and across the United States. These practices were identified by analyzing common definitions of sustainability within Maine's oyster industry, as well as farmers' and buyers' views of the current sustainability in the industry, and buyers' priorities when selecting oyster farms to work with.

The results of this report provide oyster farmers guidance on ways to simultaneously increase their social and ecological sustainability, while also potentially improving their long-term business success (economic sustainability). By taking extra steps to be stewards of the marine ecosystem in which they operate and marketing the ecosystem services that their farmed oysters naturally provide, farmers can create more demand for their product. Additionally, taking precautionary steps to ensure that Maine's oysters remain of high quality and in steady supply will help maintain the broader economic viability of the industry as the industry matures. These steps should include efforts to monitor water quality for various parameters, involve stakeholders more broadly and frequently, and create aquaculture inclusive marine spatial planning that incorporates these inputs into a comprehensive and revisable plan for the economic uses of Maine's coastal waters.

8. References

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9. Appendices

Appendix 1: Medium-Large Scale Farmer Semi-Structured Interview Guide

Oyster Farmer Semi-Structured Interview Guide (Medium-Large Scale)

Introductory Questions

1. Were you born in Maine?
 - a. If not, how long have you lived here?

2. Were you involved with the seafood industry before becoming an oyster farmer?
 - a. If yes, can you tell me more about what you were doing and what it was like?

3. How long have you been involved in aquaculture?

4. What is your job title or role at (name of oyster farm/company)?

5. How many oysters does your farm sell per week on average?
 - a. Spring:
 - b. Summer:
 - c. Fall:
 - d. Winter:

Defining Sustainability

1. What comes to mind when you hear the word “sustainability”?
 - a. Interesting, you have said a lot about (economic/environmental/social/cultural) sustainability. Do you consider (categories unmentioned) to be impacted by sustainability?
2. How do you see oyster aquaculture impacting social sustainability?
3. How do you see oyster aquaculture impacting economic sustainability?
4. How do you see oyster aquaculture impacting environmental sustainability?
5. Do you view sustainability as something that can be achieved, or as a continuum?
6. Is sustainability a priority at your farm?
 - a. If no, what do you think is preventing it from being a priority?
 - b. If yes, what do you think is helping prioritize it?
7. Do you consider current oyster farming practices to be sustainable?
 - a. If no, what do you think could be done to improve sustainability?

- b. If yes, what is being done to make oyster farming sustainable?
- 8. Are there more sustainable practices that your farm has considered, but not yet implemented?
 - a. If yes, what practices and how come?
- 9. What do you consider to be the least sustainable practice(s) of your farm? Of oyster aquaculture in Maine?
- 10. Do you incorporate sustainability into your marketing strategy? If so, how?
- 11. Have your oysters changed in price or marketability in recent years?
 - a. What factor(s) do you attribute that to?
- 12. What are your views of certification schemes for shellfish aquaculture?
- 13. What are your views of Best Management Practices for shellfish aquaculture?

Buyers

1. Before the COVID-19 pandemic, which buyers most influenced your marketing strategies and decisions? (Dealers, wholesalers, distributors, retailers, restaurant operators)
 - a. Now (during the COVID-19 pandemic)?
 - b. In the long-term (after COVID-19 pandemic)?
2. Are there barriers in place that prevent your oysters from having broader distribution?
 - a. If yes, what are they?
3. Is market saturation a concern at your farm?
 - a. If yes, why?
4. Are there specific wholesale or restaurant buyers that you recommend I speak to for this research?
 - a. If yes, who?

Other Farms

1. Are there other oyster farms that you recommend I speak to for this research?
 - a. If yes, which ones?
 - b. Do you have a specific person in mind?

Appendix 2: Oyster Buyer Semi-Structured Interview Guide

Oyster Buyer Semi-Structured Interview Guide

Introductory Questions

6. Were you born in Maine?
 - a. If not, how long have you lived here?

7. Were you involved with the seafood industry before your current job?
 - a. If yes, can you tell me more about what you were doing and what it was like?

8. How long have you been involved in the seafood industry?

9. What is your job title or role at (name of business)?

10. How many oysters does (name of business) sell per week on average?
 - a. Spring:
 - b. Summer:
 - c. Fall:
 - d. Winter:

11. Would you classify (name of business) as a:
 - a. Dealer
 - b. Wholesaler
 - c. Distributor
 - d. Retailer
 - e. Restaurant Operator
 - f. Other (please explain)

Defining Sustainability

14. What comes to mind when you hear the word “sustainability”?
- a. Interesting, you have said a lot about (economic/environmental/social/cultural) sustainability. Do you consider (categories unmentioned) to be impacted by sustainability?
15. How do you see oyster aquaculture impacting social sustainability?
16. How do you see oyster aquaculture impacting economic sustainability?
17. How do you see oyster aquaculture impacting environmental sustainability?
18. Do you view sustainability as something that can be achieved, or as a continuum?
19. Do you consider current oyster farming practices to be sustainable?
- a. If no, what do you think could be done to improve sustainability?
 - b. If yes, what is being done to make oyster farming sustainable?
20. Have the oysters you buy changed in price or marketability in recent years?
- a. What factor(s) do you attribute that to?
21. Is sustainability a priority when you buy oysters?
- a. If no, what do you think is preventing it from being a priority?
 - b. If yes, what do you think is helping prioritize it?

Willingness to Pay

1. How many oysters do you typically purchase in a week, and from how many different sources?
2. Do you currently pay more for oysters that are grown sustainably?
 - a. If no, how come?
 - b. If yes, what sustainable practices do you look for? How come?
3. Would you be willing to pay more for oysters that...
 - a. Have recognizable eco-labels on their brand?
 - b. Have a detailed story about the farm's pursuit of sustainability?
 - c. Are grown locally?
 - i. What went into your decision making?
4. If you paid more for sustainably produced oysters, would you make up that cost by...
 - a. Charging more per oyster
 - b. Assuming you would sell an increased number of oysters
 - c. Other (please explain)
5. What is your perception of end consumers of oysters' willingness to pay for sustainability?
 - a. Do they tend to care about sustainability?
 - i. Environmental?
 - ii. Economic?
 - iii. Social/cultural?
6. Do you think end consumers of oysters would be willing to pay enough to make up the difference if you increased price due to sustainability practices?

FOR DEALERS/WHOLESALE BUYERS ONLY:

1. What percentage of the oysters you buy end up being sold outside of Maine?
 - a. New England?
 - b. Beyond?

2. What do you think causes the success that some Maine oyster farms have had in finding markets beyond Maine?

Appendix 3: Oyster LPA Survey

Survey Tool: Oyster LPA Holders

1. How long have you lived in Maine?
2. Were you involved with the seafood industry before becoming an oyster farmer?
Yes _____ No _____

If yes, can you explain what you were doing and what it was like?

3. How long have you been involved in aquaculture?
4. Where is your LPA(s) located? (choose one)

South of Cape Elizabeth	Casco Bay (Cape Elizabeth to Small Point)	Midcoast Rivers, NOT including the Damariscotta	Damariscotta River
Penobscot Bay	Bagaduce River	Hancock County	Washington County

5. What is your role at your farm?
6. What is the purpose of your LPA? Circle all that apply:

Commercial

Recreation

Research

Other

If other, please explain:

7. What comes to mind when you think of the word “sustainability”? I think of:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Environment	1	2	3	4	5
Economy	1	2	3	4	5
Society/Culture	1	2	3	4	5
Other	1	2	3	4	5

8. Aquaculture and sustainability: Please rate how strongly you agree/disagree with each of the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Oyster aquaculture in Maine has a responsibility to help promote the culture of working waterfronts	1	2	3	4	5
Oyster aquaculture in Maine has a responsibility to help promote gender and racial equity	1	2	3	4	5
Oyster aquaculture in Maine has a responsibility to help promote the economic resilience of coastal communities	1	2	3	4	5
Oyster aquaculture in Maine has a responsibility to help promote the economic resilience of the aquaculture industry	1	2	3	4	5
Sustainability is a priority at your farm	1	2	3	4	5
Oyster aquaculture impacts social sustainability	1	2	3	4	5
Oyster aquaculture impacts economic sustainability	1	2	3	4	5
Oyster aquaculture impacts environmental sustainability	1	2	3	4	5
Current oyster farming practices at your farm are sustainable	1	2	3	4	5
There are sustainable practices that your farm has considered, but not yet implemented	1	2	3	4	5

9. What do you consider to be the **least** sustainable practice(s) of your farm?

10. What do you consider to be the **least** sustainable practice(s) of oyster aquaculture in Maine?

11. How many oysters do you typically harvest per week?

Spring:	0 – 1,000	1,000 – 3,000	3,000 – 5,000	5,000 or more
Summer:	0 – 1,000	1,000 – 3,000	3,000 – 5,000	5,000 or more
Fall:	0 – 1,000	1,000 – 3,000	3,000 – 5,000	5,000 or more
Winter:	0 – 1,000	1,000 – 3,000	3,000 – 5,000	5,000 or more

12. Your oysters have changed in price or marketability in recent years?

1 = strongly disagree, 5 = strongly agree

1 2 3 4 5

What factor(s) do you attribute that to?

13. Before the COVID-19 pandemic, the following buyers most influenced your marketing strategies and decisions:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Wholesale Distributors	1	2	3	4	5
Dealers	1	2	3	4	5
Direct to Restaurants	1	2	3	4	5
Direct to Consumers	1	2	3	4	5
Other	1	2	3	4	5

14. Now (during the COVID-19 pandemic):

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Wholesale Distributors	1	2	3	4	5
Dealers	1	2	3	4	5
Direct to Restaurants	1	2	3	4	5
Direct to Consumers	1	2	3	4	5
Other	1	2	3	4	5

15. In the long-term (after the COVID-19 pandemic):

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Wholesale Distributors	1	2	3	4	5

Dealers	1	2	3	4	5
Direct to Restaurants	1	2	3	4	5
Direct to Consumers	1	2	3	4	5
Other	1	2	3	4	5

16. Your oysters are primarily sold:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Locally	1	2	3	4	5
Statewide	1	2	3	4	5
New England	1	2	3	4	5
Other	1	2	3	4	5

17. Market saturation is a concern at your farm:

1 = strongly disagree, 5 = strongly agree

1 2 3 4 5

Appendix 4: IRB Approval: Non-Human Research Designation



Institutional Review Board
Mary DeSilva, Chair

Biddeford Campus
11 Hills Beach Road
Biddeford, ME 04005
(207)602-2244 T
(207)602-5905 F

Portland Campus
716 Stevens Avenue
Portland, ME 04103

To: Samuel Feldman, M.S.

Cc: Adam St. Gelais, M.S.
Barry Costa-Pierce, Ph.D.

From: Brian Lynn, J.D.

Date: November 19, 2020

IRB Project # & Title: 111920-14; Adding value through sustainability: Incentivizing ecosystem approaches to oyster aquaculture in Maine

The Institutional Review Board (IRB) for the Protection of Human Subjects has reviewed the materials submitted in connection with the above captioned project and has determined that the proposed work is exempt from IRB review and oversight as defined by 45 CFR 46.104 (d)(2).

Additional IRB review and approval is not required for this protocol as submitted. If you wish to change your protocol at any time, including after any subsequent review by any other IRB, you must first submit the changes for review.

Please contact me at (207) 602-2244 or irb@une.edu with any questions or concerns.

Sincerely,

A handwritten signature in blue ink, appearing to read "Brian Lynn", is written over a horizontal line.

Brian Lynn, J.D.
Director of Research Integrity