Has the LPA system been successful?
Small-scale marine aquaculture recruitment in Maine through the limited-purpose aquaculture ("LPA") licensing system

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Submitted in Partial Fulfillment of the
Professional Science Master's Degree
in Ocean Food Systems
School of Marine Programs

University of New England

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This thesis has been examined and approved on December 10, 2021

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Acknowledgements
To the extent that I achieved a transdisciplinary approach in this study, I was successful because of the greathearted help of many. For your tireless guidance, thank you, Barry, Zach, Adam, and Jim. Thank you to Tom McLaughlin for your methodological instruction, thank you to Sam and Dan for your survey collaboration, and thank you to the Henry L. & Grace Doherty Foundation for the opportunity to carry out this research.

Thank you to my key informants for generously supporting my work: Marcy Nelson and Flora Drury; Chris Davis, Jaclyn Robidoux, and Heather Sadusky; Sebastian Belle, Christian Brayden, and Afton Vigue; Paul Anderson; Brian Beal; and Phoebe Jekielek. Thank you to this study's survey respondents and focus group participants, who all made unselfish contributions for little reward. Thank you to Carey, Giovanni, and Shawn for your flexibility across many seasons, and thank you especially to my parents and brothers for helping me see this project home.

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Abstract

The U.S.A. state of Maine's system for leasing publicly owned, nearshore submerged lands for aquaculture development concerns the recruitment of ocean farmers into marine aquaculture in the state. Maine's "Limited-Purpose Aquaculture" (LPA) license, the only mariculture lease of its kind in the U.S., was designed to attract small-scale farmers to the industry to experiment in coastal waters with a variety of means for achieving economic sustainability. This study analyzed recruitment of new ocean farmers into small-scale, low-trophic level (LTL) marine aquaculture in Maine through the LPA licensing system. Through an online survey (n = 74) and a focus group (n = 7) of LPA-holders, data on aspects of holders' operational experiences was collected, especially of those holders who sold or intended to sell the products of their LPA(s). 74 respondents accessed the survey, thus generating an overall response rate of 28.8%; response rates to individual survey questions varied. Survey data indicated that 67% of respondents sold their LPA products, and that 32% of respondents who did not sell their products reported that they wanted to sell them. 58% of respondents wanted to expand their aquaculture operations to scale beyond the LPA license parameters. Survey and focus-group data demonstrated that although 85% of the participating LPA-holders felt that their experiences in the LPA system had allowed them to make informed decisions about whether or not to expand their farms, many were concerned about the administrative and resource barriers they faced in scaling up their operations.

1. PROJECT OBJECTIVES and SIGNIFICANCE

As have many coastal municipalities worldwide reacted to similar ecological downturns (Allison et al., 2009; Forster et al., 2014), declines in catches and market value within many of Maine's traditional fisheries such as shrimp, cod, and herring since the 1990s (State of Maine Department of Marine Resources, Historical Maine Fisheries Landings Data, 2021) have focused the state on mariculture development as a means to diversify its marine economy (Maine Department of Economic and Community Development, 2022). Incentives for sustainable marine aquaculture development include sustainable harvest practices (Hoegh-Guldberg et al., 2019; Barrett et al., 2022), recruitment opportunities for conventional fishers and newcomers (Knapp and Rubino, 2016), and community-level economic benefits, especially for rural communities (Kaminski et al., 2020). The success of Maine's mariculture leasing regime relies in part on the state's legal structures to attract and sustain ocean farmers with varied interests, from recreation to food production to scalable commercialization.

This study focused on a mechanism for leasing small areas of publicly owned marine space to aquaculture farmers in Maine, namely the "limited purpose aquaculture" (LPA) license. This license from the state's Department of Marine Resources (DMR) grants access to a parcel of up to 400 square feet of submerged lands for the farming of low-trophic level (LTL) organisms, primarily shellfish and seaweeds (State of Maine DMR, Aquaculture LPA and Lease Requirements, 2021). Recruitment of farmers into the arena of small-scale, nearshore, LTL marine aquaculture in Maine was analyzed, which included an exploration of the extents to which the LPA system supports its license holders sustain and/or expand their LPA(s), particularly holders who sell or intend to sell products from their LPAs. This study revealed that marine aquaculture development in Maine interacts at least with farm-level economic choices such as commercialization and operational scaling, "social license to operate" (SLO) phenomena, and the state's current and historical maritime usages.

The research goals of this study were to:

- analyze Maine's LPA system as a recruitment strategy for LTL Maine marine aquaculture;
- collect data on LPA-holders' reasons for joining the LPA system, particularly viz. holders' food security and commercialization choices
- respond to key informants' desires for an overview of LPA-holder demography

2. BACKGROUND

Leasing common ground

Saltwater coastal municipalities design mariculture management systems to achieve various marine development goals, from meeting nutritional demands to employment (Science Advice for Policy by European Academies, 2017). Marine development in turn intersects with, among other factors, local ecological circumstances (Byron et al., 2015), the recruitment of fishers and ocean farmers (Kaminski et al., 2020), rural development (Bunting, 2013), and fisheries management phenomena (Österblom et al., 2010). The balancing of such factors often enmeshes diverse groups that vie for access to productive ocean areas: fishers, marine harvesters, and indigenous groups with historical ties to these areas; riparian landowners; industrial maritime businesses; maritime recreational users and sailors; environmental researchers and advocates; and government and non-government agencies (Diana et al., 2013; Naylor et al., 2021). To pierce the "wicked problem" of partitioning access to discrete ocean parcels among competing parties (Flaherty et al., 2018), many coastal municipalities have developed leasing systems to govern their submerged marine lands (Davies et al., 2019).

Marine leasing in the United States

Nix (2003) described that a lease is fundamentally a division between the use and the ownership of land, terrestrial as well as marine. While within terrestrial leasing systems private landowners may outcompete public interests (Ravenscroft, 1999), marine leasing in the US and similar states concerns submerged lands that are held in the public trust and therefore not simply divisible among various stakeholders (Knapp and Rubino, 2016). US law draws from English common law that itself draws from sixth-century Roman law by which "no one is forbidden to approach the seashore…by the laws of nature" (Isley and Pebbles, 2009). Individuals or groups are "users" and not "owners" of US ocean. The friction that results among users of ocean space drives marine lease dynamics, not least in federal systems such as that of the US (Knapp and Rubino, 2016).

The legislative foundation for US nearshore ocean leasing is the Submerged Lands Act of 1953. The Act grants authority through the National Oceanic and Atmospheric Association to individual states for the "management, administration, development, and leasing of the water bodies within [their] boundaries" (43 USC 1311(a)(2) (2005)) (US Senate, 1953), i.e., within three miles of their ordinary coastal highwater marks. Thirty years after this Act, the National Aquaculture Development Plan explicitly added marine aquaculture concerns to the federalized system of facilitating access to public marine waters, and further articulated that the private sector would primarily drive the industry (Nelson et al., 1999). States subsequently developed varying lease parameters such as fees, application processes, minimum acreage, durations, and density limits (Lester et al., 2021). Unlike, for examples, aid-driven aquaculture development plans in sub-Saharan Africa in the 1970s-90s (Brummett and Moehl, 2008) or the massive investments into seaweed mariculture by East and Southeast Asian countries more recently

(Costa-Pierce and Chopin, 2021), mariculture development in the US has been shaped by the choices of individual states and is concertedly capitalistic (Lester et al., 2021).

Maine mariculture leasing

In part because of its significant nutrient inputs from the Gulf Stream, the Bay of Fundy, and the northern Atlantic Ocean (Conkling and Ralston, 2011), the U.S. state of Maine supported 1,558 acres (630 hectares) of aquaculture leases in 2021 (Costa-Pierce and Chopin, 2021). The Maine Department of Marine Resources (DMR) is the state's principal management agency for the leasing of both marine and terrestrial aquaculture activities (State of Maine DMR, Land-based Aquaculture, 2021). For marine aquaculture, the Maine DMR administrates leasing within the zone that extends three miles seaward from the state's coastline that is considered Maine's state waters, and it permits access to ocean acreage for aquaculture at three tiers. From smallest permittable area to largest, these tiers are the "LPA license," the "Experimental Lease," and the "Standard Lease."[1] Table 1 highlights parameters of Maine's mariculture license and leases.

Table 1. Requirements for Maine aquaculture LPA licenses and leases[2]

	LPA License	**Experimental Lease**	**Standard Lease**
Leased area	≤ 400 square-feet	≤ 4 acres	≤ 100 acres
Maximum number of licenses/acreages allowed for an individual	4 licenses	4 acres (An individual may only submit one Experimental Lease application at a time)	100 acres
Lease duration	1 year	3 years	20 years
Renewable?	Yes, must be yearly	No (except for scientific research)	Yes
Application fee	$100 for residents, $400 for non-residents	$100	$2,000 for farms with discharge, $1,500 for farms without discharge
Rent	None	$100/acre/year	$100/acre/year
Bond or escrow account required?	No	Yes	Yes
Site visit required?	No	Yes, but typically without a required dive inspection	Yes, with a required dive inspection
Public hearing required?	No	Held upon request of ≥ 5 people	Yes

[1] There is no definitive statutory differentiation in Maine law between an aquaculture "lease" and an aquaculture "license," though Standard and Experimental Leases may convey stronger sets of rights unto the lessee. Where an LPA license-holder is permitted to place "gear in a site in the coastal waters of the State to engage in certain aquaculture activities" (Limited-purpose aquaculture license, 2021), the state of Maine is tasked to preserve "the exclusive rights of the lessee to the extent necessary to carry out the lease purpose" (Maine DMR, Research and aquaculture leases, 2021); explicit lessee "rights" are absent from the LPA statute.

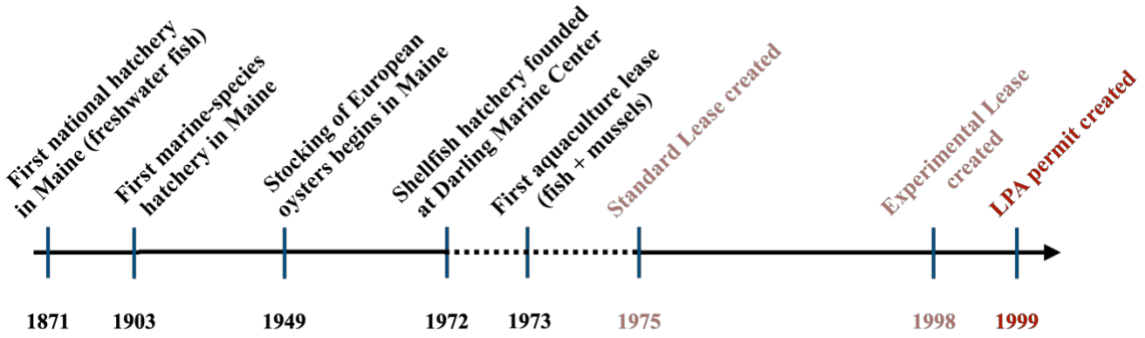
[2] Adapted from Maine DMR, Aquaculture LPA and Lease Requirements, 2022.

As of September 2021, the cultivation of "low-trophic level" (LTL) marine shellfish and macroalgae organisms constituted most of Maine's aquaculture licenses/leases, while only 3.1% of the state's mariculture leases dedicated to the culturing of "high trophic level" (HTL) finfish (State of Maine DMR, Finfish Leases 2009-2020, 2021; State of Maine DMR, Table of Active Limited Purpose Aquaculture [LPA] Licenses, 2021) despite accounting for most of the state's aquaculture value (Brickell et al., 2020).

The Maine LPA

The LPA system is embedded in the larger Maine marine aquaculture permitting system: the Maine legislature passed the LPA statute in 1999 after their creation of the Standard Lease in 1975 and the Experimental Lease in 1998 (Figure 1). Proponents of the LPA statute testified that low barriers-to-entry for licensees, combined with the creation of rules to prevent permitted areas from interfering with existing uses, could accelerate entrepreneurship as well as neighborliness in ways that Standard and Experimental Leases had not (Belle, personal communication, 2021).

Figure 1. Highlights from Maine's marine aquaculture leasing timeline[3]



As of May 2022, LPAs existed only for saltwater areas and for the culture of blue mussels; soft, hard, surf, and razor clams; American and European oysters; sea urchins; sea scallops; and marine algae (State of Maine DMR, Conducting Aquaculture in Maine, 2021). LPAs may be used for recreational, commercial, scientific research, or education purposes, or for municipal shellfish operations (State of Maine DMR, Limited Purpose Aquaculture License [LPA] Application, 2021).

Obtaining an LPA license in Maine requires applicants to complete a single application that includes a single fee, limited site surveying, and limited required economic reporting on monthly harvest amounts (State of Maine DMR, Aquaculture LPA and Lease Requirements, 2021). The Maine DMR manages the LPA application process, although all applicants must receive approval from their local harbormaster (ibid.); further, any application sited in an intertidal zone in a town with a municipal shellfish ordinance must receive approval from the local municipal shellfish committee (ibid.). A maximum of four LPAs is allowable within a radius of 1000 feet, and LPAs cannot be sited within 350 of active eagle nest (ibid.). Riparian landowners may have one LPA within 150 feet of their shoreline property (ibid.).

[3] University of Maine Aquaculture Research Institute, 2018.

Following approvals from the Maine DMR and an LPA-applicant's harbormaster, the DMR obtains input from the Army Corps of Engineers on the LPA site's potential impacts on navigation before issuing a final decision (ibid.). Upon approving the license application, the DMR notifies the Maine Department of Environmental Protection; the Maine Department of Agriculture, Conservation and Forestry; and the Maine Department of Inland Fisheries (ibid.). This study conceptualized this multi-faceted administrative process constitutes the "legal license to operate" (LLO) that ocean farmers must obtain to successfully pursue mariculture at the LPA level; LLO is discussed further in this section.

The LPA license covers a relatively small farm (≤400 square feet) and must be renewed yearly (ibid.), and the application and renewal do not require significant public participation. LPA applicants must demonstrate to the DMR that their proposed site does not unreasonably interfere with existing uses of the site: recreation, navigation, access by riparian neighbors, and traditional fishing (State of Maine DMR, Limited-purpose aquaculture license, 2021). Compared to the Experimental and Standard Leases, the LPA license has the lowest application fee, no rent fee, and no bond requirement. Additionally, whereas the DMR mandates public hearings for Experimental and Standard Lease applications and renewals during which concerned neighbors may voice support or opposition that DMR must incorporate into their Lease decision, LPA license-holders need only certifiably notify their riparian neighbors living within 1000 feet of their LPA site (State of Maine DMR, Aquaculture LPA and Lease Requirements, 2021).

National context for the LPA system

Among mariculture leasing regimes in other US states, the LPA system's relatively low administrative barriers-to-entry make it distinct. Other US states' aquaculture leasing programs as of May 2021 included, for examples, required harvest fees, high acreage minimums (e.g., 50 acres), mandatory business plans and sales tracking, high numbers of permits and applications, high culture density minimums (e.g., 100,000 oysters per acre), long lease duration periods (e.g., 20 years), insurance requirements, demonstrated farmer expertise prior to leasing, state-defined lease areas, and public hearings for proposed sites; the LPA system includes none of these. Furthermore, while some US states had low availability of farmable areas (Moehl, personal communication, December 8, 2020) or regulatory environments without significant structures for non-finfish mariculture, the LPA system also includes none of these; Maine's small-scale mariculture leasing is agency-led and grants access to the biologically rich Gulf of Maine.

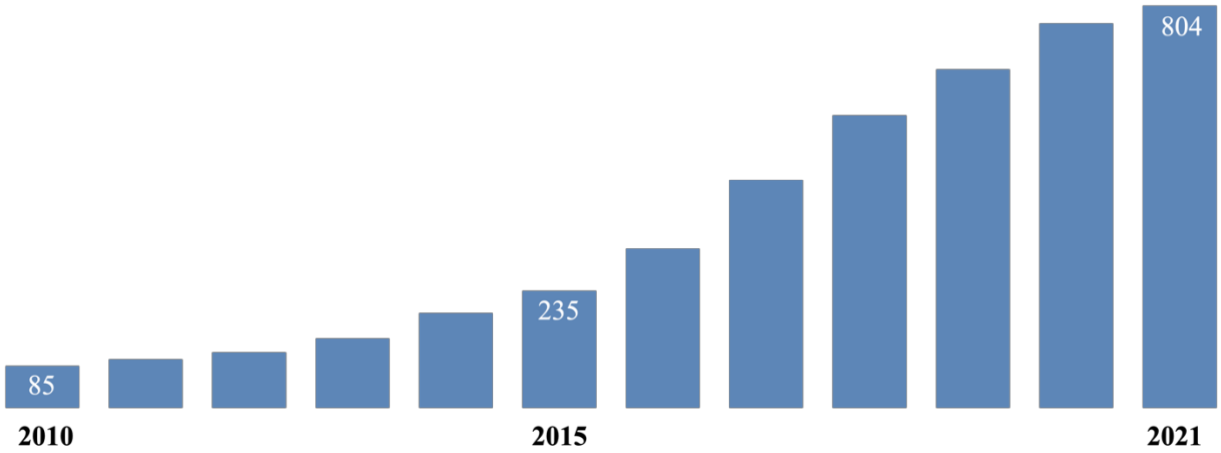
Figure 2 highlights marine aquaculture leasing parameters for coastal US states that differ from Maine's LPA parameters.[4]

[4] New Hampshire Department of Environmental Services, Shellfishing FAQs; New York State Department of Environmental Conservation, On/Off-Bottom Culture Permit; New Jersey Department of Agriculture, Aquatic Farm License Application I; Oregon Department of Agriculture, Shellfish Aquaculture Leasing Process for State-Owned Lands; Texas Agricultural Code: Title 6, Subtitle A, Chapter 134, Regulation of Aquaculture; Virginia Marine Resources Commission, General Permit #4 For Temporary Protective Enclosures For Shellfish; Delaware Administrative Code: Title 7, Section 3801; Massachusetts General Laws, Part 1: Title XIX, Chapter 130, Section 60; Delaware Division of Fish and Wildlife, Shellfish Aquaculture; Connecticut Department of Agriculture, A Guide to Marine Aquaculture Permitting in Connecticut; Maryland Department of Natural Resources, Shellfish Aquaculture Frequently Asked Questions; North Carolina Department of Agriculture & Consumer Services, Aquaculture License Application; South Carolina Code of Laws: Title 50, Chapter 5, Article 1; Georgia Department of Natural Resources, Shellfish and Mariculture Public Comment; University of Florida, Online Resource Guide for Florida Shellfish Aquaculture; Alabama Oyster Aquaculture, Permit Application Guide; Mississippi Saltwater Fishing, Oyster Aquaculture; Louisiana Department Of Wildlife And Fisheries, Application For Alternative Oyster

Figure 2. Highlights of lease parameters in US states

While the extent to which the LPA system is a practicable model of small-scale, LTL mariculture for other US states (as well as regions worldwide) requires multi-variable conceptualizations of aquaculture development, the significant expansion of Maine's LPAs, from 85 in 2010 to 804 in 2021 (Figure 3) in part demonstrates an efficacy of the state's mariculture leasing regime.

Figure 3. Number of active LPA licenses by year[5]



Culture Permit; California Fish and Game Commission, Lease Granting The Exclusive Privilege of Conducting Aquaculture at State Water Bottom No. M-000-00; Alaska Department of Fish and Game, Alaska Aquatic Farm Program Joint Agency Application – Part II; Hawaii Administrative Rules: Title 13, Subtitle 7, Chapter 190D. All these citations from 2021.

[5] State of Maine DMR, Active LPA licenses per year: 2007-2021; 2021.

Notably, roughly 90% of LPAs in 2021 were used for commercial purposes (State of Maine DMR, Interactive Data Table for current LPAs, 2021), indicating a correlation between the expansion of the LPA system and LPA-holders who sustain their farms by selling farmed products.

Marine aquaculture recruitment—Why start a small ocean farm?

Marine leasing programs such as Maine's LPA system contend with the many factors that attract individuals to small-scale mariculture (Kaminski et al., 2020). An industry's "recruitment" concerns its participants' entrance to, maintenance within, and possible exit from the industry, and the resiliency of an industry may be evaluated according to its recruitment rates over time (Sønvisen, 2013). A meta-analysis of sustainable aquaculture business models by Kaminski et al. (2020) demonstrated that sustainable aquaculture recruitment occurs when farmers are supported by a network of factors:

- Financial resources
- Accessible suitable feed and seed inputs
- Functioning infrastructure
- Accessible facilities for transport and storage
- Avenues to meet the costs of coordinating with other value-chain actors, meeting compliance standards, and meeting commercialization costs
- Skill-building programs
- Sociocultural factors, such as belief systems that encourage aquaculture
- Supportive institutions

However, research into small-holder aquaculture has largely assessed aquaculture farmers in Africa and Asia who culture finfish or shrimp (Burns et al., 2013; Pant et al., 2014); comparatively little research has focused on smallholders culturing LTL species in "aquaculture's new geographies" such as the United States (Costa-Pierce, 2021). Indeed, small- and medium-scale aquaculture—especially of oysters, the most farmed species on LPAs (State of Maine DMR, Table of Active Limited Purpose Aquaculture (LPA) Licenses, 2021)—may constitute the greatest opportunity for expansion in areas outside of Asia (FAO, 2020).

Furthermore, although studies have explored recruitment factors in certain marine-harvest industries—including kinship ties that encourage younger fishers to join their fishing forebears (Ota and Just, 2008), access to boats and processing infrastructure (White, 2015), and workforce skills that are transferable from related industries (Philipson and Symes, 2015)—small-scale LTL ocean farmers in Maine may not necessarily benefit from such customs because of the mariculture's relative novelty for many in the state. While indigenous communities in what would be called Maine by 1820 have practiced mariculture in the region for centuries at least (Soctomah, 2002), survey data from the Maine Aquaculture Innovation Center (2020) indicated in 2019 that nearly three-quarters of Maine ocean farmers on any size of lease had been involved with aquaculture for fewer than six years. With which particular development factors do Maine's small-scale LTL ocean farmers contend?

Maine mariculture and rural development

Marine aquaculture development can generate a preponderance of small-scale operations for a rural region like Maine (Hishamunda and Leung, 2009). Maine has long been "predominantly rural" according to institutional metrics (OECD, 1993; US Census Bureau, 2021) and dealt with, among other aspects of rurality, coincident wealth disparities. Historically, unemployment rates and annual income metrics illustrate that poverty in Maine increases according to communities' distance from the state's southerly urban and suburban areas. Average annual incomes in the state from 2000-2019 demonstrate a trend of northeast-southwest socioeconomic differentiation (Figure 4), and northern coastal counties (also known as "Downeast" counties) since at least 2000 have experienced higher rates of unemployment than Midcoast counties, which in turn had higher unemployment rates than southern Maine counties (Figure 5). Nonetheless, most of Maine's marine aquaculture leases as of 2021 were located outside of the state's urban center of Portland in Casco Bay (Figure 6). Most of Maine's ocean farms furthermore occupied less than four acres/1.6 hectares each, with the vast majority occupying fewer than 400 square feet/37.2 square meters (State of Maine DMR, Aquaculture Map, 2021). In Maine, mariculture development concerns rural development, with a distinct layer of regionality.

Figure 4: Average annual incomes in Maine counties and the US, 2010 – 2019[6]

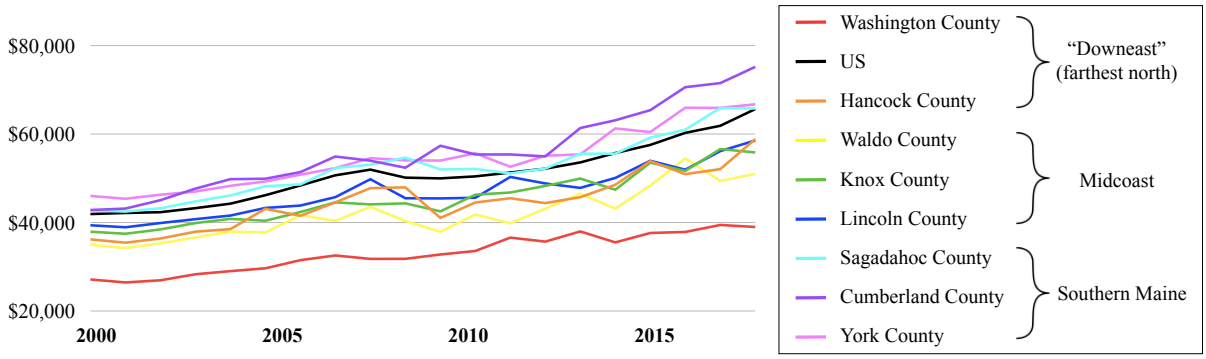
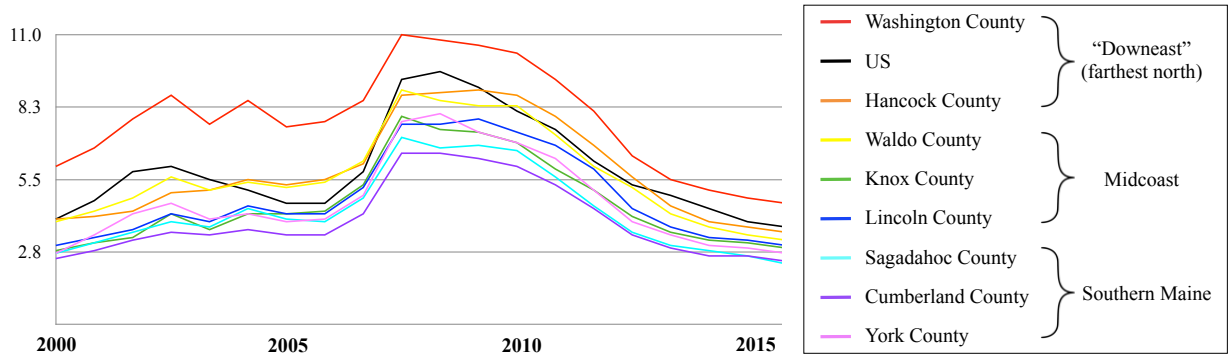
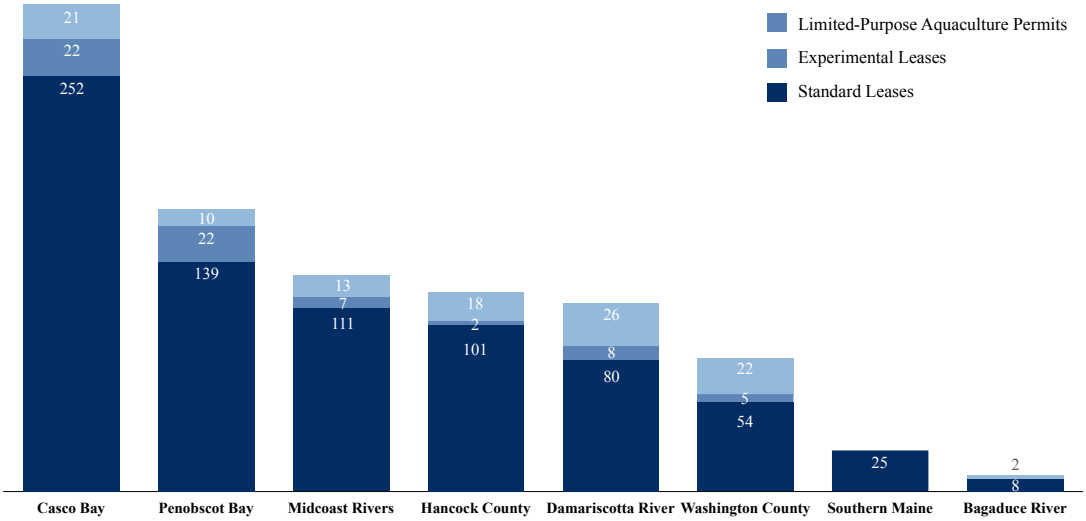


Figure 5. Unemployment levels in Maine counties and the US, 2010 – 2015[7]



[6] U.S. Census, 2020.
[7] U.S. Bureau of Labor Statistics, 2021.

Figure 6. LPA licenses, Experimental Leases, and Standard Leases, by Maine region, as of November 10, 2021[8]



Rural development and commercialization

As have researchers demonstrated in Europe (Kayser, 1991), Latin American (Escobal et al., 2015), sub-Saharan Africa (Moehl et al., 2006), and Asia (Hishamunda et al., 2009), this study focused on commercialization as a driver of rural development. Commercialization is the organizing of an operation toward "market orientation," i.e., the expectation of profit from product sales (Pingali and Rosegrant, 1995), and these sales rely on the availability of relevant inputs as well as sellers' assessments of market demand (GC and Hall, 2020). While individuals in rural communities may pursue their development goals non-commercially such as through subsistence farming (Mbatha et al., 2021), this is not the norm globally (Otero et al., 2013).

While case studies of market-oriented farms like those of Maine's small-scale mariculture operations illustrate both favorable and cautionary outcomes of commercialization—more affordable nutrition and increased employment in relevant value chains on one hand (Kissoly and Grote, 2020), vulnerability to market fluctuations and potential overexploitation of resources (Longo and Clausen, 2011) on the other—development of profit-focused smallholder aquaculture can be instrumental in generating economic prosperity overall in rural and low-incomes regions (Filipski and Belton, 2018).

The Maine lobster fishery exemplifies a pattern of rural commercialization. Lobster sales from roughly 1,500 owner-operated lobster vessels at numerous ports in the state (Conkling, 2008) produced as much as 80% of the value of all Maine fisheries in 2011 (Steneck et al., 2011); in 2021, the lobster fishers and other sellers earned nearly $725,000,000 (Chase, 2022). These sales circulate through companies such as lobster dealers, gear and bait suppliers, vehicle manufacturers and repair operations, and freight transporters in diverse in-state and out-of-state locations (Acheson, 1975). Which aspects, if any, of the trajectory of Maine's lobster industry can or should be compared to that of Maine's commercial LTL mariculture industries is likely to

[8] State of Maine DMR, Table of Standard and Experimental Aquaculture Leases, 2021; State of Maine DMR, Table of Active Limited Purpose Aquaculture (LPA) Licenses, 2021.

continue to animate conceptual development of the latter as aquaculture stakeholders deliberate development model(s) to pursue (St. Gelais, personal communication, December 15, 2021).

Rural development and food security

Rural development literature also emphasizes the importance of sustainably meeting rural communities' food-security needs, which degrees of impoverishment can exacerbate (Forrest, 2017). Ivers and Cullen (2011) described that food security "exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life." Belton et al. (2020) conceptualized that rural food security may be achieved where farmers intensify efficient production, supply chains connect to rural communities, and policies protect stakeholders in generating public goods. However, Hervas and Isakson (2020) questioned the assumption that crop commercialization in food-insecure areas consistently generates stronger food-security outcomes for those areas, highlighting cases of expansions of unaffordable commoditized goods that had the "paradoxical effect of reducing food accessibility." In addition to exploring commercialization dynamics for the state's ocean farmers, this study aimed to illuminate aspects of the food security of Maine's small-scale ocean farmers that may otherwise be unclear among international studies of rural food security.

Scaling

One route of commercialization that may especially address the socioeconomic needs of rural mariculture regions such as Maine is that of scaling (Diedrich et al., 2019). Scaling is the intensification of an enterprise's practices and/or technologies that broaden its economic and/or social reach, often capitalistically through expanded production (Schut et al., 2020). Woltering et al. (2019) argued that the process of commercializing aquaculture production through the cultivating of larger aquatic areas can lead to increased employment and wealth generation beyond what is possible through small-scale commercialization. Moehl et al. (2006) demonstrated that small- and medium-scale commercial aquaculture farmers often drive the sector's development because despite their smaller margins, such farmers often experiment with diverse operational approaches more quickly than their large-scale counterparts and subsequently propagate their successful approaches through the sector. When such experimentation proliferates, an entire industry can scale through "a process aimed at achieving sustainable systems change" (Woltering, 2019). Notable for the Maine mariculture system is an ocean farmer's possible trajectory through the state's ocean leasing system that allows for "scaled-up" operations, with users potentially expanding their operations from the smaller LPA license to the larger Experimental and Standard Leases.

However, scaling cannot be understood as an easy option for small-scale businesses because it requires strategic interaction with various societal domains, such as the accessibility of cultivation equipment, farm labor and knowledge, and product distribution avenues (Sartas et al., 2020). Indeed, elevated costs associated with scaling may deter smallholders from its pursuit. For an enterprise to successfully scale, "most, if not all, of the necessary private (or public) value-chain elements [must be] in place" (Kohl and Foy, 2018). Indeed, the successful scaling of a project implies deep institutional shifts:

> "When taking system success as a starting point—for example, overcoming the root causes of food security in a particular region—one tries to invoke change that stimulates

> the emergence of innovations that can make the system work better. Change occurs when different developments from distinct sources 'meet' to gradually shape a new configuration that brings the innovation a step forward. These changes are hardly captured by monitoring things like 'adoption by x farm households.' Rather, they involve a range of stakeholders across different disciplines (political, financial, sector governance, etc.) willing to change the way they work to shift the status quo keeping the 'bad' system in place" (Woltering et al., 2019).

Despite the challenges, exclusively small-scale aquaculture production can preclude significant economic gains that often stem from scaled-up enterprises (Gephart et al., 2020). Rural commercial ocean farmers may enter the industry at a small scale, but they need not be confined only to that scale. While the productive capacity of ocean farmers may remain at the small-scale for a variety of reasons, commercial scaling may indeed be pivotal to the economic sustainability of Maine mariculture development. the process of commercializing aquaculture production through the cultivating of larger aquatic areas can lead to increased employment and wealth generation beyond what is possible through small-scale commercialization (Woltering et al., 2019). "The optimal size of an aquaculture farm is that at which it is profitable" (Moehl, personal communication, December 8, 2021). This study sought to illuminate ways that commercial LPA-holders' who wish to scale up their operations are able or unable to translate their successes into scalable operations.

Sociocultural factors: Social license to operate (SLO)

In addition to official licensing procedures and economic factors, mariculture development is governed by processes of approval from various non-state users of ocean areas (Diana et al., 2013; Naylor et al., 2021). "Social license to operate" (SLO) is the negotiation of access to environments of shared resources between a newcomer and preceding users of those resources, e.g., between recently established ocean farmers and the variously populated community that "hosts" them (van Putten, 2018; Billing, 2018; Thomson and Boutilier, 2011).

SLO phenomena influence nearshore marine aquaculture development because such ocean spaces worldwide are, like those in the United States, often legally designated as common resources and therefore subject to contestation by many local users (Ford et al., 2022). Varied users of mariculture areas include riparian landowning neighbors, local conventional fishers, indigenous groups, industrial maritime entities such as shipping businesses, and sailors and recreational users. While other formal and informal organizations may influence mariculture SLO dynamics—particularly those of environmental, aquatic-animal-welfare, social-justice, commercial-development, and media organizations—aquaculture-leasing processes often empower these groups over others because of their proximal relationship to proposed ocean farms; these groups' formal and informal negotiations directly impact ocean-farm development (Billing, 2018). "The fundamental aim of understanding the context of SLO and engaging in [SLO-informed] activities…is to establish trust between those running industrial operations and local communities and communities of interest" in order to determine various and potentially prohibitive costs of aquaculture development (Billing et al., 2022).

- *SLO: Riparian landowning neighbors*

Negotiations between ocean farmers and the individuals and entities that farmers must cross, and/or that overlooks ocean farms heavily influence nearshore ocean leasing (Evans et al., 2017). These SLO issues concerning riparian access may stem from "NIMBY" ("Not In My

Backyard")[9] arguments that can encompass environmental, aesthetic, and property-valuation contentions (Whitmarsh and Palmieri, 2009; Evans et al., 2017; White, 2019), as well from ocean farms' neighbors' concerns around the equitable distribution of the benefits of aquaculture development (Campbell et al., 2021). Such NIMBY concerns vary geographically: while Apostle (2012) demonstrated that such concerns dominate US opposition to salmon mariculture, in Norway "support for large aquaculture expansion is higher among people who consume farmed salmon frequently and those living in areas with a high density of aquaculture farms" (Aanesen et al., 2023). Furthermore, researchers emphasize that conceptualizing opposition to marine development among a project's riparian neighbors as purely NIMBY-ism may incompletely encapsulate this domain of SLO (Soma and Haggett, 2015; Haggett, 2011). "People do not selfishly protest [marine projects] only if they are likely to be affected…[Notions] of attachment-to-place likely have more resonance" (Firestone et al., 2009).

- *SLO: Conventional fishers*

Competition for access to working-waterfront and marine resources between ocean farmers and conventional fishers is a demonstrated mariculture SLO issue in many world regions (Mather and Fanning, 2019). These fishers often possess knowledge of local ecologies, "particularly where multiple users may be leading to deleterious interactions" (Wiber et al., 2012), and may wield political, cultural, and/or social capital to inhibit aquaculture development (Agúndez et al., 2022; McDonagh, 2021). These groups may compete for limited coastal space, shrinking working-waterfront infrastructure, and market share with similar products (FAO, 2012; Martinez et al., 2017). In other instances, however, traditional fishers and farmers may collaborate to inform policymaking (Siddiki and Goel, 2015). When fishers and farmers are supported to establish shared goals for sharing ocean space, friction between these users need not be inevitable (Costa-Pierce and Chopin, 2021).

- *SLO: Indigenous groups*

As the partitioning of nearshore ocean areas increases with expanding mariculture leasing, claims of sovereignty and equity often correspondingly intensify, especially when aquaculture development occurs in indigenous groups' territories (Tollefson and Scott, 2006). Legal and protest-driven challenges by First Nations peoples in British Columbia and Maori communities in New Zealand to the expansion of ocean farming emphasized farms' encroachment onto native harvesting sites, for examples, illustrate complexly contested rights-based arguments of whom deserves priority in apportioning common-resource access (Wiber et al., 2021).

National and international treaties such as the United Nations Convention on the Law of the Sea arguably heighten such deliberations by enfranchising native claims to ocean lands to 200 miles from the relevant coastlines (Valencia and VanderZwaag, 1989), and increasingly so when aquaculture advocates assert that the sector's development should specifically benefit native communities, as have many proponents of a "Blue Economy" approach to mariculture that enshrines "equitable, sustainable, and viable" outcomes to ocean development (Bennett et al., 2019). Given that many indigenous groups have also long practiced sustainable marine

[9] From Whitmarsh and Palmieri (2009): "NIMBY is an acronym for 'Not In My Back Yard,' referring to opposition of local residents to development in their area. The term carries a connotation that such protests are fueled by a selfish concern for one's own area, while similar development in other areas would not be opposed."

ecosystem management (Obiero et al., 2022), their inclusion into mariculture governance negotiations may be a moral as well as ecological necessity.

- *SLO: Industrial maritime entities*

Rigorous consultation with industrial maritime entities—particularly those within the commercial shipping, offshore oil and gas, and offshore wind power sectors—that regularly navigate through proposed aquaculture areas is often critical for ocean-farming development (Lauer et al., 2015; Pataki and Kitsiou, 2022; Gómez-Ballesteros et al., 2021). While marine spatial planning programs have especially accounted for the interests of industrial ocean-users since at least the 1970s, interactions between these users and mariculture development advocates are a more recent area of theory and research (Smith and Jaleel, 2019). Given the economic and political capital of large-scale commercial ocean users, however, it is likely that their SLO will remain pivotal to marine aquaculture siting dynamics (Turschwell et al., 2022).

- *SLO: Sailors and recreational users*

Mariculture development occurring where sailors, maritime recreational users, and coastal tourism businesses operate can spur concerns about the visual impacts of ocean-farming equipment, reduction of anchorage options, economic losses from the limiting of access by non-ocean farmers to aquaculture sites, and farm waste (FAO, 2008; European Maritime Spatial Platform, 2021). While aquaculture activities can generate tourism opportunities on their own (Hendrix, 2014; European Maritime Spatial Platform, 2021), research demonstrates that successful SLO negotiation between aquaculturists and their recreational-use neighbors results from proactive and sustained communication, relationship-development, and information-sharing among these parties that proceeded informally as well as through formal, agency-led outreach (Flannery and Ó Cinnéide, 2008; Smith, 2015).

Social License to Operate in Maine

- *Maine SLO: Riparian landowning neighbors*

Lapointe (2013) summarized that for opposition to nearshore marine aquaculture development from Maine to Connecticut, "the first, and primary, category is the public resistance, or 'not in my backyard' (NIMBY) views, with objections from riparian landowning neighbors of aquaculture farms in the state largely focusing "on localized changes in aesthetics and property values" (Evans et al., 2017).

Indeed, a representative of neighbors to a proposed nearshore fish farm in Maine claimed in 2021 that they were "not necessarily agreeable to outside corporate control of a large swath of the ocean and feel disenfranchised from the process" (Nargi, 2021). Opponents to the expansion of a Maine oyster farm in 2018 expressed that the size of the farm was incongruous with the area's traditional uses (Strout, 2018), and that the farm's lease would prevent nearby landowners from accessing the site (Laclaire, 2019). In 2022, an organization speaking for neighbors of a potential marine fish farm advocated for the limiting of farming of any aquatic organism to ocean areas less than a maximum of five acres (Genter, 2022), though local voters rejected this proposed moratorium (Beal, 2022).

However, while Chen (2017) demonstrated that change in housing prices in coastal Maine regions are not linked to the expansion of ocean farming, NIMBY arguments do not characterize all opposition by landowning neighbors near to marine-aquaculture projects. Speaking about the

possible establishment of large-scale seaweed farms in Maine, a neighbor of several ocean farms who also represents a group advocating for small-scale mariculture development asserted that "we want to protect this [marine] space [in Maine] from being captured…We want to make sure there's room for small, locally owned businesses and conservation-minded humans to undertake this work and not be crowded out and outgunned" (Cebula, 2022).

Shifts in Maine's demographics may illustrate the state's SLO dynamics among residents living near proposed marine farms. Hanes (2017) pointed to Maine's "post-productive transition" of the late nineteenth century in which the state's population expanded primarily in rural areas between 1960-2000 as "rusticators" moved to coastal areas and de-commercialized spaces vacated by traditional fishers; these "newcomers tend to favor conservation over commodity production." Evans et al. (2017) documented that Maine residents are often "more sensitive to marine development and less accepting of [proposed farms], despite acknowledging the potential economic benefits to the local community." The SLO impacts on mariculture development of the new residents brought to Maine amid the global migration patterns of de-urbanization compelled by the COVID-19 pandemic (Argüelles, 2021) remain to be seen.

- *Maine SLO: Conventional fishers*

Maine's past and present capture-based fisheries are numerous, but whereas some of the state's largest capture-based fisheries by value have seen significant volatility in markets and catches since at least 1950 (apart from Maine lobstering) (Figure 7), the shellfish and seaweed farming industries appear less economically and ecologically volatile, albeit young (Figure 8). The sustained lucrativeness of the Maine lobster fishery, as well as the lineages of the state's long-established fisheries, may position individual Maine fishers to oppose aquaculture or to acquire aquaculture licenses/leases themselves.

For long-established fishers, aquaculture can entail a significant adjustment from wild harvesting to farming, especially when marine aquaculture does not necessarily replicate fishing's regularized routine of "getting one's feet wet" (Moehl, personal communication, December 8, 2021). At the same time, Grabowski et al. (2010) argued that lobstering in Maine has always been a form of mariculture because of the large supply of bait regularly used by lobster fishers. In any case, integration of mariculture into Maine lobster fishers' economic activities is a focus of ocean-farming stakeholders in the state (Island Institute, 2019; Maine Sea Grant, 2021).

Historically, Maine fishers have harvested different species according to seasonal abundances and regulations. Figure 9 demonstrates how cultured species (in bold print) can fit into Maine's traditional wild-harvest cycles (in italics). However, while there may be overlaps between the required skills and physical resources for a traditional fishery and an ocean farm (e.g., navigating a boat), marine aquaculture in Maine today is driven by relatively new entrants to mariculture (Maine Aquaculture Innovation Center, 2020).

Figure 7. Five of Maine's largest-by-value traditional fisheries[10]

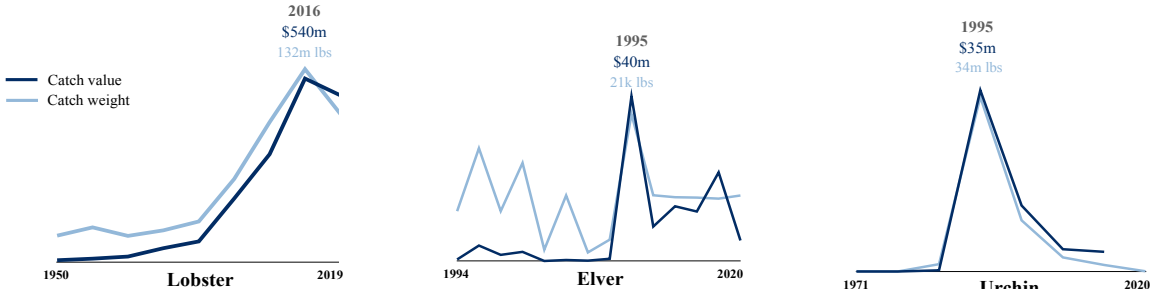


Figure 8. The three largest-by-value marine aquaculture species in Maine[11]

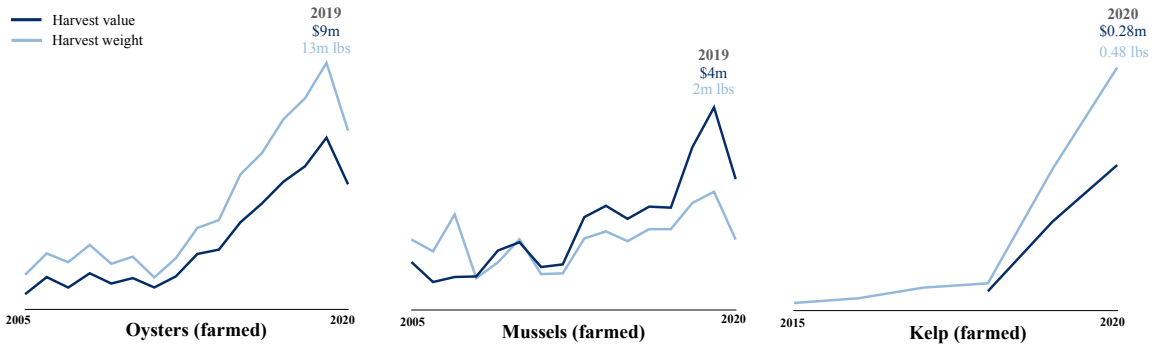
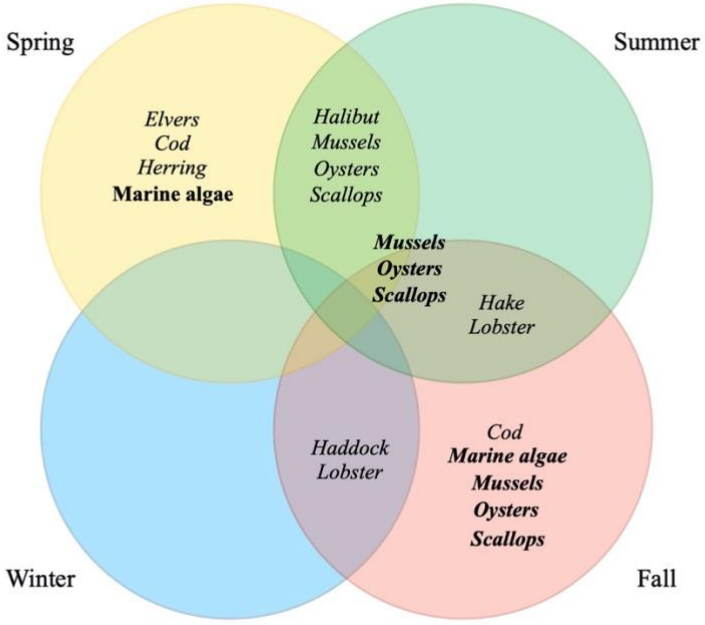


Figure 9. Overlapping seasonality of work culturing organisms on LPA(s) (in bold) and in selected traditional Maine fisheries (in italics)[12]



[10] State of Maine DMR, Historical Maine Fisheries Landings Data, 2021.

[11] Harvest of Farm-Raised American Oysters (Crassostrea virginica) in Maine, 2021; Harvest of Farm-Raised Blue Mussels (Mytilus edulis) in Maine, 2021; Harvest of Farm-Raised Marine Algae in Maine, 2021.

[12] Conkling, 2011.

Lastly, small-scale marine harvesting operations have long defined fisheries and aquaculture development in Maine. Woodard (2007) described that small boats primarily propelled indigenous and early colonial fisheries, and argued that an ethic of small-scale ownership has persisted. Where Massachusetts in the nineteenth century, for example, consolidated its groundfishing fleet under relatively few owners, independent captains owned nearly three-quarters of Maine's fishing vessels in 1829 (ibid.). In 1920, still 70% of Maine fishing vessels were singly owned (Conkling, 2011). By the 2000s, roughly 1,500 lobster boats supplied Maine's $1.5b lobster industry, 1,500 independent clammers supplied its soft-shell clam fishery, and the state had an 80-foot limit on the size of groundfish vessels (Woodard, 2007). Maine's ethos of small-scale fisheries is a cultural phenomenon with which the state's expanding mariculture development will continue to interact (St. Gelais, personal communication, December 15, 2021).

Supportive institutions: Legal license to operate (LLO)

With many stakeholders involved in marine aquaculture development, governmental agencies often proceduralize mariculture governance, incorporating ecological data and codifying select SLO concerns as well as civil engineering and military interests into aquaculture leasing systems (Ford et al., 2022). In granting or withholding legal permission for the construction of ocean farms, these agencies become highly visible targets for groups that disagree with their decisions: van Putten et al. (2018) summarized that increases in SLO issues indicate a widespread deterioration of trust between the publics and their associated regulatory agencies. This study conceptualized that ocean farmers obtaining "legal license to operate" (LLO) is critical to mariculture development and recruitment.

For a US state encouraging the farming of LTL marine species, in a place with distinct marine-leasing administrative characteristics, regional demographics, economic indicators, and routes for commercial mariculture scaling, which theories of marine aquaculture development and recruitment are relevant for Maine?

In all, which barriers and which facilitating mechanisms impact Maine smallholder marine aquaculture, especially those of commercial LPA-holders? What can be inferred from the trends within the LPA system, viz. the development of marine aquaculture in Maine? For local, national, and international mariculture stakeholders, which patterns of LTL aquaculture development, nearshore marine leasing, and rural economic access does the LPA system reveal?

Research Questions

To achieve this study's research goals, the following primary research questions were asked:

- Does Maine's LPA system support sustainable marine aquaculture recruitment in the state?
- Does the LPA system support small-scale ocean farmers' commercialization efforts?
- What do LPA-holders' experiences in sustaining their aquaculture farms reveal about aquaculture governance in Maine?

3. RESEARCH METHODS

3.1.1 Key informants

A transdisciplinary approach to this study was taken, through which a diverse group of relevant stakeholders contributed at multiple stages to an intensive inquiry project, with an evolving methodology, around a complex problem (Wickson et al., 2006). Following a literature

review of drivers of small-scale LTL aquaculture, thirteen key informants were recruited: six representatives of four Maine aquaculture non-profits, two Department of Marine Resources representatives, two aquaculture researchers, one social science professor, two Maine oyster farmers, and a Maine seaweed farmer. Guidance from these informants was sought during the development of a survey and focus group questions, as well as after survey results were analyzed. This process produced an initial framework for small-scale LTL marine aquaculture recruitment in Maine with themes that impact an individual's establishment and maintenance of a small-scale LTL ocean farm using the LPA system:

- Environment resources, such as the biological health of the LPA's natural surroundings
- Knowledge and skills, such as for the assembly of LPA gear
- Physical resources, such as boats and trucks
- Economic resources, such as personal financial resources
- SLO issues, such as relationships with riparian landowners
- Legal-license-to-operate (LLO) issues, such as formal approval from the Maine DMR

For LPA-holders intending to sell their aquaculture products, this framework included the above factors as well as those of commercialization, such as a seller's access to local markets. To elucidate this framework and to obtain farm and farmer characteristics, the following inquiry areas for this study's survey and focus group were developed:

- Farm characteristics: organisms permitted to be cultured and organisms regularly harvested; farm location and size; number of aquaculture sites regularly operated
- Demographics: farmer age; number of years lived in Maine, years working in aquaculture, and years farming their LPA(s); involvement in the seafood industry before aquaculture; participation in formal aquaculture training programs
- Labor and costs: seasonal weekly work hours; total dollar investment into LPA-holders' farms; number of assistants, difficulty in finding them, and whether they were mostly from an education institution
- Physical resources: Farm gear and vehicles; waterfront access
- Food-security issues relating to their LPA(s)[13]
- Reasons for having an LPA(s)
- SLO: relationships with recreational users as well as with riparian landowning, traditional-fisher, and fellow LPA-holder neighbors
- LLO: Licensure capacity and regulations of Maine DMR; Army Corps of Engineers navigation regulations
- Commercialization: intent to sell their LPA product(s); whether they are or intend to become certified shellfish dealers; the location of buyers for the majority of their LPA product(s); annual sales, before and during the -19 pandemic; projected sales after the COVID-19 pandemic; influence of various buyers before and during the pandemic
- Scaling: desire to expand their farm; the degree of "informed decision-making" for this desire, stemming from their LPA experience

[13] Survey questions relating to food security were adapted from the "Screen and Intervene: A Toolkit for Pediatricians to Address Food Insecurity" from the American Academy of Pediatrics, 2021.

3.1.2 System map

A conceptual map of the LPA system was created from a literature review—especially the meta-analysis by Kaminski et al. (2020) of commonly used aquaculture business models from low-income countries—and this study's survey data, focus group data, and the initial framework described above. See Appendix 1 for this conceptual map. This map also highlighted intersections with the United Nations Sustainable Development Goals (SDGs) (United Nations, 2021) to reinforce the global implications of Maine's LTL marine aquaculture (Figure 10). Below are the SDGs included in this conceptual map, shortened for brevity; see Appendix 2 for the complete list of included SDGs:

- SDG #1.2: Reduce by half the proportion of men, women, and children of all ages living in poverty
- SDG #2.1: Ensure access by all people, in particular the poor and people in vulnerable situations to safe, nutritious and sufficient food all year round
- SDG #2.3: Double the agricultural productivity and incomes of small-scale food producers
- SDG #2.4: Ensure sustainable food production systems
- SDG #2.a: Increase investment in rural infrastructure, agricultural research, and extension services
- SDG #8.3: Support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises
- SDG #9.2: Promote inclusive and sustainable industrialization
- SDG #14.2: Sustainably manage and protect marine and coastal ecosystems

3.2 Surveys

An anonymous online survey was developed and data were collected and managed using REDCap (Research Electronic Data Capture) electronic data capture tools (Harris et al., 2009) hosted at the University of New England. This survey was emailed to all 250 individual email addresses associated with the 675 LPAs that were registered with the Department of Marine Resources as of May 10, 2021. 74 respondents accessed the survey and thus generated an overall response rate of 28.8%; response rates for individual questions varied. Approval for non-human research was granted by the University of New England Institutional Review Board (IRB) for the survey. See Appendix 3 for a copy of the survey questions used in this study and Appendix 4 for documentation of this study's IRB approval.

Survey questions were developed with the guidance from key informants and from two University of New England graduate researchers (Delago, 2021; Feldman, 2021). A maximum of 53 survey questions were sent to potential respondents. REDCap's skip logic function managed inclusive, contingent, and exclusive questions to avoid directing irrelevant questions to certain respondents (i.e., a respondent who did not indicate that they farm oysters were not asked subsequent questions about oysters). All questions were optional except for the first three: a question concerning respondents' consent to participate, the location of their LPA(s), and the organism(s) they are licensed to harvest.

Of the 53 total possible questions in the survey, this study collected data from 39. The final two survey questions asked if respondents wished to join a follow-up focus group with the goal of

hearing from other LPA-holders about their aquaculture experiences, and to leave contact information if they indicated this interest.

To each question that did not require a written response, REDCap assigned each question a variable and a value, thus furnishing quantifiable data, largely at the nominal level. (Seven questions furnished ordinal-level data, i.e., questions concerning the number of seasonal weekly work hours; total dollar investment in LPA-holders' LPAs; and the influence of various buyers on commercialization choices before and during the COVID-19 pandemic.) Margins of error (MoE) were calculated for each of these questions, using the MoE formula for finite populations, i.e., the MoE with Finite Population Correction Factor (MoE with FPCF) (Wolter, 1984):

$$MoE = z * \sqrt{P * (1 - P)/\sqrt{N - 1) * n/(N - n)}}$$

where *P* is the sample proportion, *N* is the population size, *n* is the sample size, and *z* is the confidence level. A *P* of 0.5 was used for all calculations, as was a 95% confidence level, i.e., a *z* of 1.96. For clarity in this document, the MoE with FPCF is subsequently referred to as simply "MoE."

3.3 Focus Group

A focus group of seven participants was convened from the 19 survey respondents who had indicated their interest in joining the focus group. These seven participants were selected because they indicated that they sold or intended to sell products from their LPA(s). Focus group questions were also developed with the guidance of the abovementioned key informants. Approval for non-human research was granted by the University of New England IRB for the focus group. See Appendix 5 for a copy of the focus group questions used in this study.

The focus group was conducted virtually using the Zoom software, which recorded video and a rough audio transcript of the session. To preserve as much anonymity for the participants as possible, participants were instructed in advance of the session that the video recording would be deleted, as well as any personally identifying information that they may have shared, after the researcher had promptly edited the transcript for any transcription errors. Participants were also instructed that they could enter the session using a pseudonym and/or without their video feed enabled.

3.5 Data Analysis

3.5.1 Survey Data Analysis

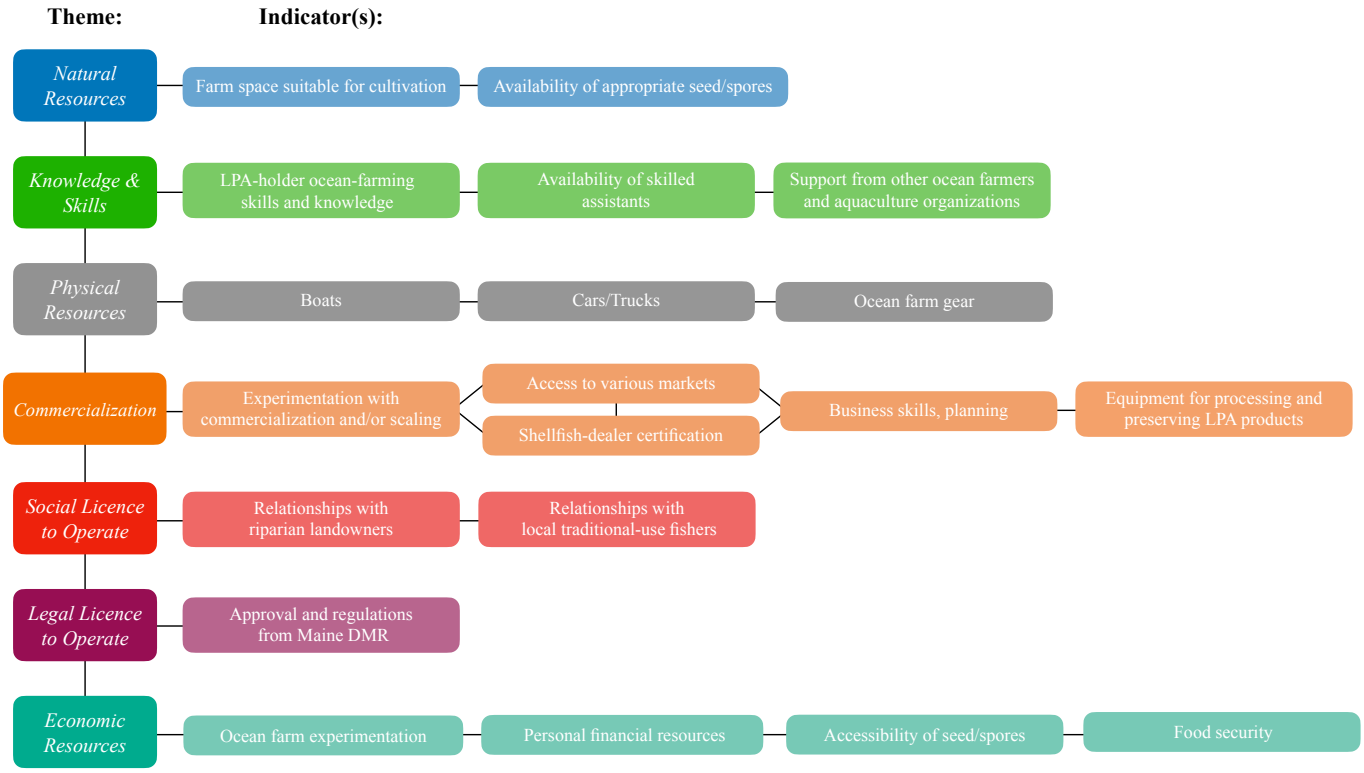
The REDCap application organized the survey's quantitative results into proprietary charts according to the percentages of each question's response options values. The researcher converted these data into graphics suitable for this format and calculated MoE for each nominal- and ordinal-level survey question.

3.5.2 Focus Group Data Analysis

Data analysis of the focus-group data followed the methods of thematic analysis as outlined by Braun and Clarke (2006) and was organized using the coding software Atlas.ti (Atlas.ti, 2021). These data were assessed using the themes of the framework described in

Section 3.1.1, with indicators from key informant consultations elucidating those themes (Figure 10).

Figure 10: Conceptual framework, with focus-group data indicators added



4. RESULTS

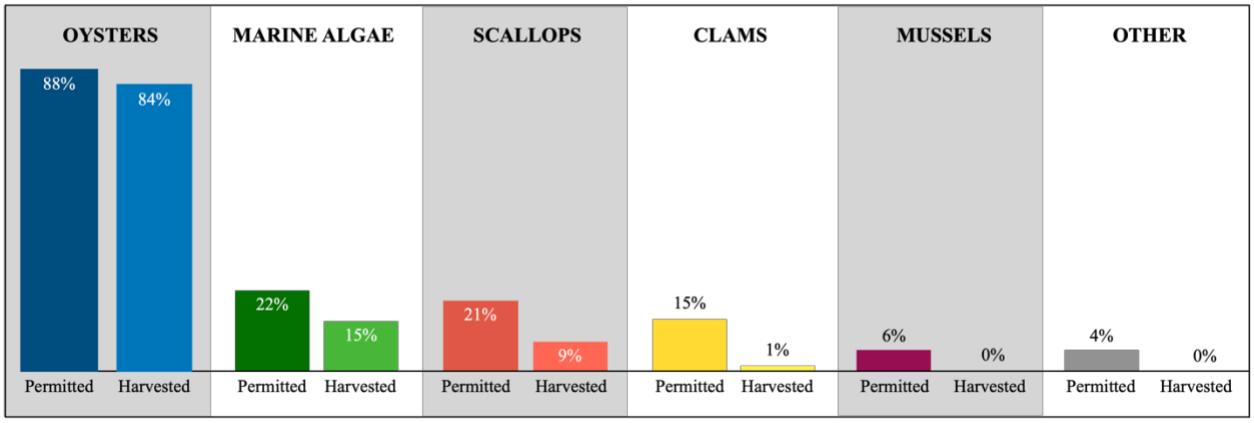
4.1 Survey Results

Farm Characteristics

Eighty-eight percent (88%) of respondents indicated they were licensed to grow oysters, and 84% that they regularly harvested oysters (Figure 11). For marine algae, these respective figures are 22% and 15%; 21% and 9% for scallops; and 15% and 1% for clams (Figure 11). No respondent reported that they regularly harvested mussels or other organisms, although 6% and 4% of them indicated that were permitted to, respectively (Figure 11).

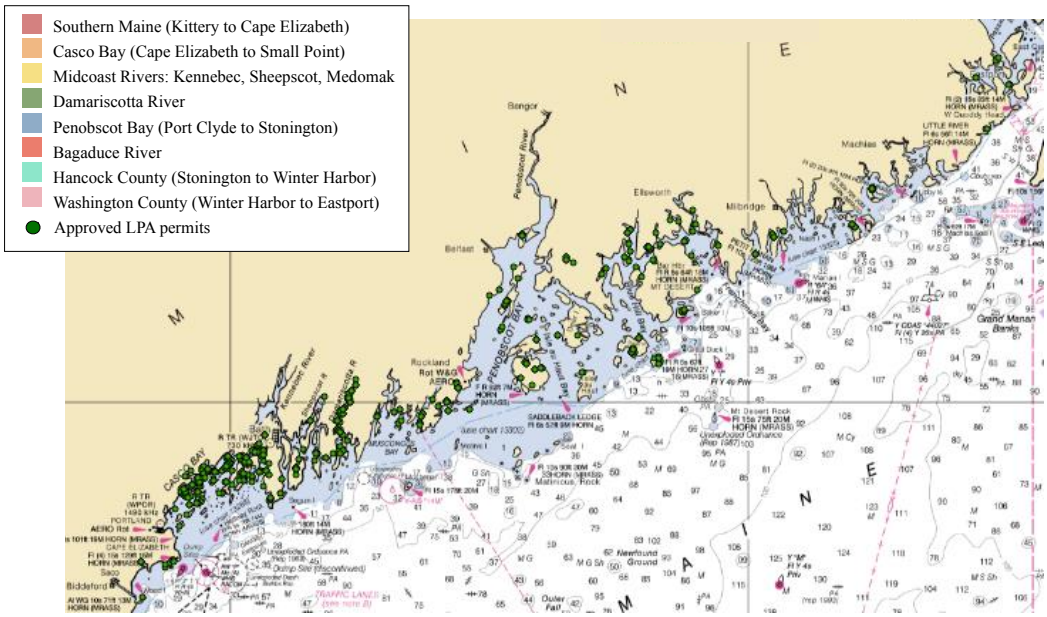
Figure 11. Organisms that respondents were licensed to grow (n = 72; MoE = 9.8%), and organisms that they regularly harvested (n = 69; MoE = 10.1%)

"What are you licensed to grow on your LPA(s)? (Check all that apply.)"



Survey respondents were asked to indicate the location(s) of their farms from eight regions of the Maine coast; Figure 12 highlights these regions. These regions were selected for inclusion in the survey through guidance from key informants based on conventional community associations and known concentrations of aquaculture activity.

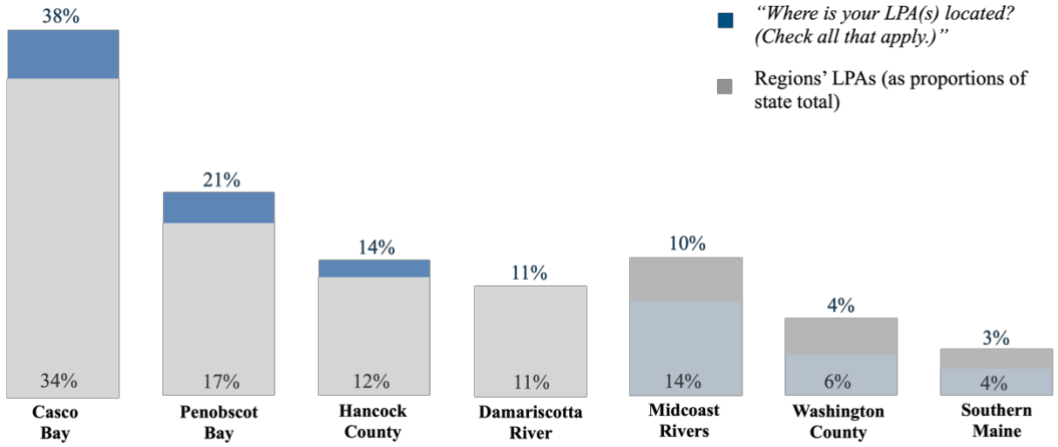
Figure 12. Regions that survey respondents could indicate for the location of their farm(s)



Thirty-eight percent (38%) of respondents' farms were in Casco Bay, 21% in Penobscot Bay, 14% in Hancock County, 11% in the Damariscotta River, 10% in Midcoast rivers, 4% in Washington County, and 3% in Southern Maine (Figure 13). Because no surveys were returned from LPA-holders operating in the Bagaduce River region, this region was omitted during analysis. These percentages roughly correspond to each region's proportions of the state's

overall LPA locations[14]; the Midcoast Rivers region was slightly underrepresented in the survey, while the other regions were overrepresented by 1-4%.

Figure 13. Regions in which respondents' farms were located[15] (n = 70; MoE = 8.9%)



In assessing the size of their aquaculture farm and the number of sites on which they regularly worked, survey data demonstrated that respondents regularly worked on the same number of LPAs that they were licensed to operate, +/- 4 percentage points (Figure 14). 65% of respondents only operated LPAs, 17% additionally operated one or more Standard Lease aside from their LPA(s), 12% additionally operated one or more Experimental Lease, and 6% of respondents additionally operated one or more non-leased aquaculture site (Figure 15).

Figure 14. Sizes of respondents' aquaculture farms (n = 70; MoE = 9.9%).

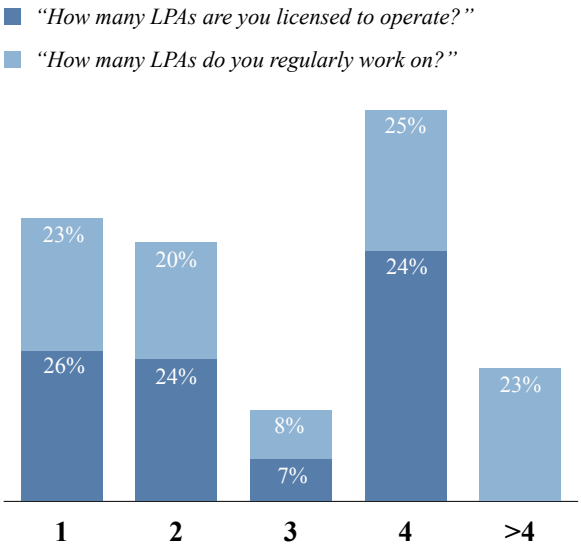
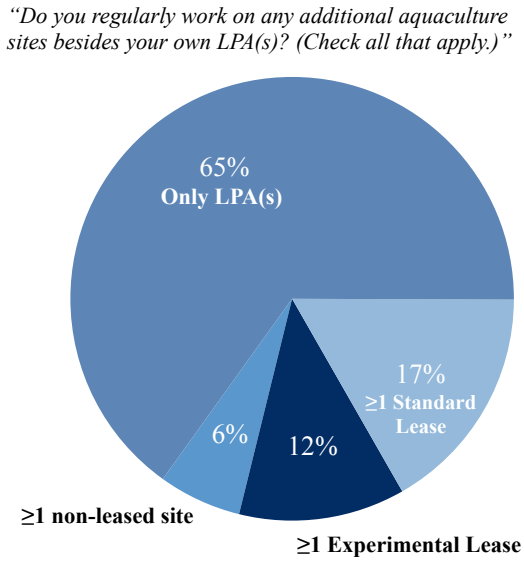


Figure 15. Whether respondents operated additional aquaculture sites aside from their LPA(s) (n = 65; MoE = 10.5%)

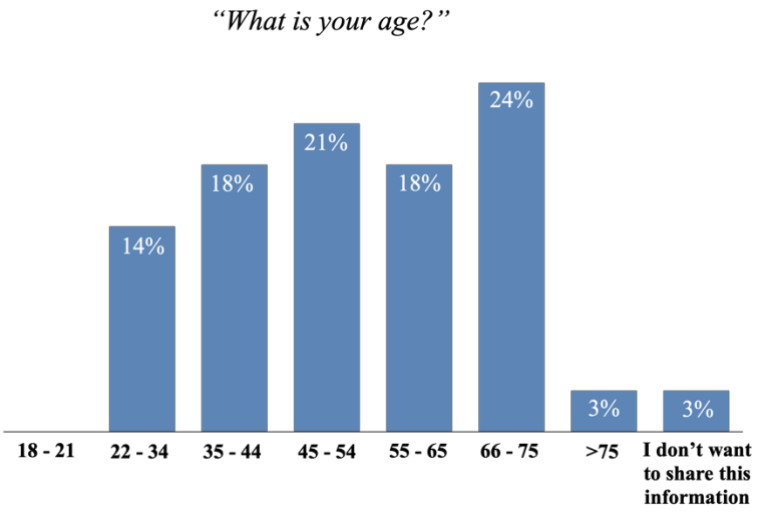


[14] State of Maine DMR, Table of Active Limited Purpose Aquaculture (LPA) Licenses, 2021.
[15] Data for locations for Figure 13's "Region's LPAs (as proportions of state total)" from State of Maine DMR, Interactive Data Table for current LPAs, 2021.

LPA-holder demographics

Fourteen percent (14%) of respondents were 22-34 years old, 18% were 35-44, 21% were 45-54, 18% were 55-64, 24% were 65-75, and 3% were over 75 years old; 3% of respondents indicated that they did not wish to share this information (Figure 16).

Figure 16. Ages of respondents[16] (n = 72; MoE = 8.9%)

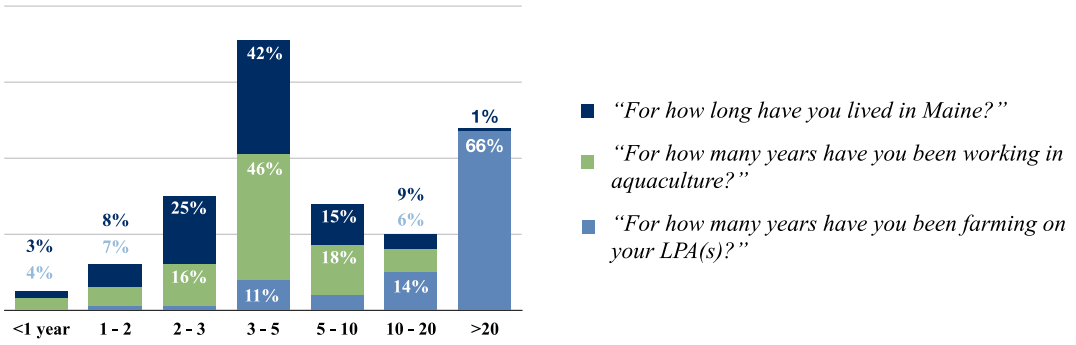


66% of respondents had lived in Maine for more than 20 years, 14% for 10-20 years, and 11% for 3-5 years; less than 5% of respondents had lived in Maine for >1-3 years and 5-10 years (Figure 17).

46% of respondents had worked in aquaculture for 3-5 years (Figure 17), a figure that mirrors data from the Maine Aquaculture Innovation Center survey of Maine aquaculture farmers on any size ocean farm (Maine Aquaculture Innovation Center, 2020). 18% of respondents had worked in aquaculture for 5-10 years, and 16% for 2-3 years. 7%, 6%, and 4% of respondents reported they had worked in aquaculture for 1-2 years, 10-20 years, and >1 year, respectively.

42% of respondents had farmed on their LPAs for 3-5 years, 25% for 2-3 years, 15% for 5-10 years, 9% for 10-20 years, 8% for 1-2 years, and 3% for <1 year (Figure 17).

Figure 17. Number of years respondents had lived in Maine (n = 71; MoE = 9.9%), worked in aquaculture (n = 71; MoE = 9.9%) and farmed their LPAs (n = 72; MoE = 9.8%)



[16] Age categories selected to correspond to those used by the US Bureau of Labor Statistics (Foster, 2015).

Survey data demonstrated that 61% of respondents were not involved in the seafood industry before starting in aquaculture (Figure 18). Of the 39% who responded that they were involved in the seafood industry before aquaculture, 36% were involved in commercial lobstering, 32% in commercial shellfishing, 7% in seafood processing, 4% in seafood research, and 4% in a seafood-industry non-profit (Figure 19). No respondents in the 39% subgroup indicated they were involved in commercial groundfishing, although it should be noted that respondents were forced to pick only one response option; many commercial fishers in Maine have experience in more than one fishery (Figure 19). 18% of respondents had prior seafood-industry experience in "other" seafood sectors (Figure 19), with 5 respondents in this group elaborating:

- "Urchins"
- "Aquaculture research, development, education"
- "Pelagic Longlining, Groundfishing, Tuna fishing, Charters"
- "Regulations"
- "Worked in commercial fishing (not lobstering, groundfishing, or shellfishing); also worked in seafood processing and distribution, seafood research, and marine-oriented non-profit"

Figure 18. Respondents who were/ were not involved in the seafood industry before starting in aquaculture (n = 71; MoE = 9.9%)

"Did you work in the seafood industry before you started working in aquaculture?"

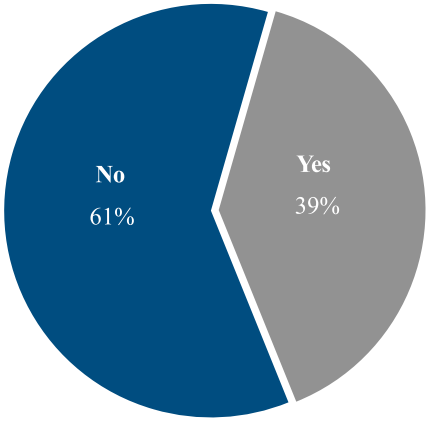
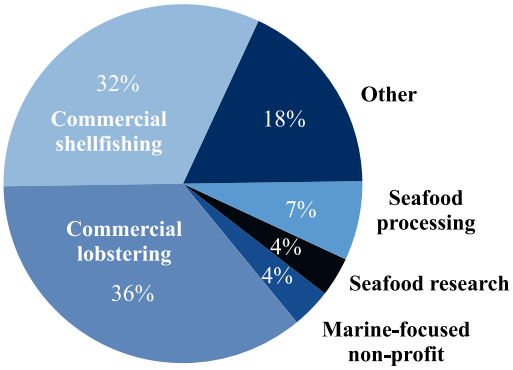


Figure 19. Seafood-industry sectors in which respondents were involved before starting in aquaculture, of those who were involved in a sector before starting aquaculture (n = 28, MoE = 17.5%)

"In what part of the seafood industry did you primarily work before you started working in aquaculture? (Please select only one response.)"

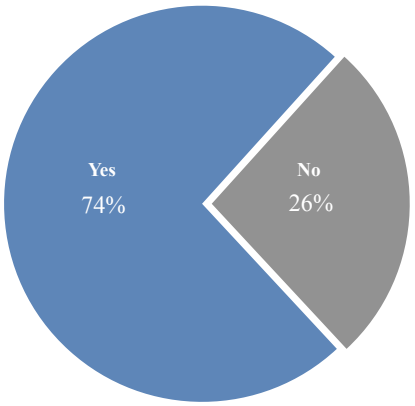


Seventy-four percent (74%) of respondents had participated in a formal aquaculture training program (Figure 20). Of the 26% who had not, 53% were not interested in participating in the future, 42% indicated "I don't know," and 5% were not interested in participating in the future (Figure 21).

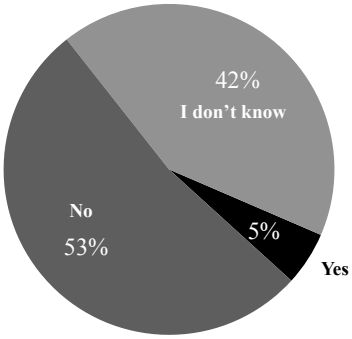
Figure 20. Respondents who participated in a formal aquaculture training program n = 71; MoE = 9.8%)

Figure 21. Respondents' interest in participating in a future formal aquaculture training program, of those who had not already participated (n = 19, MoE = 21.7%)

"Have you participated in a formal aquaculture training program?"



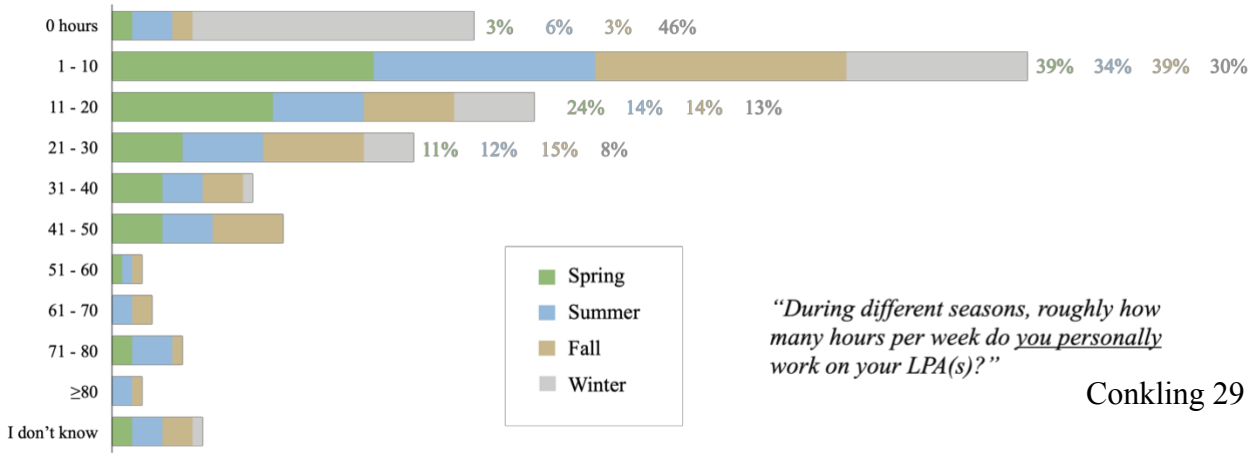
"Do you want to participate in a formal aquaculture training program?"



Labor and Costs

Three percent (3%), 6%, and 3% of respondents indicated they usually did not spend any time on their LPA(s) in spring, summer, and fall, although 46% of respondents reported that they did not spend any time on their LPA(s) in winter (Figure 22). A plurality of respondents reported that they worked an average of 1-10 hours weekly on their LPA(s) in spring, summer, and fall (39%, 34%, and 39%, respectively), but only 30% worked 1-10 average weekly hours in winter (Figure 22). 24%, 14%, 14%, and 13% of respondents indicated working averagely 11-20 hours in spring, summer, fall, and winter, respectively (Figure 22). 11%, 12%, 15%, and 8% of respondents worked 21-30 average weekly hours in each season, respectively (Figure 23). 3% of respondents reported that they did not know how many weekly hours they averagely spent on their LPA(s) in spring; 5% reported the same for the summer and fall, and 2% for the winter (Figure 22). Respondents worked significantly fewer than 40 hours per week on their LPA(s) through the year; further percentage analysis of respondents' answers to this survey question was not necessary.

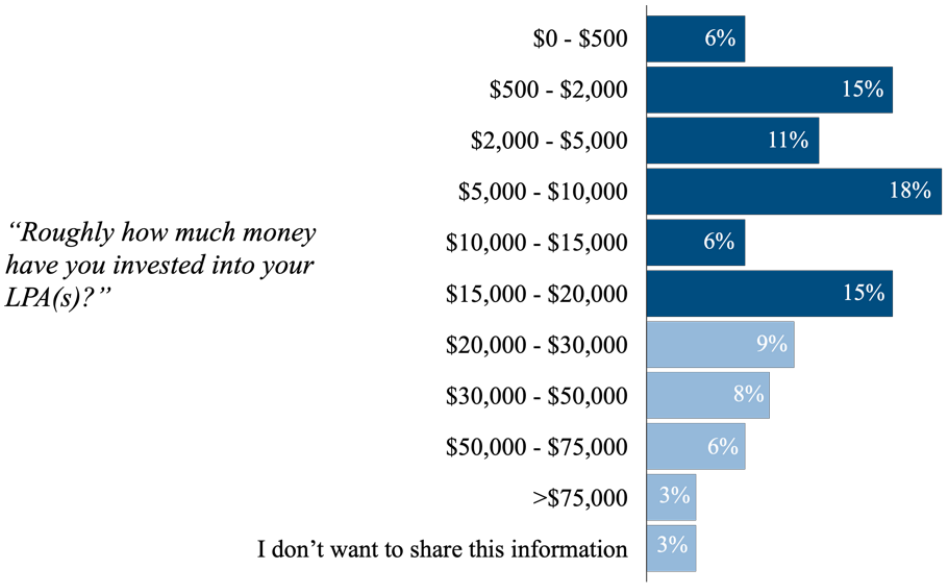
Figure 22. Respondents' average seasonal weekly hours spent working on their LPA(s) (For "Spring" n = 66; MoE = 10.3%) (For "Summer," n = 64; MoE = 10.6%) (For "Fall," n = 65; MoE = 10.5%) (For "Winter," n = 61; MoE = 10.9)



"During different seasons, roughly how many hours per week do you personally work on your LPA(s)?"

The survey furnished that 6% of respondents had invested $500 or less into their LPA(s) (Figure 23). 15% of respondents had invested between $500-$2,000, 11% between $2,000-$5,0000, 18% between $5,000 and $10,000, 6% between $10,000-$15,000, 9% between $20,000-$30,000, 6% between $50,000 and $75,000, and 3% over $75,000 (Figure 23).

Figure 23: Respondents' total dollar investment into their LPA(s) (n = 66; MoE = 10.3%)



Maine DMR rules allow LPA-holders a maximum of three unlicensed assistants, although there is no DMR limit on assistants from an education institution (Limited purpose aquaculture license [LPA] application, 2021). 10% of respondents indicated they only had had licensed assistants during the most recent year of work; 16% of respondents reported having had no assistants in the most recent year (Figure 24). For unlicensed assistants, 24% of respondents reported having had 1 assistant, 26% having had 2 assistants, and 14% having had 3 assistants; 10% of respondents reported having had more than three unlicensed assistants (Figure 24). Of those respondents with assistants, 52% indicated that it was "neither difficult nor easy" to find assistants; 29% that it was "very difficult" or "somewhat difficult;" and 19% that it was "very easy" or "somewhat easy" to do so (Figure 25). Of the respondents with at least one assistant in the most recent year of work, 14% reported that their assistant(s) were from an education institution (Figure 26).

Figure 24. Number of assistants respondents' LPA(s) most recent year of work (n = 70; MoE = 9.9%)

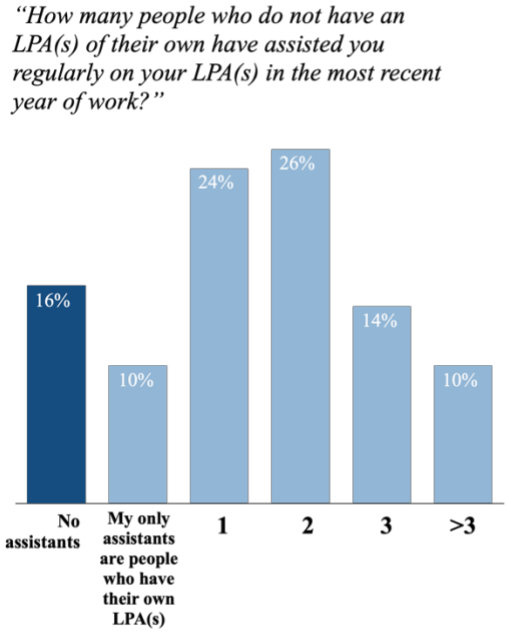


Figure 25. Respondents' difficulty finding regular assistants (n = 52, MoE = 12.1%)

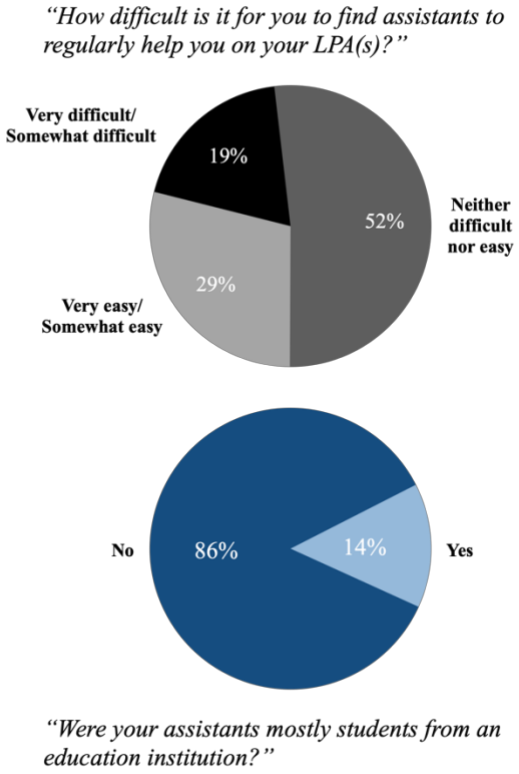


Figure 26: Whether respondents' regularly on assistants were mostly from an in the in in the education institution (n = 7; MoE = 36.6%)

Reasons for having an LPA(s)

Respondents were asked two questions concerning their choice to have an LPA(s): "What are the main reasons that you have your LPA(s)?" and "Why did you choose an LPA(s) for your farm?" For both questions, respondents could select one or two response options. For the former question, 33% of respondents reported that one of the two primary uses for their LPA(s) was secondary income; 16% reported that one of these uses was primary income (Figure 27). 17% of respondents indicated that food was a primary use of their LPA(s), 16% recreation, 8% scientific research, 6% for municipal shellfish purposes, and 1% for education purposes (Figure 27). 3% of respondents selected "Other" for this question, with 5 of these respondents elaborating:

- "In lieu of a retirement plan"
- "Experimental sites for my farm"
- "Educate local fishermen as to the merit of growing seaweed to create an alternative revenue source and diversify their fishing efforts"
- "Improve water quality"
- "Belief in oysters as a sustainable food source that also cleans the water"
- "Community effort to diversify our marine economy"

For the latter question, 28% of respondents indicated that they chose an LPA(s) for their farm because was "the easiest lease for them to obtain (Figure 28). 21% answered that they chose LPAs because they are "the right size for what I want to farm," 14% indicated that they chose an LPA(s) for a temporary grow-out operation, 8% to experiment with new species, 5% for scientific research, and 4% for a floating upwelling system ("FLUPSY")[17] (Figure 28). 3% of respondents chose an LPA(s) for education purposes, as well as 3% for municipal shellfish purposes (Figure 28). 1% of respondents indicated "Other" purposes (Figure 28), with five of this group elaborating:

- "I chose sugar kelp because it was important to my culture"
- "Relay site from grow-out"
- "Cannot yet afford a Standard Lease, and wanted to test these locations first"
- "I need seed sites and purge sites in the river in which my Standard Lease is in"
- "Nursery and additional space"

Figure 27. Respondents' primary two uses for their LPA(s) (n = 70; MoE = 9.9%)

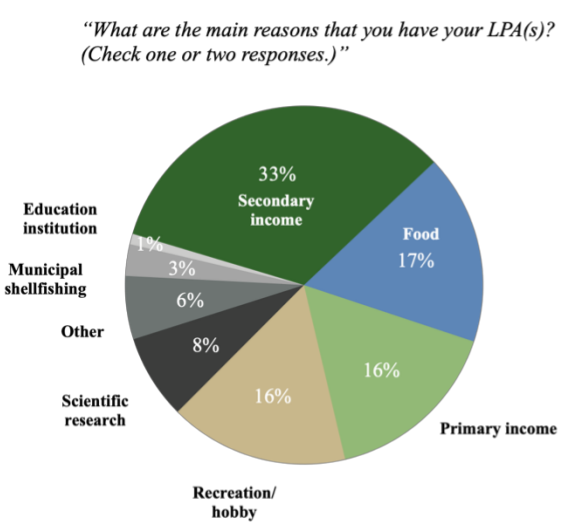
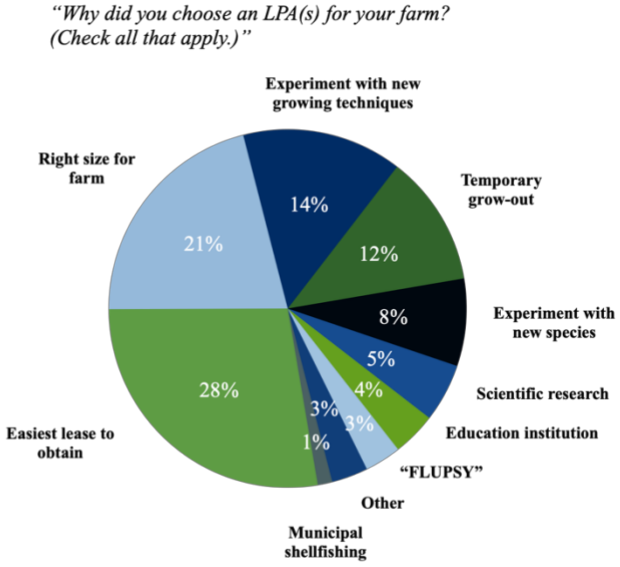


Figure 28. Respondents' primary two reasons for choosing LPA licenses versus other aquaculture lease types (n = 70; MoE = 9.9%)



Food security

Respondents who indicated that producing food is one of their primary reasons for having their LPA(s) were subsequently asked two questions related to food security and their LPA(s): "Do you rely on the food product(s) from your LPA(s) for you or your family to eat?" and "Would you be worried about how to get food if you suddenly could not eat the product(s) from your LPA(s)?" For the former question, 80% of respondents reported that they did not rely on their LPA product(s) for food (Figure 29). Of the 20% who reported that they did, 23% responded that they would be worried about how to get food if suddenly they could not from their LPA(s) (Figure 30).

[17] A floating upweller system ("FLUPSY") is an apparatus that protects juvenile shellfish growing in open water (Skelton et al., 2021).

Figure 29. Respondents' reliance on their LPA product(s) for food (n = 66; MoE = 10.3%)

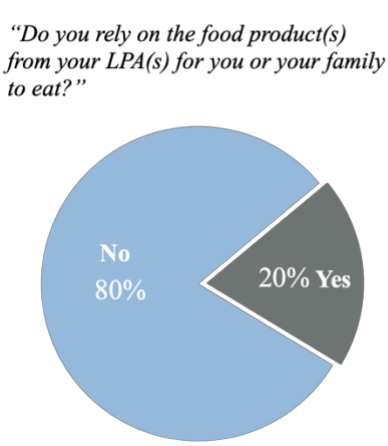
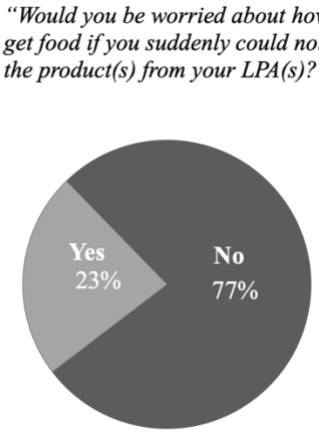


Figure 30. Expressing respondents' food security related to their LPA, of those who responded that they relied on the products of their LPA(s) for food (n = 13; MoE = 26.5%)



Scaling

Fifty-eight percent (58%) of respondents reported that were interested in expanding the size of their farm now or in the future (Figure 31). Of these, 59% reported that they wanted to expand with one or more Standard Leases, 24% with one or more Experimental Lease, 15% with one or more LPA(s), and 2% with one or more non-leased aquaculture sites (Figure 32). Also of these 58% of respondents, 85% indicated that working on their LPA(s) had given them enough information about whether to expand their farm; 5% indicated that their LPA experience had not given them enough information to this end, and 11% responded that they did not know if their experience had given them enough information (Figure 33).

Figure 31. Respondents' desire to scale up their farm (n = 66; MoE = 10.3%)

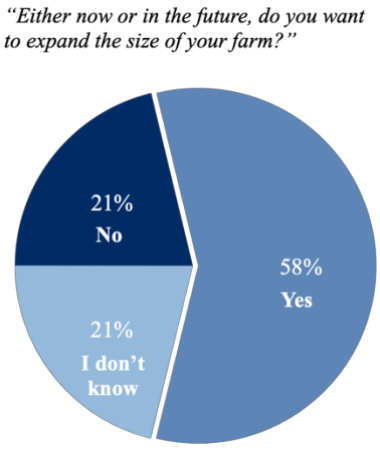


Figure 32. Respondents' desired method of scaling their farms, of those who indicated they desired to do so (n = 38 MoE = 14.7%)

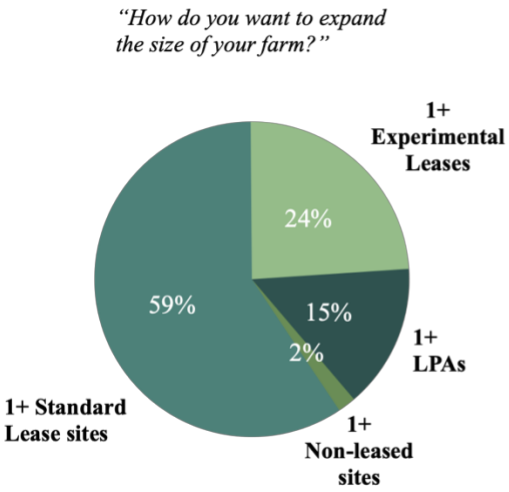
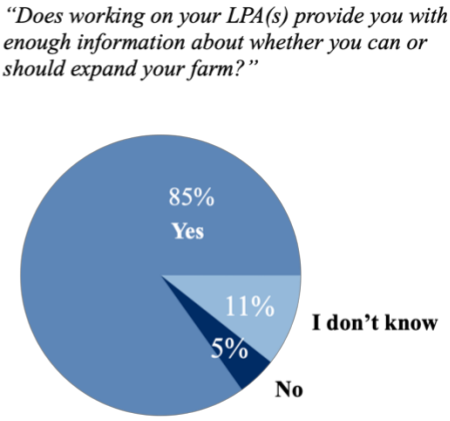


Figure 33. Respondents who felt they can make an informed decision about scaling up their farm, of those who indicated they desired to do so (n = 66; MoE = 10.3%)



Commercialization

Sixty-seven percent (67%) of respondents indicated that they sold product(s) from their LPA(s) (Figure 34). Of the 32% of respondents who indicated that they did not sell their LPA products, 32% reported that they want to sell them, and 23% reported that they did not know (Figure 35).

Figure 34: Respondents' current market orientation (n = 66; MoE = 10.3%)

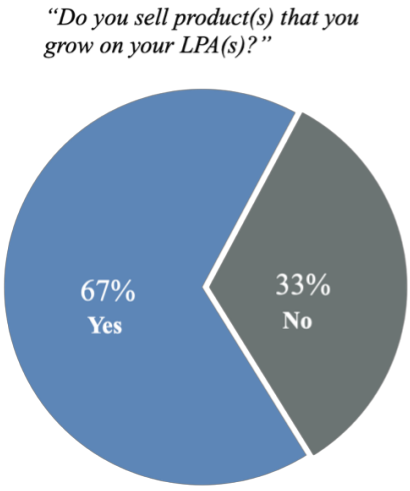
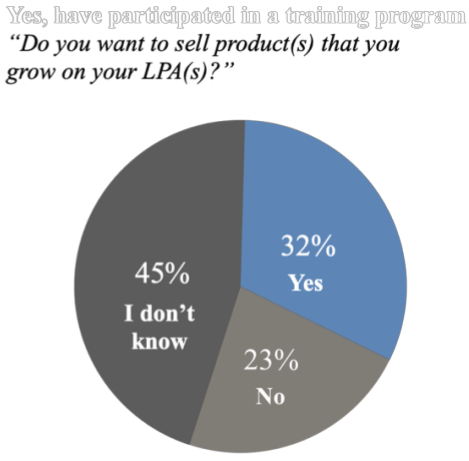


Figure 35: Respondents' intended orientation, of those who indicated they did not sell their LPA products (n = 22; MoE = 19.9%)

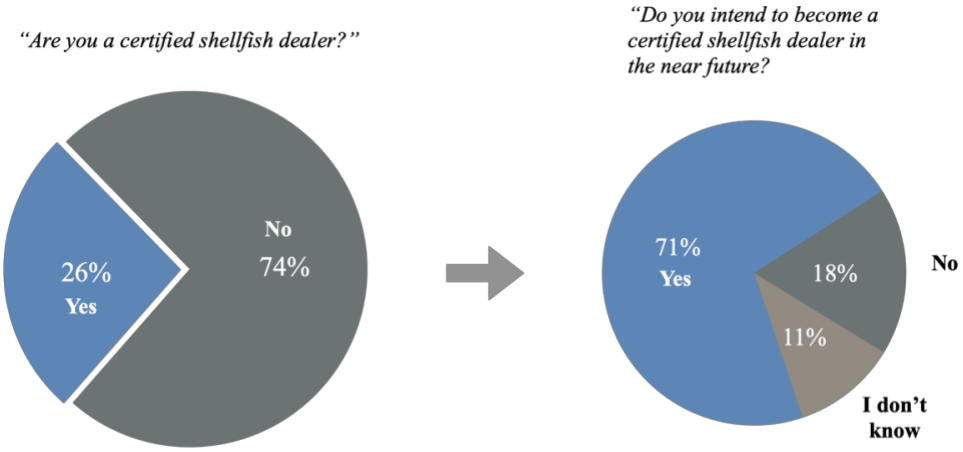


Seventy-four percent (74%) of respondents answered that they were certified shellfish dealers (Figure 36). Of the 26% of these respondents who answered that they were not certified shellfish

dealers, 71% indicated that they intended to become certified in the near future and 11% did not know whether they intended to do so (Figure 37).

Figure 36: Respondents who are certified shellfish dealers (n = 64 (MoE = 10.6%)

Figure 37: Respondents' intentions to soon become certified shellfish dealers, of those who responded they were not certified shellfish dealers (n = 45; MoE =13.3%)

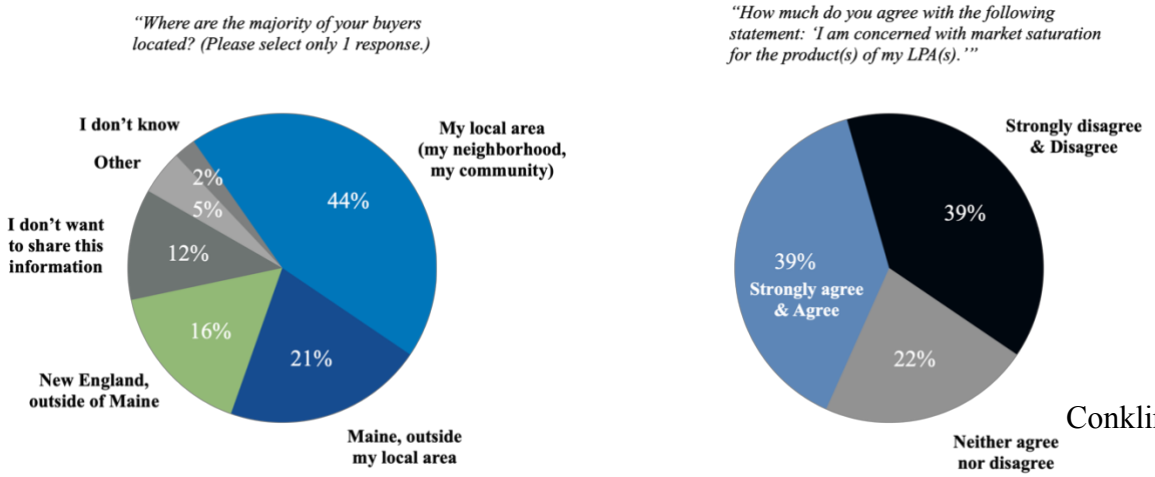


Of those who previously indicated that they sold their LPA product(s), 44% of respondents reported that the majority of their buyers were from their local area, whereas 21% answered that they largely sell to buyers who were outside their local area but still in Maine (Figure 38). 16% of respondents' majority buyers were reportedly outside Maine but still in New England, and 5% reported they had majority buyers from "Other" locations (Figure 38).

Thirty-nine percent (39%) of respondents expressed that they "strongly agree" or "agree" with the statement: "I am concerned with the market saturation for the product(s) of my LPA(s)" (Figure 39). 39% of respondents also answered that they "strongly disagree" or "disagree," and 22% indicated that they "neither agree nor disagree" with the statement (Figure 39).

Figure 38: Location of the majority of buyers of market-oriented respondents' products (n = 43; MoE = 13.6%)

Figure 39: Degree of market-oriented respondents' concern with the market saturation of their LPA products (n = 55; MoE = 11.7%)



Nineteen percent (19%) of respondents reported $0-$500 in average yearly sales before the COVID-19 pandemic (Figure 40). 10% of respondents reported pre-COVID-19 average yearly sales between $500-$2,000; the same percentage of respondents reported $2,000-$5,000 sales (Figure 40). 10% of respondents also indicated average pre-COVID sales of $10,000-$20,000 (Figure 41). 5% of respondents each reported average yearly sales within the $5,000-$10,000 and $15,000-$20,000 brackets (Figure 41); 5% within the $20,000-$30,000 bracket and 2% within the $30,000-$50,000 bracket (Figure 42); and 2% and 5% within the $50,000-$75,000 bracket and over $75,000 bracket, respectively (Figure 43).

For their rough yearly sales during the pandemic (which required projections because the pandemic was still affecting respondents), 12% of respondents indicated $0-$500, 16% reported $500-$2,000, and 12% indicated $2,000-$5,000 (Figure 40). 5% of respondents indicated $5,000-$10,000, 5% indicated $10,000-$15,000, and 10% indicated $15,000-$20,000 for their projected sales (Figure 41). 5% of respondents each reported projected yearly sales for the $20,000-$30,000, $30,000-$50,000 (Figure 42), and $50,000-$75,000 brackets (Figure 43). No respondent indicated projected sales of over $75,000 for during the pandemic.

Figure 40: Annual sales averages of LPA farms earning $0-$5,000 (for pre-Covid figures, n = 42; MoE = 13.8%. For during COVID figures, n = 43; MoE = 13.6%)

Figure 41: Annual sales averages of LPA farms earning $5,000-$20,000 (for pre-Covid figures, n = 42; MoE = 13.8%. For during COVID figures, n = 43: MoE = 13.6%)

"Roughly how much were the yearly sales of the product(s) from your LPA(s), before the COVID-19 pandemic?"

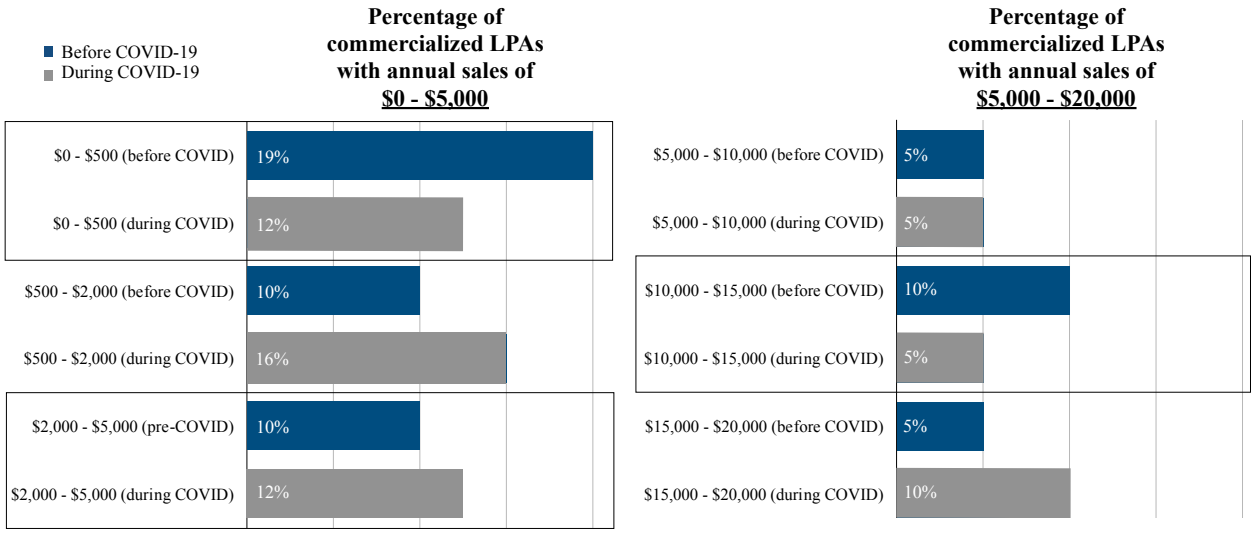
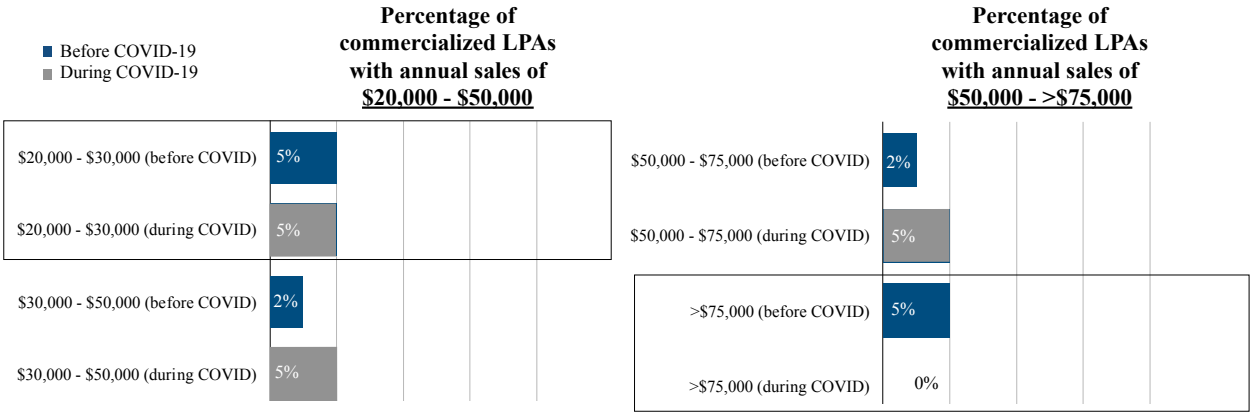


Figure 42: Annual sales averages of LPA farms earning $20,000-$50,000 (for pre-Covid figures, n = 42; MoE = 13.8%. For during COVID figures, n = 43, MoE = 13.6%)

Figure 43: Annual sales averages of LPA farms earning $50,000->$75,000 (for pre-Covid figures, n = 42; MoE = 13.8%. For during COVID figures, n = 43, MoE = 13.6%)

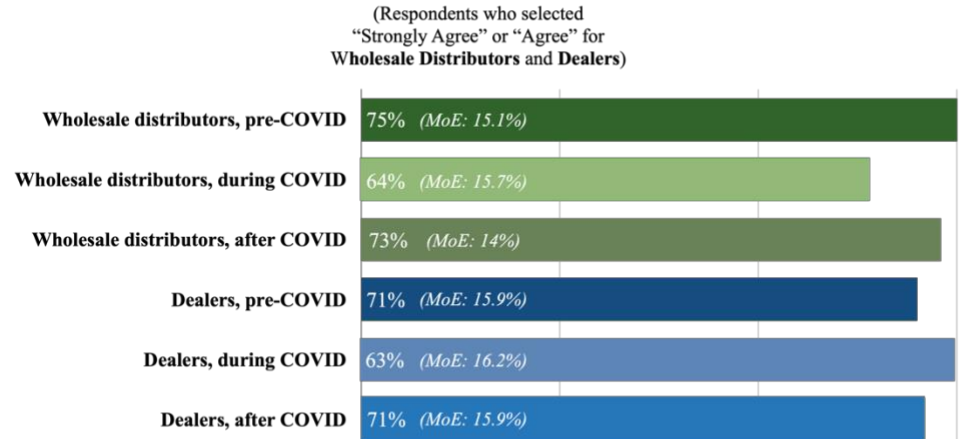
"Roughly how much are the yearly sales of the product(s) from your LPA(s) now, during the COVID-19 pandemic?"



Seventy-five percent (75%) of respondents answered that wholesale distributors most influenced their marketing strategies and decisions before the COVID-19 pandemic (Figure 44). This figure dropped to 64% for those during the pandemic, although 73% projected that this type of buyer would be most influential after the pandemic (Figure 44). 71% of respondents indicated that dealers had the most influence over their marketing before the pandemic; during the pandemic, 63%, and 71% of respondents projected that this buyer type would be most influential (Figure 44).

Figure 44: Influence of wholesale distributors and dealers on LPA-holders' marketing before, during, and (projected) after the COVID-19 pandemic

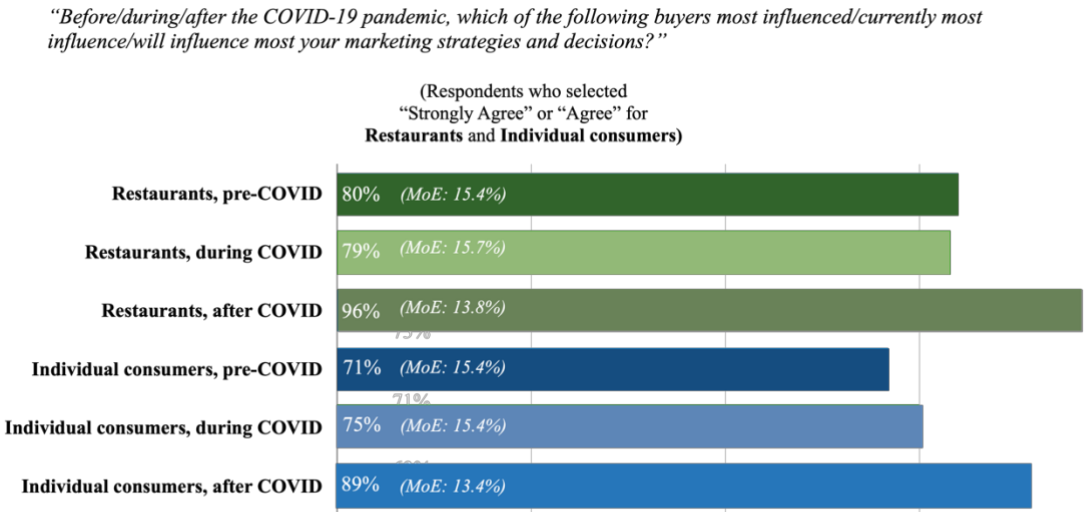
"Before/during/after the COVID-19 pandemic, which of the following buyers most influenced/currently most influence/will influence most your marketing strategies and decisions?"



75% of respondents answered that restaurants most influenced their marketing strategies and decisions before the COVID-19 pandemic (Figure 45). This figure dropped to 64% for those

during the pandemic, although 73% projected that this type of buyer would be most influential after the pandemic (Figure 45). 71% of respondents indicated that dealers had the most influence over their marketing before the pandemic; during the pandemic, it was 63%, and 71% projected that this buyer type would be most influential (Figure 45).

Figure 45: Influence of restaurants distributors and consumers on LPA-holders' marketing before, during, and (projected) after the COVID-19 pandemic



4.2 Focus Group Data Results

Tables 2-8 highlight the themes of focus-group participants' statements, with added indicators for definition of the themes in this study's conceptual framework (Figure 10). See Appendix 6 for tables for all of the participants' statements that were coded according to this scheme.

Table 2. Highlights from participants' statements coded as relating to "Commercialization" indicators

Theme	Indicator	Highlight
Commercialization	Commercialization and/or scaling experimentation (8 participant statements)	"Once I figured out the ins-and-outs and kind of go, 'okay, this is how it has to happen from year to year,' and then becomes a question of, right, do you get bigger and actually turn into an income stream or do you – do I – move on?
	Access to various markets (7 participant statements)	"…When you have product and it's time to get markets going – that is a little bit of a challenge. That was the thing that probably took the most new energy from me was to set that stuff up."
	Business planning (6 participant statements)	"I have nothing in writing [for a business plan] because I would end up having to throw it out the window and rewrite it every couple of months."
	Business skills (5 participant statements)	"Sales is a skill and not everybody has it. Not everyone has a knack for it. But if you're actually going to try and have an LPA or have an aquaculture business and sell stuff, it's a necessary evil."

	Shellfish-dealer certification (2 participant statements)	"You're not really supposed to go sell directly to restaurants that don't have that license and many restaurants do not. So, I actually went to the additional step of getting my wholesale dealer certificate so that I could essentially become my own middleman and that, that created way more opportunities for me to sell to whoever I needed to."
	Equipment for processing and preserving LPA products (2 participant statements)	"You need…a three-way sink and a cooler and you have to have temperature logs and it's fairly onerous as far as what you're required to have."

Table 3. Highlights from participants' statements coded as relating to "Economic Resources" indicators that are not related to commercialization per se

Theme	Indicator	Highlight
Economic Resources (not related to commercialization per se)	Personal financial resources (10 participant statements)	"That's also why I have the LPA, to see if it works here, and parts of it didn't work, so it's, it's a learning process. There's the wild harvest and…I have two other sources of income."
	Farm experimentation (7 participant statements)	"It's a really innovative, great way to kind of allow people to dabble in aquaculture."
	Business planning (5 participant statements)	"I have nothing in writing [for a business plan] because I would end up having to throw it out the window and rewrite it every couple of months."
	Business skills (5 participant statements)	"Sales is a skill and not everybody has it. Not everyone has a knack for it. But if you're actually going to try and have an LPA or have an aquaculture business and sell stuff, it's a necessary evil."
	Accessibility of seed/spores (3 participant statements)	"The seed is so hard to get."
		"Who's providing my seed? Are they providing the seed and I have to figure out what to do with it, or I get to figure out what to do with it? Or are they providing seed on a contract basis where they get first right-of-refusal on what comes off those lines?"
		"We had to have a meeting with somebody at Atlantic Sea Farms to set up the whole process of getting the seed and then having a market for the product so, so, that's a whole different thing than, say, shellfish."

Table 4. Highlights from participants' statements coded as relating to "Knowledge and Skills"

Theme	Indicator	Highlight
Knowledge and Skills	Operator knowledge and skills (11 participant statements)	"The whole business of rigging is kind of something that seems natural to you if you grew up doing it, but probably isn't if you didn't. You know, if you were a fisherman or something like that to start with, it probably helps a lot."

	Support from other ocean farmers and aquaculture organizations (5 participant statements)	"The continuing culture of aquaculture supports the incoming generation in the way that I've been supported and mentored."
	Skilled and knowledgeable assistants/partners (1 participant statement)	"Can I do it just with my four [LPAs]? Do I need my four plus a partner and their four?"

Table 5. Highlights from participants' statements coded as relating to "Social License to Operate" indicators

Theme	Indicator	Highlight
Social License to Operate	Relationships with riparian landowners (11 participant statements)	"Everybody thinks that aquaculture is great—growing kelp, growing oysters–'yay, save the planet, we're going to be great'–but then they don't want to see it in their front yard."
	Relationships with local traditional-use fishers (1 participant statement)	"I've gotten a fair amount of help from the working-water community. Folks who've looked at what I did, like when I was having rigging trouble, and was like, 'well, you should try this, it'll probably work better,' things like that. Guys who have helped me in with my motor died, you know, things like that. Folks have been around, who understand being on the water and that it is a marine business like lobster – and even if it's not lobstering – have been willing to lend a hand and advice."

Table 6. Highlights from participants' statements coded as relating to "Legal License to Operate"

Theme	Indicator	Highlight
Legal License to Operate	Approval of the Maine DMR (7 participant statements)	"The DMR, when I applied during COVID, was slow, but I found it effective."
	Regulations of the Maine DMR: Density limit (4 participant statements)	"I can't start out small further out because the density limit is exceeded by folks taking out as much as they can. And I can't go further in because there's…I'm just stuck."
	Regulations of the Maine DMR (1 participant statement)	"The regulations seem to change. Frequently, and, you know, stay on top of that."

Table 7. Highlights from participants' statements coded as relating to "Natural Resources"

Theme	Indicator	Highlight
Natural Resources	Farm space suitable for cultivation (5 participant statements)	"I don't know whether it's going to be a great location unless I test it."
	Availability of appropriate seed/spores (1 participant statements)	"We've got a couple of great hatcheries here in Maine, so [getting my oyster seed] wasn't an issue."

Table 8. Highlights from participants' statements coded as relating to "Physical Resources" indicators

Theme	Indicator	Highlight
Physical Resources	Boats	"My wife likes to joke that I have a kelp farm to justify my ownership of a boat."

	(1 participant statement)	
	Farm gear (1 participant statement)	"I was even able to…borrow some stuff or get some hand-me-down stuff from people I knew, so that wasn't so much of a challenge."
	Cars/trucks (1 participant statement)	"Transport [of my harvested products once on land] is a challenge on my end…I've got to get stuff in, load it, and then drive three-and-a-half hours to Portland where I can sell it."

5. DISCUSSION

This study aimed to assess the recruitment in Maine marine aquaculture through the experience of LPA-holders, with special focuses on LPA-holder demography, food security, and commercialization. These goals are now returned to with insights from the data collected, in combination with relevant information from existing literature, to bolster the framework shown in Section 3.5.2.

Farm and farmers characteristics

As a recruitment factor, oyster farming is the most successful path for small-scale aquaculture development in Maine. LPAs to grow oysters have attracted far more ocean farmers than LPAs for any other permitted organism. Many LPA-holders are permitted to harvest more than one organism, but oysters dominate actual harvests. It appears that very few holders actually grow clams, and fewer still actually grow mussels.

LPAs have enabled a wide age range of ocean farmers who are largely decades-long Maine residents, most of whom come with prior experience in the seafood industry, predominantly in lobster fishing. Aquaculture training programs targeting traditional fishers interested in diversifying their maritime work, as the state's two most prominent aquaculture training programs have, have demonstrably expanded Maine's aquaculture industry, although remaining interest in formal training among survey participants was low. Indeed, with many LPA-holders working 10-30 hours per week on their farms, an LPA's part-time commitment and modest economic returns are disincentives for lobster fishers and their current/prospective crews to enter small-scale LTL marine aquaculture while the price for lobster is high (>$10.50/lb in December 2021) (Whittle, 2021).

While LPA-holders sustain their farms with small or large amounts of money, they tend to obtain and maintain multiple LPAs simultaneously, and most did not appear to be accessing larger aquaculture leases because of the economic costs and/or administrative requirements involved. Marine knowledge and skills obtained prior to their aquaculture experience provide significant boosts to LPA farm development, perhaps because physical capital costs for operating LPAs may be diminished by obtaining LPAs in intertidal areas that do not require boat access, and the transfer of physical capital (boats, gear, etc.) by former/diversifying fishers, may make such investment figures appear lower than if holders needed to newly purchase these components.

Data indicate that the process for applying for an LPA is not overly restrictive, although focus-group participants expressed a strong worry that the Maine DMR does not have the capacity to timely process license and Lease applications, and thus have low expectations for any growth of their farm beyond the LPA level.

Social license to operate

Focus-group participants in this study emphasized that complaints from the riparian neighbors of their LPA sites were the most significant obstacle to their farms' development in general and the growth of their farms in particular, despite that the LPA approval process does not strongly enfranchise such complaints. Absent increased labor and/or innovation with administrative capacity at Maine DMR, NIMBY as a "social-ecological constraint" to aquaculture (Costa-Pierce and Chopin, 2021) will likely remain as the most prominent obstacle to small-scale LTL commercial aquaculture development in Maine.

Economic resources and food security

Commercial activity (i.e., use for primary and secondary income sources) comprises half or more of LPA activity, although most LPA-holders were not expecting their farms to generate their primary income. Two-thirds of holders surveyed were selling their LPA products, and well over three-fourths of them understood that a shellfish-dealer certification was an important commercial checkpoint. (Clandestinely accessing the restaurant market without a shellfish-dealer certification is possible, but this certification along with additional business skills and equipment are likely unavoidable to access larger markets.) Evidently, in order to commercialize, LPA-holders must invest significant amounts of their personal finances into developing their farm, and likely even more so into developing additional business skills in order to access various markets.

Many LPA-holders ate their LPA products, but only a small proportion (under 5%) of them were using their LPAs to address urgent food-security needs.

Commercialization and scaling

Most LPA-holders wanted to expand their farms, largely in order to continue commercialization. Nearly two-thirds (65%) of commercial LPA-holders projected that their sales will be primarily to customers in Maine, and 91% and 89% of holders projected that these customers would be individual consumers or restaurants, respectively (as opposed to dealers and wholesale distributors), although these in-state markets likely yield less than $20,000 in yearly sales to individual LPA sellers. Even with shifting ecological and regulatory conditions that deter many from the business planning that is necessary for sustainable economic expansion (Mackenzie, 2017), most holders felt that their experiences in the LPA system gave them a significant level of informed decision-making about scaling up.

6. CONCLUSIONS and RECOMMENDATIONS

Is the LPA system working as it was designed, namely, to attract small-scale entrants into Maine's regulated mariculture system in ways that do not promote conflicts with growers' existing-use neighbors? This study indicates that this design is being significantly realized. Efforts to support LPA applicants and holders have created a boom of successful small-scale ocean farmers that appears to be spread relatively evenly throughout Maine's coastal counties. Commercialization is notably a primary vehicle for economic sustainability at the LPA level, which formal aquaculture training programs have especially supported since the mid-2010s; these programs likely have produced a high proportion of successful LPA-holders. Importantly, the LPA system has equipped LPA-holders to make informed decisions about whether to expand their operations. It may be theorized that the variable successes of the LPA system illustrate that Maine hosts the economic, administrative, and sociocultural institutions conceptualized by

Kaminski et al. (2020) to support successful small-scale aquaculture businesses in low-income areas.

Yet this study also elucidated nuanced aspects of the LPA system's successes. First, to the extent that the system incentivizes experimentation at the small scale as a temporary, transitional step toward Experimental and Standard Leases, 21% of LPA-holders of surveyed respondents did not want to increase the size of their farm. Maintaining four or fewer LPAs is evidently a viable choice for many of Maine's mariculture smallholders, yet the intention of the LPA statute was in part for experimentation, not necessarily viability, as the yearly renewal requirement for LPAs indicates.

Conversely, the fact of 23% of this study's respondents who regularly worked on more than the four legally permitted number of LPAs per individual represents a further research opportunity to determine the extent to which individual small-scale ocean farmers in Maine are misusing the LPA system. Anecdotal evidence suggests that some commercial Maine ocean farmers pool the products from LPAs in their names as well as LPAs on which they are listed as assistants (Jim Balano, personal communication, May 3, 2021; Adam St. Gelais, personal communication, November 16, 2021); such occurrences may account for this 23%. That only 6% of respondents regularly worked on non-leased aquaculture sites may indicate that illegal small-scale mariculture activity in Maine occurs well within the regulated environment—smallholders who sought to evade the rigors of the Experimental and/or Standard Lease processes were nevertheless largely pursuing aquaculture with LPAs and not through unregulated means.

Saliently, sustainable commercialization and sustainable scaling within the LPA system are evidently variable. The 1600 combined square feet of ocean area afforded an individual LPA-holder with the maximum of four LPAs (or more if the individual regularly works on more than this maximum) appears to be a viable farm size for only some commercial LPA-holders. Critically, commercial LPA activity is firmly situated in economically small farms: seasonal, non-full-time farmers who have invested less than $20,000 into their farms and largely access local, small-scale markets. The COVID-19 pandemic may indeed continue to shift LPA-holders' market attention even closer to local individual consumers and restaurants, as many mariculture stakeholders may count on, but the lack of structural economic support for farmers and the uncertain capacities of those markets for small-scale goods will likely continue to inhibit farmers' investments.

Although commercial LPA-holders surveyed in this study were optimistic about the capacities of their markets to continue to absorb their products, their abilities to efficiently contribute to Maine aquaculture development will presumably remain suppressed if larger-scale and out-of-state markets largely remain accessible only by Experimental and/or Standard lessees. Commercial LPA-holders appear pessimistic that the value-chain for selling their products outside Maine exists or is accessible to them. Fortunately for these LPA-holders, however, is the recent emergence of seafood buyers in Maine that explicitly purchase from LPA-holders highlights a particular market opportunity for the state's small-scale commercial ocean farmers. "There are companies in Maine that are working to aggregate product from small farms and distribute them out-of-state"; one such company explicitly purchases from more than 30 small-scale aquaculture farms (Hupper, personal communication, January 10, 2022). Further research may reveal the

extents to which these seafood aggregators' purchasing prioritization presents competitive pricing for profit-oriented LPA-holders.

Successful mariculture development in Maine likely relies in part on sustainably transferring a critical mass of commercial ocean farmers from the LPA level to the Experimental and/or Standard levels, and the steady rush for LPA licenses, as well as the barriers to accessing larger leases, appears to be pushing against some of Maine's SLO trends, government capacity, and economic readiness.

Unlike the LPA application, applications for Experimental and Standard Leases strongly recognize SLO concerns, and a significant portion of LPA-holders in this study worried about managing conflicts with their riparian neighbors and the conventional fishers with whom they share ocean space. Conflict-mitigation along these lines may or may not include the easing of SLO-based requirements for LPA-holders who want to expand their farms and who have shown themselves to be responsible stewards—lease-policy flexibility is a characteristic of successful mariculture regimes (Green, 2023)—but mariculture "diplomacy" that thoughtfully recognizes asymmetric power relations between riparian landowners and their ocean-farming neighbors is indubitably crucial for sustainable marine aquaculture development (Gerhardinger et al., 2020).

Relatedly, continued SLO-oriented efforts to affirm the shared interests between conventional fishers and ocean farmers for the simultaneous development of fisheries and mariculture is a likely route for reducing friction among these parties in Maine (Costa-Pierce and Chopin, 2021). This study did not identify clear indicators of which demographic group(s) will primarily drive the labor side of Maine's LTL marine aquaculture, but that 81% of this study's survey respondents reported that it was "very easy," "somewhat easy," or "neither difficult nor easy" to obtain assistants strongly suggests a workforce with a degree of mariculture competency and willingness broadly exists in Maine. At the same time, while this study highlighted degrees of solidarity with small-scale commercial ocean-farm competitors as well as with their conventional-fisher neighbors, the growing of different organisms for different purposes in different regions with different SLO dynamics complicates a vision of aquaculture production becoming as organized as some of Maine's prominent traditional fisheries such as lobstering.

While this study did not investigate the dynamics of ocean-farm license and lease applications for which the Maine DMR is responsible (e.g., how much labor and time are required of the agency to review these applications), results point to the importance of assessing whether the requirements of the department to process Experimental and Standard Lease applications stifle LPA-holders' scaling ambitions and therefore the resiliency of Maine's mariculture development. With so many skilled ocean farmers moving steadily into the LPA system, there is no consensus on whether mariculture-product markets are saturated, and a bottleneck of labor may be coalescing amid the current constraints to larger-scale leasing for LTL marine aquaculture in Maine.

Whether the overall system of Maine aquaculture permitting can sustainably transfer ocean farmers from the LPA level to the Experimental and/or Standard levels, with the value-chain expansions required therein, appears questionable. Is accessing Experimental and/or Standard Leases too onerous for Maine's small-scale commercial mariculturalists, or is accessing the LPA

system too easy? Is the LPA system attracting economically secure ocean farmers, or is it producing them?

For rural regions like Maine that are in developed countries, practical lessons from New Zealand's approach to aquaculture development of systematic consensus-building among government agencies, aquaculture organizations, researchers, community groups, and the public may be relevant (New Zealand Aquaculture Council, 2006). Developments in community-based marine aquaculture (CBA) through which marine ocean-farming stakeholders systematically explore the shared benefits of collaborative development may also be instructive (Wynberg and Hauk, 2014; Ateweberhan et al., 2018), and additional international lessons may come from Norway, whose "one-stop [leasing] process…appears to have allowed growth of aquaculture within a comprehensive regulatory framework." (Engle and Stone, 2013).

> "Developed countries such as Norway, Canada and New Zealand that export to the United States have comprehensive, well-developed sets of regulations. However, some have a more efficient permit process that allows for access to sites and increasing aquaculture production as compared to the United States. In these countries, regulations are just as stringent as in the United States, but the permitting process is more efficient and entails greater certainty and less risk for the producer……[T]he lack of such a streamlined approach in the United States appears to have contributed to the decline of existing industries and to serve as a deterrent to investment in newly emerging technologies" (ibid.).

7. IMPACT STATEMENT

This study conceptualized that commercialized marine LTL aquaculture is a sustainable recruitment strategy in Maine when certain factors align, and its results indicate that the LPA system contributes to the alignment of those factors: LPA-holders' knowledge and skills; sustainable access to natural, physical, and economic resources; engagement with SLO and LLO issues; and commercialization and scaling factors. However, while it appears likely Maine has developed a sustainable system for recruiting small-scale ocean farmers who contribute positively to many of the state's coastal communities, deeper research is required to precisely theorize a development plan for Maine's marine aquaculture system that streamlines the transitions to larger-scale operations for interested users. Indeed, the success of marine aquaculture in Maine may indeed be part be a function of its commercial scalability if governance structures continue to facilitate accessibility for rural, small-scale ocean farmers.

Maine's distinct sociopolitical and environmental characteristics, like those of any location, demand distinct development approaches. While the broad-strokes experiences of small-scale marine aquaculturists such as those studied by Kaminski et al. (2020) may overlap with those of Maine's small-scale commercial ocean farmers, LTL marine aquaculture in Maine remains a distinct theoretical space because it has:

- intentionally low barriers-to-entry for small-scale entrants, most of whom come from rural areas that are nonetheless wealthier than rural areas in the global South;
- governance models heavily influenced by its lobster fishery;
- pronounced SLO complexities; and
- complex scaffolding for sustainable scaling

Maine's unique social-ecological conditions and its singular LTL marine aquaculture leasing system position the state to join efforts around the world to "develop place-based, global centers of excellent in ocean foods ecosystems" (Costa-Pierce, 2016) and address global sustainable development goals. Recent workforce-development programs in Maine have propelled millions of dollars into the expansion of marine aquaculture facilities and the creation of a pool of diversely skilled aquaculture labor (MaineBiz, 2022; MaineBiz, 2021); Maine's aquaculture workforce "is poised to grow across all existing and nascent sub-sectors" (Gulf of Maine Research Institute, 2020). Yet attempts to welcome a greatly increased number of ocean farmers into the Experimental and Standard Lease systems will likely require similar or greater levels of attention to governance as those that have been applied to the LPA system, including expanded regulatory agency capacity, investment in larger-scale market development, and support for ocean farmers' balancing of SLO and LLO dynamics. Sustainable mariculture development in Maine likely requires "policy…built on an understanding of the socio-economic drivers, resources (human and natural), and the constraints of community members intended to be involved" (Slater et al., 2013) that simultaneously supports considerable aquaculture expansion and the growth of aquaculture value chains (Woltering et al., 2019).

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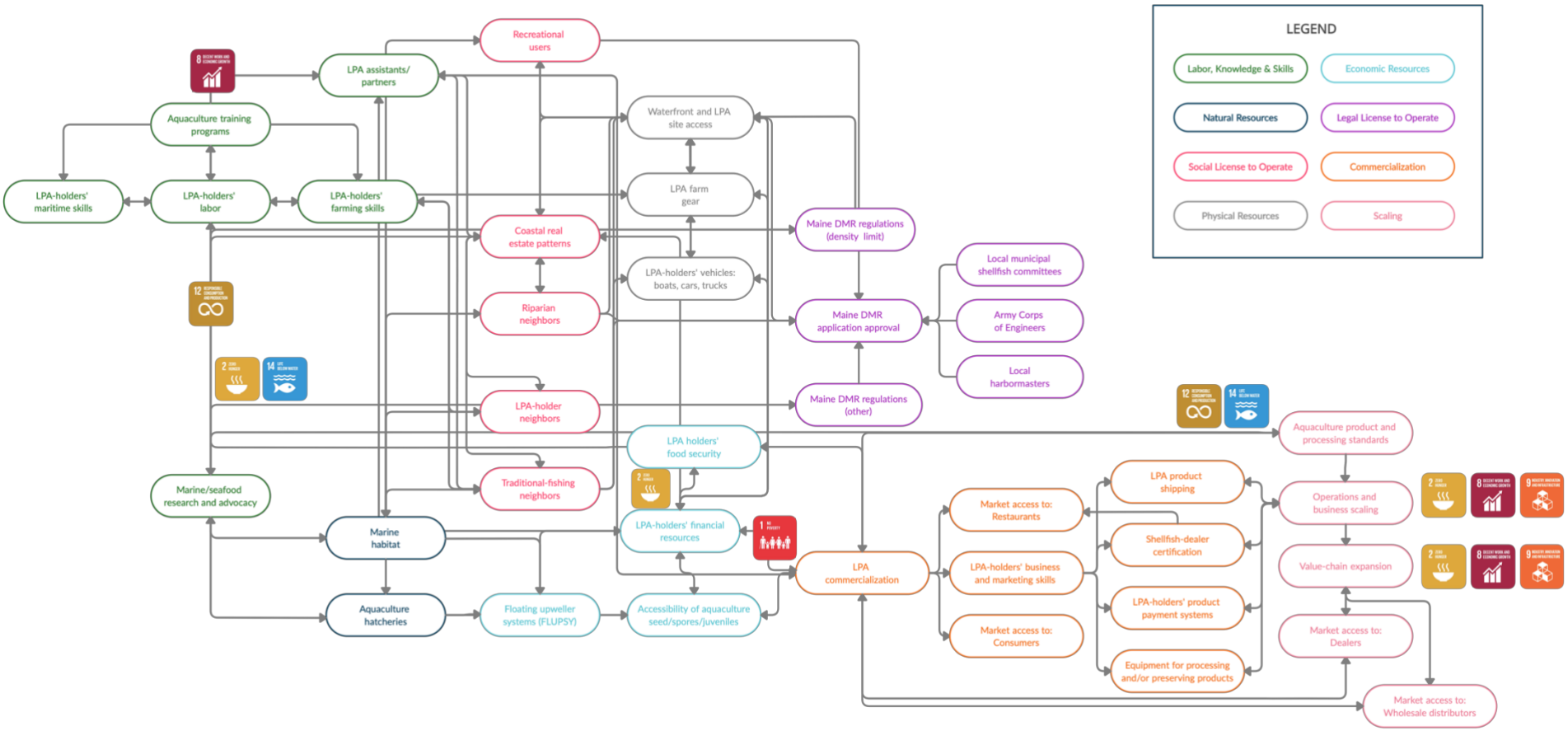
9. APPENDICES

Appendix 1. Conceptual map of the recruitment factors of small-scale LTL marine aquaculture in Maine using the LPA system



Appendix 2. United Nations Sustainable Development Goals summarized in Section 3.1.2 and used in this study's conceptual map the recruitment factors of small-scale LTL marine aquaculture in Maine through using the LPA system.

- Sustainable Development Goal #1.2: "By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions"
- Sustainable Development Goal #2.1: "By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round"
- Sustainable Development Goal #2.3: "By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment"
- Sustainable Development Goal #2.4: "By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality"
- Sustainable Development Goal #2.a: "Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries"
- Sustainable Development Goal #8.3: "Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services"
- Sustainable Development Goal #9.2: "Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries"
- Sustainable Development Goal #14.2: "By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans"

Appendix 3. Survey questions (layout format)

#	*REDCap variable name*	*Description*	*Phrasing*	*Response format*	*• Skip logic: PARENT to further CHILD questions • Inclusive of all respondents/Exclusive to only some respondents/Contingent*
0	consent	Consent	1) I affirm that I have read and understood this consent form and that I am 18 years old or older.	• Yes • No *Response required*	PARENT of: All questions • Inclusive
Sample population determination (2-3 questions, depending on skip logic)					
1	farm_location	Farm location	Where is your LPA(s) located? (Check all that apply.)	• Kittery to Cape Elizabeth • Casco Bay (Cape Elizabeth to Small Point) • Midcoast rivers, not including the Damariscotta River (Kennebec, Sheepscot, and Medomak Rivers) • Damariscotta River • Penobscot Bay, not including the Bagaduce River (Port Clyde to Stonington) • Bagaduce River • Hancock County (Stonington to Winter Harbor) • Washington County (Winter Harbor to Eastport) *Response required*	PARENT "Damariscotta River" of: 37, 38 • Inclusive
2	organisms_permitted	Organisms permitted	What are you licensed to grow on your LPA(s)? (Check all that apply.)	• Algae/seaweed • Clams • Mussels • Oysters • Scallops • Other *Response required*	PARENT "Other" of: 2a PARENT "Oysters" of: 22-25, 27, 30, 30a, 36, 37 • Inclusive

2a	organisms_permitted_other	Organisms permitted	If you selected "Other," please list the organism(s) that you are licensed to grow on your LPA(s).	(write in organism(s))	CHILD of: 2- Other • Contingent
General respondent information (7-11 questions)					
3	organisms_harvested	Organisms harvested	What do you harvest regularly on your LPA(s)? (Check all that apply.)	• Algae/seaweed • Cams • Mussels • Oysters • Scallops • Other	PARENT "Other" of: 3a, • Inclusive
3a	organisms_harvested_other	Organisms harvested	If you selected "Other," please list the organism(s).	(write in organism(s))	CHILD of: 3- Other • Contingent
4	respondent_age	Respondent age	What is your age?	• 18 - 21 years old • 22 - 34 years old • 35 - 44 years old • 44 - 54 years old • 55 - 65 years old • 66 - 75 years old • Older than 75 years old • I don't want to share this information	• Inclusive
5	years_in_maine	Years in Maine	For how long have you lived in Maine?	• Less than 1 year • 1 - 2 years • 2 - 3 years • 3 - 5 years • 5 - 10 years • 10 - 20 years • More than 20 years	• Inclusive
6	harvest_cycles	Harvest cycles	For how many years have you been farming on your LPA(s)?	• Less than 1 year • 1 - 2 years • 2 - 3 years	• Inclusive

				• 3 - 5 years • 5 - 10 years • 10 - 20 years • More than 20 years	
7	seafood_prior_experience	• Seafood industry prior experience • Knowledge and skills	Did you work in the seafood industry before you started working in aquaculture?	• Yes • No	PARENT "Yes" of: 7a, 7c • Inclusive
7a	seafood_prior_experience_detail	• Seafood industry prior experience • Knowledge and skills	In what part of the seafood industry did you primarily work before you started working in aquaculture? (Please select only one response.)	• Commercial lobstering • Commercial groundfishing • Commercial shellfishing • Seafood processing • Seafood distribution • Seafood retail • Seafood research • Marine-oriented non-profit • Other	CHILD of: 7- Yes PARENT "Other" of: 7b • Contingent
7b	seafood_prior_experience_detail_other	• Seafood industry prior experience • Knowledge and skills	If you selected "Other," please describe your work in the seafood industry.	(write in description)	CHILD of: 7a- Other • Contingent
8	aq_years_experience	• Aquaculture prior experience • Knowledge and skills	For how many years have you been working in aquaculture?	• Less than 1 year • 1 - 2 years • 2 - 3 years • 3 - 5 years • 5 - 10 years • More than 10 years	• Inclusive
9	aq_training	• Aquaculture training program • Knowledge and skills	Have you participated in a formal aquaculture training program?	• Yes • No	PARENT "No" of: 9a • Inclusive
9a	aq_training_interest	• Aquaculture training program, follow-up	Do you want to participate in a formal aquaculture training program?	• Yes • No • I don't know	CHILD of: 9- No • Contingent

		• Knowledge and skills			
		LPA-specific information *(6-10 questions, depending on skip logic)*			
10	reasons_for_aq	Reason for entering aquaculture with LPA	What are the main reasons that you have your LPA(s)? (Check 1 or 2 responses.)	• Food/nutrition for myself or my family • Primary income • Secondary income • Recreation/Hobby • Scientific research • Education • Municipal shellfish management • Other	PARENT of: 10a • Inclusive
10a	reasons_for_aq_other	Reason for entering aquaculture with LPA, follow-up	If you selected "Other," please describe the main reason that you have your LPA(s).	(write in description)	CHILD of: 10 • Contingent
11	reasons_for_lpa	Reasons for using LPA	Why did you choose an LPA(s) for your farm? (Check all that apply.)	• It was the easiest license/lease to get • It is the right size for what I want to farm • To experiment with new species • To experiment with new ways of growing products • For a floating upweller system • For temporary grow-out space until my larger lease is approved • It is appropriate for my scientific research • It is appropriate for my work in an education institution • It is appropriate for my municipal project • Other	PARENT "Other" of: 11a • Inclusive
11a	reasons_for_lpa_other	Reasons for using LPA, follow-up	If you selected "Other," please explain why you chose an LPA(s) for your farm..	(write in explanation)	CHILD of: 11- Other • Contingent
12	number_of_lpas_license	• Number of LPA licenses	How many LPAs are you licensed to operate?	• 1 LPA • 2 LPAs	• Inclusive

		• Legal license to operate		• 3 LPAs • 4 LPAs	
13	number_of_lpas_operate	• Number of LPAs operated • Legal license to operate	How many LPAs do you regularly work on?	• 1 LPA • 2 LPAs • 3 LPAs • 4 LPAs • More than 4 LPAs • I don't want to share this information	• Inclusive
14	other_sites	• Other sites • Legal license to operate	Do you regularly work on any additional aquaculture sites besides your own LPA(s)? (Check all that apply.)	• Yes, I work on 1 or more Experimental lease(s) • Yes, I work on 1 or more Standard lease(s) • Yes, I work on 1 or more unlicensed aquaculture site(s) • No, I only have an LPA(s) • I don't want to share this information	• Inclusive
15	number_of-assistants	• Number of assistants • Knowledge and skills	How many people who do not have an LPA(s) of their own assisted you regularly on your LPA(s) in the most recent year of work?	• I am the only person who regularly works on my LPA(s) • My only assistants are people who have their own LPA(s) • 1 assistant • 2 assistants • 3 assistants • More than 3 assistants • I don't want to share this information	PARENT "More than 3 assistants" of: 15a PARENT "1 person, 2 people, 3 people, More than 3 people" of: 16b • Inclusive
15a	number_of_assistants_students	• Student assistants • Knowledge and skills	Were your assistants mostly students from an education institution?	• Yes • No • I don't know • I don't want to share this information	CHILD of: 15- More than 3 assistants • Contingent
15b	assistant_recruitment	• Assistant recruitment difficulty • Knowledge and skills	How difficult is it for you to find people to regularly help you on your LPA(s)?	• Very difficult • Somewhat difficult • Neither difficult nor easy • Somewhat easy • Very easy	CHILD of: 15- 1 person, 2 people, 3 people, More than 3 people • Inclusive

16	weekly_seasonal_hours	• Weekly and seasonal hours- Individual	During different seasons, roughly how many hours per week do <u>you personally</u> work on your LPA(s)?	• Spring: 0, 1-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81+ hours • Summer: 0-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81+ hours • Fall: 0-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81+ hours • Winter: 0-10, 11-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81+ hours • I don't know	• Inclusive
Selling Products *(6-9 questions, depending on skip logic)*					
17	selling_or_not	• Selling or not • Commercialization	Do you sell product(s) that you grow on your LPA(s)?	• Yes • No	PARENT "No" of: 17a PARENT "Yes" of: 29-30a, 31- 35 • Inclusive
17a	selling_or_not_want	• Selling or not, want • Commercialization	Do you want to sell the product(s) from your LPA(s)?	• Yes • No • I don't know	CHILD of: 17- No PARENT "Yes" of: 33 • Contingent
18	rely	• Eat your farm products • Subsistence farming	Do you rely on the food product(s) from your LPA(s) for you or your family to eat?	• Yes • No • I don't want to share this information	PARENT of: 18 • Inclusive
18a	rely_worry	• Eat your farm products • Subsistence farming	Would you be worried about how to get food if you suddenly could not eat the products from your LPA(s)?	• Yes • No • I don't want to share this information	CHILD of: 18 • Contingent
19	desire_to_scale	• Desire to scale up • Commercialization	Either now or in the future, do you want to expand the size of your farm?	• Yes • No • I don't know • I don't want to share this information	PARENT "Yes" of: 19a, 19c PARENT "I don't know" of: 19c

					• Inclusive
19a	desire_scale_preference	• Desire to scale, scale preference • Commercialization	Do you want to expand your farm through any of the following? (Check all that apply.)	• Getting 1 or more additional LPAs(s) • Getting 1 or more Experimental aquaculture leases • Getting 1 or more Standard aquaculture leases • Getting 1 or more non-lease aquaculture sites • Other	CHILD of: 19- Yes PARENT "Other" of: 19b • Exclusive
19b	desire_scale_preference_other	• Desire to scale, scale preference, other • Commercialization	If you selected "Other," please explain how you want to expand your farm..	(write in explanation)	CHILD of: 19a- Other • Contingent
20	informed	• Desire to scale, informed decision • Commercialization	Does working on your LPA(s) provide you with enough information about whether you can or should expand your farm? In other words, can you make an informed decision about possibly expanding your farm based on your experience with your LPA(s)?	• Yes • No • I don't know	CHILD of: 19- "Yes" or "I don't know" • Inclusive
21	dollar_investment	• Total dollar investment • Commercialization	Roughly how much money have you invested into your LPA(s)?	• $0 - $500 • $501 - $2,000 • $2,000 - $5,000 • $5,000 - $10,000 • $10,000 - $15,000 • $15,000 - $20,000 • $20,000 - $30,000 • $30,000 - $50,000 • $50,000 - $75,000 • More than $75,000 • I don't know how much I have roughly invested in my LPA(s) • I don't want to share this information	• Inclusive
Markets					

(10 - 12 questions)					
26	shellfish_cert	• Shellfish dealer certification • Commercialization	Are you a certified shellfish dealer?	• Yes • No • I don't know	PARENT "No" of: 26a • Inclusive
26a	shellfish_cert_future	• Shellfish dealer certification, future • Commercialization	Do you intend to become a certified shellfish dealer in the near future?	• Yes • No • I don't know	CHILD of: 26 • Contingent
27	oysters_per_week	Oysters harvested per week	During different seasons, roughly how many oysters do you typically harvest per week?	Spring, Summer, Fall, Winter • 0 - 1,000 • 1,000 - 3,000 • 3,000 - 5,000 • More than 5,000	CHILD of: 3- Oysters • Exclusive
28	yearly_sales	• Yearly sales • Commercialization	Roughly how much were the yearly sales of the product(s) from your LPA(s), before the COVID-19 pandemic?	• $0 - $500 • $501 - $2,000 • $2,001 - $5,000 • $5,001 - $10,000 • $10,001 - $15,000 • $15,001 - $20,000 • $20,001 - $30,000 • $30,001 - $50,000 • $50,001 - $75,000 • More than $75,000 • I don't know roughly how much my yearly sales from my LPA(s) were • I don't want to share this information	CHILD of: 17- Yes • Exclusive
29	yearly_sales_covid	• Yearly sales • Commercialization	Roughly how much are your sales of the product(s) from your LPA(s) now, during the COVID-19 pandemic?	• $0 - $500 • $501 - $2,000 • $2,001 - $5,000 • $5,001 - $10,000 • $10,001 - $15,000 • $15,001 - $20,000 • $20,001 - $30,000 • $30,001 - $50,000	CHILD of: 17- Yes • Exclusive

				• $50,001 - $75,000 • More than $75,000 • I don't know roughly how much my sales from my LPA(s) are • I don't want to share this information	
30	marketability	Oyster marketability changes	How much do you agree with the following statement: "My oysters have changed in marketability in recent years."	Likert: 1 - 5 (Strongly Agree – Strongly Disagree, I don't know)	CHILD of: 2- Oysters and 17- Yes PARENT of: 30a • Exclusive
30a	marketability_factors	Oyster marketability changes, factors	What factor(s) do you attribute that change to?	(write in explanation)	CHILD of: 30 "Strongly Agree" or "Agree" • Contingent
31	buyers_before_covid	• Buyers before COVID • Commercialization	Before the COVID-19 pandemic, which of the following buyers most influenced your marketing strategies and decisions:	• Wholesale distributors • Dealers • Restaurants • Individual consumers • Other • I don't know • I don't want to share this information Likert: 1 - 5 (Strongly Agree – Strongly Disagree)	CHILD of: 17-Yes • Exclusive
32	buyers_during_covid	• Buyers during COVID • Commercialization	Now (during the COVID-19 pandemic), which of the following buyers currently influence your marketing strategies and decisions:	• Wholesale distributors • Dealers • Restaurants • Individual consumers • Other • I don't know • I don't want to share this information Likert: 1 - 5 (Strongly Agree – Strongly Disagree)	CHILD of: 17- Yes • Exclusive
33	buyers_after_covid	• Buyers after COVID • Commercialization	In the long-term (after the COVID-19 pandemic), which of the following	• Wholesale distributors • Dealers	CHILD of: 17- Yes, 17a- Yes

			buyers will most influence your marketing strategies and decisions:	• Restaurants • Individual consumers • Other • I don't know • I don't want to share this information Likert: 1 - 5 (Strongly Agree – Strongly Disagree)	• Exclusive
34	buyers_location	• Primary location of buyers • Commercialization	Where are the majority of your buyers located? (Please select only 1 response.)	The majority of my buyers are from... • My local area (your neighborhood, your community) • Maine, outside my local area • New England, outside of Maine • Other • I don't know • I don't want to share this information	CHILD of: 17 • Exclusive
35	market_saturation	• Market saturation • Commercialization	How much do you agree with the following statement: "I am concerned with market saturation for the product(s) of my LPA(s)."	Likert: 1 - 5 (Strongly Agree – Strongly Disagree)	• Inclusive
			Concluding Questions *2-3 questions*		
38	focus_group	Focus group recruitment	Would you be interested in joining a small focus group to hear from other LPA-holders about their aquaculture experiences?	• Yes • No	
38a	focus_group_contact	Focus group recruitment, contact information	Please write your name, contact information (phone number and/or email address), and the organisms that you harvest on your LPA(s) so that you may be contacted for a focus group. (Your participation and contact information will remain private, and any	(write in name and contact information)	(Personal identifier)

			personally identifying information that you share during the focus group process will be deleted.)		
39	comments	Comments	Is there anything that we or others should consider as aquaculture research continues?	(write in explanation)	

Appendix 4. IRB approval: Non-Human Research Designation

UNIVERSITY OF NEW ENGLAND

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: Micah Conkling

CC: Barry Costa-Pierce, Ph.D.

From: Brian Lynn, J.D.
Director of Research Integrity

Date: April 9, 2021

IRB Project # & Title: 0421-06; Small-scale aquaculture commercialization in Maine's limited-purpose aquaculture ("LPA") system

The Institutional Review Board (IRB) for the Protection of Human Subjects has reviewed the materials submitted in connection with the above captioned project, and after a *limited IRB Review* has determined that the proposed research 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.

Best of luck with your research, please contact me at (207) 602-2244 or irb@une.edu with any questions or concerns.

Sincerely,

Brian Lynn, J.D.
Director of Research Integrity

Appendix 5. Focus Group Questions

1. Why did you choose an LPA? What do you hope an LPA(s) will help you achieve?

2. Why did you choose an LPA(s) instead of an Experimental or Standard lease?

3. How frequently do you eat the product(s) from your LPA(s)? Do you rely on your LPA product(s) mainly for food or for income, or for both?

4. What skills are the most important to run your LPA(s), and did you have these skills before you started with your LPA?

5. What was your biggest challenge during the application process for your LPA permit(s)?

6. What were your biggest challenges when you started your business, such as finding start-up money or finding the right seed/spores?

7. What is your biggest challenge in the day-to-day operations of your LPA(s)?

8. What is your biggest challenge in selling your LPA product(s)? Do you have a formal business plan for selling your LPA product(s)?

9. Have your operations on your LPA(s) changed over time based on what you have learned? In what specific ways have your operations changed? How were these changes advantageous?

10. What has helped you the most to sustain your aquaculture business?

11. What would you be doing if you did not have your LPA(s)? Would you stay working in aquaculture?

12. How would you change the LPA system, and what would you keep the same?

13. What advice would you give to someone starting aquaculture on a new LPA?

Appendix 6. Focus Group participants statements, coded

Table 9. Participants' statements coded as relating to "Commercialization" indicators

Statements coded as "Commercialization"	Indicators
"…it allows you in a timely way to get into it and try things out before you start the longer process. If you're needing to wait two years before you can even put your gear in the water, then that's kind of defeats the purpose of having this be a new business for you."	Commercialization and/or scaling experimentation
"I grow kelp, so it's still a bit of an experimental market."	Commercialization and/or scaling experimentation
"It's not like you can take the wild harvester plan and their conversion rates for, say, wet-to-dry and move that into the line-grown kelp arena because the, the organisms, the plants that are coming off really different: they dry at different, at different rates and it really affects what your conversion is as far as funds at the end for what you can sell."	Commercialization and/or scaling experimentation
"And that requires planning…how you're going to get whatever you grow to whoever's going to buy it."	Commercialization and/or scaling experimentation
"Once I figured out the ins-and-outs and kind of go, 'okay this is how it has to happen from year to year,' and then becomes a question of, right, do you get bigger and actually turn into an income stream or do you – do I – move on?"	Commercialization and/or scaling experimentation
"The LPA gets you let you get around a number of things that would stand in the way of a Standard license or an Experimental license. To experiment with something, but really you're going to try and run it as a business."	Commercialization and/or scaling experimentation
"In terms of size, at what point do you have to start hiring people, do you want to do everything yourself, or do you want to start hiring people? And if you start hiring people, you're going to need much larger scale, just, you know, in order to make it worth their while."	Commercialization and/or scaling experimentation
"Another appealing thing about an LPA and the scale, that it's a manageable startup."	Experimentation with commercialization and/or scaling
"I've eaten a little of it but that's mostly as experimentation, trying to get to reasonable secondary products or value-added products, but for the most part, I sell it."	Access to various markets
"Ultimately, I do plan on selling—that was the point of taking out the commercial LPA."	Access to various markets
"I plan on selling."	Access to various markets
"I've got to get stuff in, load it, and then drive three and a half hours to Portland where I can sell it. Or they got to come to me and get it."	Access to various markets
"…When you have product and it's time to get markets going – that is a little bit of a challenge. That was the thing that probably took the most new energy from me was to set that stuff up."	Access to various markets

“I've got buyers out-of-state, so I'm dealing with the vehicle to get that—not, not literally the vehicle—but the mechanism to get them out of state.”	Access to various markets
“You got to know your market and what you want to get out of it on the other end.”	Access to various markets
“I have nothing in writing [for a business plan] because I would end up having to throw it out the window and rewrite it every couple of months.”	Business planning
“In this line of work, it's also volatile…I never even thought about writing it down.”	Business planning
“We don't need anybody else helping us with business plan templates.”	Business planning
“There's so many kinds of things that gets thrown in along the way that are unexpected that you really cannot have a business plan and it grows organically. People get to know about your product, they like your product and they want it, and it grows of its own, it just grows by itself way.”	Business planning
“There's a point where you're big enough or want to get big enough, that you can't get additional funding without having a business plan.”	Business planning
“We had to have a meeting with somebody at Atlantic Sea Farms to set up the whole process of getting the seed and then having a market for the product so, so, that's a whole different thing than, say, shellfish.”	Business planning
“Another appealing thing about an LPA and the scale, that it's a manageable startup.”	Business skills
“Sales is a skill and not everybody has it. Not everyone has a knack for it. But if you're actually going to try and have an LPA or have an aquaculture business and sell stuff, it's a necessary evil.”	Business skills
“I actually got several of the restaurants that I now sell to message me through Instagram.”	Business skills
“Social media and especially something is kind of esoteric and simple as Instagram is a fairly good marketing tool these days for oysters.”	Business skills
“My Instagram presence has helped me to get expand my sales.”	Business skills
“You're not really supposed to go sell directly to restaurants that don't have that license and many restaurants do not. So, I actually went to the additional step of getting my wholesale dealer certificate so that I could essentially become my own middleman and that, that created way more opportunities for me to sell to whoever I needed to.”	Shellfish-dealer certification
“In addition to the wholesale deals license you need something from the Department of Health and Human Services. You need a four-basin sink with hot water and sewage disposal and a washable floor, which you can’t do at, like, a farmers’ market or roadside site so easily unless you invest a lot of money in a food cart-type thing.”	Shellfish-dealer certification

“You do need to have a fixed facility.”	Equipment for processing and preserving LPA products
“You need…a three-way sink and a cooler and you have to have temperature logs and it's fairly onerous as far as what you're required to have.”	Equipment for processing and preserving LPA products

Table 10. Participants’ statements coded as relating to “Economic Resources” indicators that are not related to commercialization per se

Statements coded as “Economic Resources” (not related to commercialization per se)	**Indicators**
“Compared to other lease processes, it's a fairly low barrier as far as procedurally and cost.”	Personal financial resources
“I don't know whether it's going to be a great location unless I test it.”	Personal financial resources
“That was another part of the reasoning—it was just to make sure that I wasn't doing something faster than I was ready to put money into it.”	Personal financial resources
“It's not a significant huge cost to get started up.”	Personal financial resources
“You probably are going to need something supplemental to do just because of the lag times involved with the permitting process at this point.”	Personal financial resources
“I have a background in harvesting licenses. I would, probably, but if wasn't growing oysters, I would probably just go back to the other side of things.”	Personal financial resources
“I have employment from other sources. This is the smallest of them.”	Personal financial resources
“That's also why I have the LPA, to see if it works here, and parts of it didn't work, so it's, it's a learning process. There’s the wild harvest and…I have two other sources of income.”	Personal financial resources
“In terms of size, at what point do you have to start hiring people, do you want to do everything yourself, or do you want to start hiring people?”	Personal financial resources
“I'm doing diversified, you know, blueberry jam and seaweed sprinkle, apple cider vinegar, a lot of value-added products from land and sea.”	Personal financial resources
“It’s a really innovative, great way to kind of allow people to dabble in aquaculture.”	Farm experimentation
“My approach to things is to start off small, learn what you can, and get big.”	Farm experimentation
“It's just provided me with a good pace to get into this without feeling like I'm either all in or all out.”	Farm experimentation
“To start small, which is why I chose an LPA.”	Farm experimentation

“I'm not going to go the route of maximizing the number of LPAs because I don't need them.”	Farm experimentation
“I want to be able to expand and it's easier for me to take out a couple of extra LPAs to grow, but the logical step would be to take out an Experimental lease and then a Standard lease. It's a lot of work, and the LPA kind of skirts this so I think it's a shortcut that a lot of people take to have something that's somewhere in between.”	Farm experimentation
“The LPA gets you let you get around a number of things that would stand in the way of a Standard license or an Experimental license.”	Farm experimentation
“The seed is so hard to get.”	Accessibility of seed/spores
“Who's providing my seed? Are they providing the seed and I have to figure out what to do with it, or I get to figure out what to do with it? Or are they providing seed on a contract basis where they get first right-of-refusal on what comes off those lines?”	Accessibility of seed/spores
“We had to have a meeting with somebody at Atlantic Sea Farms to set up the whole process of getting the seed and then having a market for the product so, so, that's a whole different thing than, say, shellfish.”	Accessibility of seed/spores
“I'm doing diversified, you know, blueberry jam and seaweed sprinkle, apple cider vinegar, a lot of value-added products from land and sea.”	Food security
“There’ll always be the, you know, the weird-shaped ones or the doubles or whatever and I always take those home.”	Food security
“For me, it's an income generator.”	Food security
“I eat what I grow.”	Food security
“When the apocalypse happens, yes, I will be also relying on food [from my LPA] just like I have my garden here to rely on.”	Food security

Table 11. Participants’ statements coded as relating to “Knowledge and Skills” indicators

Statements coded as “Knowledge and Skills”	**Indicators**
“The whole business of rigging is kind of something that seems natural to you if you grew up doing it, but probably isn't if you didn't. You know, if you were a fisherman or something like that to start with, it probably helps a lot.”	Operator knowledge and skills
“You need some level of physical ability and you need to be comfortable being on the water, I mean those are kind of basic skills.”	Operator knowledge and skills
“I purposely chose floating bags so that it wouldn't be as kind of physically demanding as some of the farms that choose to use cages where you can slide a lot more and you can grow a lot more oysters.”	Operator knowledge and skills
“You still need to be pretty comfortable being on the water.”	Operator knowledge and skills
“With kelp lines, it's literally you're putting something out there that's all rope and you're counting on it to not go anywhere for four or five months.”	Operator knowledge and skills

“It's good to have some of that basic knowledge for how to put things in the water and make them stay where they're supposed to be.”	Operator knowledge and skills
“It's, you know, going to be different, every day, and they're always going to be problems presented, so that's part of it. I'm not afraid of hard work, and I think everybody here can probably attest that it's, yeah, there's always something, never…never mind the weather or other variables in it.”	Operator knowledge and skills
“I'm not gonna say a “jack of all trades,” but willing to learn and not just do one thing.”	Operator knowledge and skills
“Because of my background I already worked in the fishing industry a little bit, so I knew what I needed for gear.”	Operator knowledge and skills
“The oyster business has been a lot more work than I thought it was going to be. I mean, that's partially my own fault—I know that my operations pretty inefficient and there a lot of ways I can improve but that I haven't made that investment yet.”	Operator knowledge and skills
“Be prepared to learn a lot of stuff on your LPA.”	Operator knowledge and skills
“Other people have been very helpful…other individuals in aquaculture. You know, that the neighboring farm or the company that's been in business for 20 years, they've been very helpful and become friends, and technically we're competition.”	Support from other ocean farmers and aquaculture organizations
“The farmers that I've gotten to know have been nothing but helpful, whether it's with advice or just, just being friendly and not looking at you as competition or that there's too many people in the game.”	Support from other ocean farmers and aquaculture organizations
“A number of individuals and organizations that are very helpful. Maine Sea Grant and even local land conservation groups—there's, there's no shortage of people that have expertise in the fields that are willing to help.”	Support from other ocean farmers and aquaculture organizations
“We're pretty far from anybody but have been mentored extensively by our neighbors in (location x) and (location y), and our friends in (location z). Basically, I wouldn't be able to do anything that I am doing, except for the mentorship and kindness and teaching. And people have been extraordinarily generous.”	Support from other ocean farmers and aquaculture organizations
“The continuing culture of aquaculture supports the incoming generation in the way that I've been supported and mentored.”	Support from other ocean farmers and aquaculture organizations
“Can I do it just with my four [LPAs]? Do I need my four plus a partner and their four?”	Skilled and knowledgeable assistants/partners

Table 12. Participants’ statements coded as relating to “Natural Resources” indicators

Statements coded as “Natural Resources”	Indicators
“Once you're actually in it, it's literally you're winging it, because you don't know what's necessarily going to…what kind of environmental challenges you might have, if you've got, you know,	Farm space suitable for cultivation

your stuff grows slower than you thought it would or faster than you thought it would."	
"I don't know whether it's going to be a great location unless I test it."	Farm space suitable for cultivation
"Can I do it just with my four? Do I need my four plus a partner and their four? And once you get into that, then, yeah, you got to start looking around for space where you can put this thing."	Farm space suitable for cultivation
"I did not take out four LPA is all in one location. I took out one to see if it would work."	Farm space suitable for cultivation
"My farm is eight miles off [the mainland]."	Farm space suitable for cultivation
"We've got a couple of great hatcheries here in Maine, so [getting my oyster seed] wasn't an issue."	Availability of appropriate seed/spores

Table 13. Participants' statements coded as relating to "Social License to Operate" indicators

Statements coded as "Social License to Operate"	Indicators
"Everybody thinks that aquaculture is great—growing kelp, growing oysters – 'yay, save the planet, we're going to be great' – but then they don't want to see it in their front yard."	Relationships with riparian landowners
"They put up an awful fuss and threatened to sue the DMR."	Relationships with riparian landowners
"One of the biggest things people don't want to see: floating gear, you know, and ruin the environment, but at the same time they want to support it."	Relationships with riparian landowners
"When I went and applied for my Experimental lease which is essentially the same footprint as my LPA—just an extra string of gear—they rallied several other people and got some more than five people to request a public hearing and that's actually what is tripped up my application and created the two-year delay."	Relationships with riparian landowners
"I would say riparian owners are a whole new challenging breed, especially post-COVID because a lot of the kind of seasonal residents that would come up here to Maine for a week or two in the summer, many of them decided they're going to just move in full-time or spend extended periods here, more people are buying places here from other areas of the country."	Relationships with riparian landowners
"I agree entirely with that the gentrification of the coast and all that money coming into a place. These sorts of things, you know, the NIMBY mentality is very distressing."	Relationships with riparian landowners
"[There is] a NIMBY problem, and it's a big problem."	Relationships with riparian landowners
"I tried to be as, you know, a good neighbor, as much of a good neighbor as I could be and they smiled in my face and thanked me and then when it came time for the, the, the waiting period was open for a request for public hearing, they signed right up."	Relationships with riparian landowners
"I've actually changed my approach because of the because of riparian landowners. I'm planning on going gearless and bottom-planting, which means I'll be diving, which is a lot more work. Yeah, so it's the only solution I have."	Relationships with riparian landowners

“The issue with riparian landowners is, can you get far enough away so they don't have a reason to come after you?”	Relationships with riparian landowners
“I've got no problem riparian landowners, but my farm is eight miles off.”	Relationships with riparian landowners
“I've gotten a fair amount of help from the working-water community. Folks who've looked at what I did, like when I was having rigging trouble, and was like, ‘well, you should try this, it'll probably work better,’ things like that. Guys who have helped me in with my motor died, you know, things like that. Folks have been around, who understand being on the water and that it is a marine business like lobster – and even if it's not lobstering – have been willing to lend a hand and advice.”	Relationships with local traditional-use fishers

Table 14. Participants’ statements coded as relating to “Legal License to Operate” indicators

Statements coded as “Legal License to Operate”	Indicator
“I've been waiting for well over a year just to get the public hearings scheduled.”	Approval of the Maine DMR
“The DMR, when I applied during COVID, was slow, but I found it effective.”	Approval of the Maine DMR
“The paperwork itself is not that challenging.”	Approval of the Maine DMR
“I just wrote a lease for a neighbor fishes out of here for a lease for a kelp farm out here. And he's been told that it's going to be two years before they even look at it, and that's a staffing problem at DMR.”	Approval of the Maine DMR
“[Getting permits/Leases approved] is also a staffing problem.”	Approval of the Maine DMR
“You probably are going to need something supplemental to do just because of the lag times involved with the permitting process at this point.”	Approval of the Maine DMR
“Stay on top of that…the lag time when you do, when you do apply for any kind of expansion.”	Approval of the Maine DMR
“The regulations seem to change. Frequently, and, you know, stay on top of that.”	Regulations of the Maine DMR
“I've got some neighbors…taking out a Standard Lease, which is one of the largest in our area, at the same time as they applied for an LPA—actually, four LPAs—and with another associated group of four have completely exceeded the density limit around where I am, so their business approach is very different.”	Regulations of the Maine DMR: Density limit
“I can't start out small further out because the density limit is exceeded by folks taking out as much as they can. And I can't go further in because there's…I'm just stuck.”	Regulations of the Maine DMR: Density limit
“I finally selected the location, which was not where I wanted to be because of the density limit.”	Regulations of the Maine DMR: Density limit
“The density limit is exceeded by folks taking out as much as they can.”	Regulations of the Maine DMR: Density limit

Table 15. Participants' statements coded as relating to "Physical Resources" indicators

Statements coded as "Physical Resources"	Indicators
"My wife likes to joke that I have a kelp farm to justify my ownership of a boat."	Boats
"I was even able to…borrow some stuff or get some hand-me-down stuff from people I knew, so that wasn't so much of a challenge."	Farm gear
"Transport [of my harvested products once on land] is a challenge on my end…I've got to get stuff in, load it, and then drive three-and-a-half hours to Portland where I can sell it."	Cars/trucks

This thesis has been examined and approved on December 10, 2021

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