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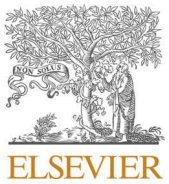

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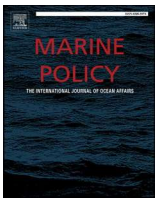

Full length article

Different coasts for different folks: Place-based community values and experience mediate social acceptability of low-trophic aquaculture

Megan E. Rector [a,b,*], Ramón Filgueira [b]

[a] Institute of Aquaculture, University of Stirling, Scotland FK9 4LA, United Kingdom
[b] Marine Affairs Program, Dalhousie University, B3H 4R2, Canada

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ABSTRACT

The expansion of low-trophic aquaculture (shellfish and sea plants) is limited in many regions by a fragmented regulatory process that is difficult for smallholder farmers to navigate. Small-scale Aquaculture Development Areas (ADAs) can remove some of this regulatory burden by establishing pre-approved zones for aquaculture development; however, an understanding of local support for low-trophic aquaculture is needed to understand the potential of ADAs. A survey was used to solicit information about community support for shellfish and sea plant aquaculture in Pictou County, a coastal area of Nova Scotia, Canada. Participants had a positive impression of low-trophic aquaculture, but residents in one coastal area reported greater perceived negative impacts on the recreational use and enjoyment of coastal areas and views, while residents in another coastal area reported a higher level of support for shellfish aquaculture. In general, participants also valued community involvement in aquaculture management, local ownership of farms, and community benefits from the presence of farms. Results suggest that top-down communication is unlikely to play a significant role in acceptability. Instead, experience of low trophic aquaculture and place-based values are important for understanding social acceptability. Community involvement in the development of ADAs and the distribution of benefits from farming could support trust in ADAs and social licence for low-trophic aquaculture.

1. Introduction

Aquaculture, the farming of aquatic organisms, is the world's fastest growing food industry, now accounting for over 50 % of global seafood production [21]. In addition to food, cultivated aquatic species are being used to produce biofuels [57], fertilizers, pharmaceuticals, cosmetics, and other goods [42,67]. Aquaculture is also being used towards conservation goals including habitat restoration, improved water quality, and reduction of greenhouse gas emissions [24]. The growth of responsible and sustainable aquaculture is needed to meet the growing demand for seafood as the global population increases, as well as sustainability goals, including biodiversity and climate change mitigation targets [18,24].

Low-trophic aquaculture, which includes farming shellfish and sea plants, provides a low-impact source of seafood that offers additional ecosystem and cultural benefits [3,42]. For example, low-trophic aquaculture does not require feed or the use of antibiotics [77] and has the potential to clean the waters where farms are operating, removing excess nutrients and preventing algal blooms [18,6]. Despite these benefits, negative environmental impacts can emerge in low-trophic aquaculture sites. For example, shellfish farming can lead to eutrophication in areas with low flushing rates [72] and reduce primary production where carrying capacity is exceeded [77], making both site selection and stocking density important factors for farming sites.

Despite growing demand for aquaculture products and the green reputation of low-trophic aquaculture, there are several challenges to the growth of shellfish and marine plant industries. First, social licence to operate (SLO) and social acceptance of low-trophic aquaculture is required. Definitions and the conceptualization of both social licence and social acceptance have evolved over time [23,40], but SLO can be generally described as the ongoing public approval of a project [76]. Although social acceptance and social acceptability have been used interchangeably in social research as the concept of acceptance has expanded, some authors have called for the separation and clarification of these terms, where acceptance is an outcome and acceptability is the complex social, political, and economic processes that can result in a range of possible results including rejection and acceptance [23,8]. These terms also differ in their perspective, where acceptance from the

* Corresponding author at: Institute of Aquaculture, University of Stirling, Scotland FK9 4LA, United Kingdom.
E-mail address: megan.rector@stir.ac.uk (M.E. Rector).

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proponent's point of view is barrier-oriented focusing on resistance to development. For example, public acceptance of wind energy was initially viewed as a barrier to development that could be addressed through public communication [78]. This assumption follows from the information deficit model which suggests that opposition to science and technology is a result of a public deficit of knowledge [81]. However, the deficit model is now widely criticized, and the relationship between knowledge and acceptance or support for science and technology issues is more complex than the deficit model suggests [61,78]. Social acceptability reaches beyond this perspective and the limitations of the information deficit model by recognizing the role of value-based arguments and judgements in acceptability decision-making; acceptability decisions are not a product of knowledge, but of interactions between actors in context [8].

Social acceptability research has identified issues involved in the acceptability of low-trophic aquaculture. For example, research has identified community concerns related to low-trophic aquaculture including conflicts with other uses of nearshore areas, conflicts with fisheries, unresolved Aboriginal territorial claims, and the appearance of shellfish farms amongst other perceived and experienced impacts [14,30,34,47]. These examples of place-based research suggest that low-trophic aquaculture development is shaped by local social acceptability in addition to biophysical suitability and economic opportunity [33,34]. The importance of place in social acceptability is further reflected in differences in perceptions of aquaculture found between countries [25,60], regions [22,41], and communities [79].

Second, aquaculture is subject to a complicated and fragmented regulatory regime in many locations around the world [20]. Complex and lengthy permitting processes can make it especially difficult for new entrants to the industry and small-scale enterprises to establish farms [31,53,70]. Government-led aquaculture zoning can remove some of this burden and support sustainable aquaculture development by identifying areas that are suitable for aquaculture [2]. Aquaculture zoning has been referred to by a number of names in regions around the world, including Offshore Aquaculture Zones, Areas for Development of Aquaculture, Suitable Areas for Aquaculture, and Aquaculture Management Areas, which combine aquaculture zoning with management planning. These areas have been collectively referred to as Allocated Zones for Aquaculture (AZA), areas that are meant to prioritize aquaculture development, avoid conflict with other marine users, and minimize negative environmental and social impacts [58]. AZAs have been implemented in different ways under different regulatory frameworks by national and regional governments, and at national and regional spatial scales [58]. Identifying and designating AZAs can reduce financial risk by improving regulatory certainty for investors and in turn, access to finance for farmers [2]. For example, in the United States, large-scale mapping projects are being used to support policy and permitting decisions, and identify Aquaculture Opportunity Areas (AOAs) for offshore aquaculture [56]. Aquaculture Development Zones (ADZs) have been established in Western Australia where they provide 'investment-ready' opportunities for specified aquaculture sectors [73]. Zone leasing has improved access for new entrants to shellfish aquaculture in Florida [80]. In the Canadian province of Nova Scotia, government and stakeholders are working collaboratively to collect and analyse information that would typically be collected by an aquaculture lease applicant, and to use that information to establish Aquaculture Development Areas (ADAs) [48].

Aquaculture development and expansion is limited by social and administrative barriers [16], which can be addressed through aquaculture zoning. However, the underlying social conditions and values that shape these barriers vary across jurisdictions [22,25,41,79]. Therefore, place-based research is needed to understand the potential of and support for aquaculture development and AZAs in specific contexts. In this study, perceptions of and priorities for low-trophic aquaculture development were explored in an area where shellfish farms are already present. Focusing on a single coastal county allowed for a comparison of support for and perceptions of low-trophic across adjacent coastal areas within that county at a higher degree of resolution than typically explored in aquaculture perception research.

1.1. Study area and context

Nova Scotia is a maritime province located on the Atlantic coast of Canada. Despite excellent biophysical conditions and potential for growth of low-trophic aquaculture in Nova Scotia [64], the value of shellfish aquaculture ($13.7 million) remains low in comparison to neighbouring provinces New Brunswick ($29.9 million) and Prince Edward Island ($45.4 million) [65]. Sugar kelp growth trials have taken place in Nova Scotia [13], but commercial marine plant aquaculture is not fully established in the province [35].

Marine aquaculture sites in Nova Scotia require a licence from the provincial government as well as a lease from the province for the use of the waterway and seabed. To request a new lease, applicants provide information including the species to be farmed, potential location, industry experience, and a business plan. If the Nova Scotia Department of Fisheries and Aquaculture (NSDFA) approves the request to explore the area, the applicant is given six months to collect biophysical information about the area, share information with stakeholders, and hold at least one public meeting near the potential site location. The applicant can then submit an application including site-specific biophysical, environmental, and social data that the NSDFA then shares with relevant federal and provincial departments which may include Fisheries and Oceans Canada, Transport Canda, Environment and Climate Change Canada, and the Canadian Food Inspection Agency for input. Consultation with First Nations may also be required. The application is then provided to the Nova Scotia Aquaculture Review Board, an independent decision-making body, which holds a public hearing on the application. The Aquaculture Review Board then issues a decision to approve, approve with conditions, or reject the application [50]. Aquaculture expansion has been identified as a priority for Nova Scotia, but the lengthy approval process for new farm sites has been a barrier to entry into and expansion of shellfish farming, with one applicant reporting that their application had not made progress after over four years [11,10]. This regulatory burden has led to interest in establishing Aquaculture Development Areas (ADAs), areas that have been identified as being suitable for aquaculture development through a collaborative and science-based review process [48]. Nova Scotia's first ADA, located in the Municipality of Argyle on the southern coast of the province, was developed with the goal of shortening and simplifying the process for new aquaculture leases [46]. The first 6 of 53- pre-approved sites for shellfish or marine plant aquaculture within the Argyle ADA became available to lease in April 2024, and are estimated to reduce the licensing process by two to three years [12].

During the development of Nova Scotia's first ADA in Argyle, the Pictou County Partnership, a non-profit economic development organization, expressed interest in working towards the development of an ADA in Pictou County. Pictou County is located in the northeastern region of Nova Scotia with a population of 43,647. The county includes several towns located in its central region but is largely rural with a population density of 15.4 people per square kilometre. The population of Pictou County has been declining over the past 10 years, in contrast to positive population growth in Nova Scotia and Canada, and the median total income including COVID-19 earning replacement benefits ($48,800) was below both the Nova Scotian ($51, 500) and Canadian ($57, 200) median in 2021 [66]. Where a lobster fishery was once central to social and economic life in coastal regions of the county, a decline in the inshore lobster fishery has led to a dilution of fishing culture and affected families and coastal communities that rely on this resource [32].

The coastal portion of Pictou County lies along the Northumberland Strait and is already home to several shellfish farms. The coastal zone holds potential for further development of low-trophic aquaculture;

commercial leases have been issued to grow Eastern oysters, bay quahaugs, bay scallops, bar/surf clams, and razor clams (Fig. 1). The majority of shellfish licences in the area are for bottom culture of shellfish, with and without gear, but there are also licences for suspended culture of shellfish [49]. Both the slow licensing and leasing regulatory process and negative community perceptions have proven to be barriers to the development of shellfish farms in neighbouring regions [11]. Research in Nova Scotia suggests that environmental, social, and governance factors may affect perceptions and acceptability of marine aquaculture [36,55,74,79]; therefore, a public survey was conducted to help understand the level of community support, perceptions, and priorities for low-trophic aquaculture in Pictou County.

2. Method

An online survey (Appendix 1) about shellfish and sea plant aquaculture in Pictou County was used to solicit information about community perceptions and priorities for aquaculture in Pictou County. Participants were recruited to the survey through a targeted mail campaign and social media. Canada Post's Precision Targeter™ was used to create a mailing list targeting households and businesses in rural coastal areas of Pictou County. The target area spanned the full coastline of Pictou County, excluding areas surrounding Pictou Harbour as this area is not suitable for aquaculture development (participants from this area were included through social media recruitment, but were not specifically targeted though the mail campaign). The mail campaign included lock box, rural route, and general delivery addresses in the targeted areas (see Figure A1 for details). A postcard introducing the study and inviting recipients to participate using a web link or QR code was mailed to 6000 addresses on August 2, 2023. A link to the survey was also shared on the Pictou County Partnership, Pictou County Community Notices, and What's Going On in Pictou County & Surrounding Areas Facebook pages. The survey was open from early August to late September 2023. Participants were required to be 18 years of age or older and live in Pictou County. Although recruitment specifically targeted people living in coastal areas of Pictou County, people living outside the specified regions were not excluded from participation. The survey was administered online through Opinio, a survey tool hosted on Dalhousie University servers, under Dalhousie University Research Ethics Board file #2020–6650.

The survey began with demographic questions, including a question asking participants to indicate where they live, as indicated by polygons outlined on a map of the county. Participants could indicate in which of five areas they lived or respond that they lived in an area of Pictou County outside of those areas outlined on the map. Two of these areas were later combined during analysis, resulting in four coastal areas used to compare support, perceptions, and priorities for aquaculture in Pictou County (Fig. 1). These four areas represent locations with similarities within the county and not jurisdictional boundaries. The *Northwest* area includes rural areas along the northeastern shore and is home to both active and proposed oyster farms located in Caribou Harbour. *Pictou Harbour* is the most densely populated area of Pictou County as it is home to the largest town centres within the county, including New Glasgow, Stellarton, Westville, Pictou, and Trenton, as well as Fisher's Grant 24, a reserve of the Pictou Landing First Nation. Pictou Harbour has experienced decades of local pollution resulting from effluent from a pulp mill that has been in operation since 1967. Local communities, including the Pictou Landing First Nation, have raised concerns over air and water pollution caused by the pulp mill, odour, and potential links between air pollution and high rates of cancer and respiratory diseases in the area [29]. There are no aquaculture farms located in Pictou Harbour. The *Little Harbour* coastal area is another rural region of Pictou County. It is also home to popular beaches and oceanfront properties, which attract tourists and cottagers to the area. There are several shellfish farms in the Little Harbour area, including the largest lease in Pictou County at 58.5 ha. Finally, the *Merigomish Harbour* area is another rural area of the county and is home to the largest number of shellfish farms in the county.

The remaining survey questions were based on Wood and Filgueira's [79] adaptation of D'Anna and Murray's [14] survey investigation of perceptions of shellfish aquaculture in British Columbia. These survey questions were adjusted to reflect the research goals and specific context of low-trophic aquaculture and the potential for an ADA in Pictou County. Changes to the survey included a greater focus on the governance of low-trophic aquaculture and use of identical sets of questions related to shellfish and sea plant farming to allow for comparison

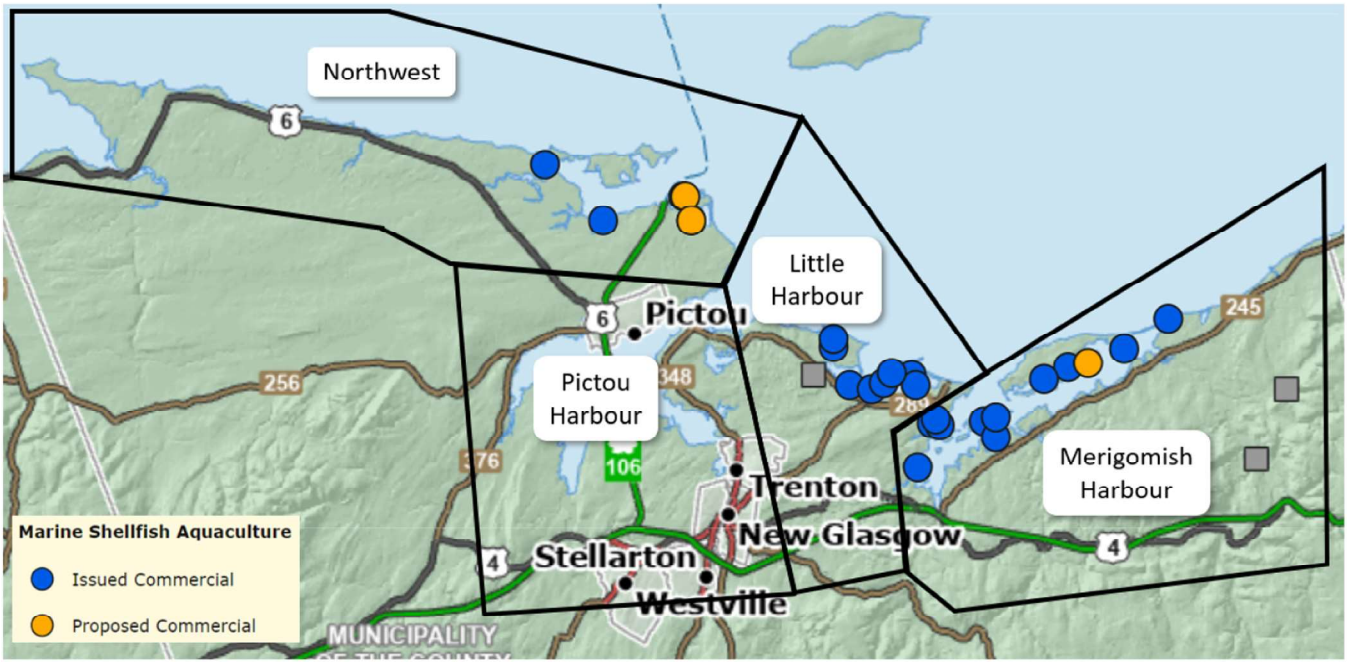

Fig. 1. Shellfish aquaculture sites in Pictou County, Nova Scotia are indicated by blue (issued) and yellow (proposed) circles [51]. There are no marine plant sites in Pictou County. The coastal areas of Pictou County that were targeted in survey recruitment are outlined in black.

between these two types of low-trophic aquaculture. This resulted in a series of 5-point Likert scale questions about support, perceptions, and priorities for low-trophic aquaculture in Pictou County. Participants were able to select an 'I don't know' or 'I prefer not to answer' option for each Likert scale question. A final open-ended question was included inviting participants to include any comments about topics not captured in the survey.

Given the use of Likert scales, nonparametric statistics were used to analyze differences in responses to survey questions for shellfish and sea plant aquaculture, and between areas of Pictou County. Differences in familiarity, impression, and perceptions and priorities for shellfish in comparison to sea plant aquaculture were analyzed using Wilcoxon signed-rank tests. Differences in survey responses between coastal areas of Pictou County were compared using Kruskal-Wallis tests, and significance values of post-hoc tests were adjusted using the Bonferroni correction for multiple tests. For comparisons between areas, responses from participants living outside of the coastal areas defined on the survey map were excluded from analysis. All analyses were performed using IBM SPSS Statistics Version 27.

3. Results

3.1. Survey population

A total of 121 people participated in the survey. This low response rate is similar to other aquaculture surveys using mail recruitment in nearby communities (Wood, 2020); still, this sample represented a 95 % confidence interval and 9 % margin of error. The area with the highest number of participants was *Pictou Harbour* (n=45) followed by *Little Harbour* (n=30), *Merigomish Harbour* (n=23), and *Northwest* (n=17). The population of these individual areas is unknown and therefore an accurate margin of error cannot be calculated for individual locations; however, based on the population of towns within the areas and the total number of addresses included in the targeted mailing campaign, the margin of error for each area is roughly 14–15 % with a 95 % confidence interval. Therefore, these samples cannot be generalized for their specific area populations and differences in survey responses between areas should be interpreted as differences between people in each area who chose to take part in the survey rather than differences between the population of each area.

The survey population skewed older than the population of Pictou County; the percentage of people over 55 in Pictou County was 35 % in the 2021 census, compared to 58 % within the survey population (Table 1). Most participants indicated that they live in Pictou County year-round (98 %). Some participants work in the aquaculture industry (11 %), and many have family or friends who work in the aquaculture industry (40 %) (Table 1). The highest proportion of participants with friends or family working in aquaculture was in *Merigomish Harbour* (70 %). All other coastal areas had fewer than 40 % of participants with friends or family working in aquaculture.

Table 1
Survey participant demographics.

	#	%
Age		
18–24	3	2 %
25–34	14	12 %
35–44	15	12 %
45–54	19	16 %
55–64	27	22 %
65+	43	36 %
Live >50 % of year in Pictou County		
No	9	7 %
Yes	112	93 %
Work in aquaculture		
No	108	89 %
Yes	13	11 %
Friends/family work in aquaculture		
No	70	58 %
Yes	49	40 %
Prefer not to say	2	2 %

3.1.1. Level of support for low-trophic aquaculture

Three survey questions were related to general familiarity and impression of low-trophic aquaculture (Fig. 2). Self-reported familiarity with aquaculture was higher for shellfish than marine plants amongst participants (p<.001, Table A2.1). Interest in and the need to know more before making decisions about aquaculture expansion was evident in participant comments at the end of the survey; e.g. "*I lack specific knowledge related to aquaculture to have informed opinions about any potential negative community impacts*", "*We need education prior to making decisions*", "*Feedback from communities previously exposed to this activity would be very helpful*". There was also some evidence of confusion between or conflation of low-trophic aquaculture and finfish aquaculture, "*I am not impressed with the fish farms in Cape Breton*," "*Is it not a Scandinavian company seeking to set up because our restrictions are considerably more lax than in their country?*".

The majority of participants reported a somewhat or very positive impression of both shellfish (65 %) and marine plant (51 %) aquaculture, with no significant difference in impression between these types of low-trophic aquaculture (p=0.302, Table A2.1). Participants were neutral about having more low-trophic aquaculture in their community, with no difference between types of aquaculture (p=0.815, Table A2.1), but with more participants agreeing or strongly agreeing than disagreeing or strongly disagreeing that there should be more shellfish (50 % agree/strongly agree, 24 % disagree/strongly disagree) and marine plant (47 % agree/strongly agree, 20 % disagree/strongly disagree) aquaculture in their community (Fig. 2). There was no strong preference for one type of aquaculture over another with 23 % of participants preferring shellfish farms instead of marine plant farms, and 16 % of participants preferring marine plant farms instead of shellfish farms (p=0.176, Table A2.1).

3.1.2. Level of support for low-trophic aquaculture across coastal areas

Median level of familiarity with shellfish aquaculture did not differ across coastal areas, and although familiarity with marine plant aquaculture was highest in *Merigomish Harbour*, this difference was not statistically significant (Table A2.2). Impression of aquaculture was more positive in *Merigomish Harbour*, followed by *Pictou Harbour*, *Northwest*, and *Little Harbour* for both shellfish and marine plant aquaculture. However, the only statistically significant difference between areas was a more positive impression of shellfish aquaculture in *Merigomish Harbour* than in *Little Harbour* (p<.05, Table A2.2, Fig. 3). Agreement that there should be more shellfish and marine plant aquaculture in communities followed a similar pattern to impression for both types of marine aquaculture, with the highest level of agreement in *Merigomish Harbour*, followed by *Pictou Harbour*, *Northwest*, and *Little Harbour*; however, the only significant difference between areas was stronger support for shellfish farming expansion in *Merigomish Harbour* compared to *Little Harbour* (p<.05, Table A2.2, Fig. 4).

In comparing support for types of low-trophic aquaculture, participants in *Merigomish Harbour* reported a preference for shellfish instead of marine plant farms in their community (p<.05, Table A2.3, Fig. 5). Preference for shellfish instead of marine plant farms was also higher in both *Merigomish Harbour* and *Pictou Harbour* than *Little Harbour* (p<.01, p<.05, Table A2.2, Fig. 5).

3.1.3. Community perceptions and priorities for low-trophic aquaculture

The level of agreement with statements about specific perceptions and preferences related to the potential impacts and management of aquaculture did not differ between shellfish and marine plant aquaculture (Table A2.4). The majority of participants agreed or strongly agreed that shellfish (67 %) and marine plant (60 %) farms could clean the

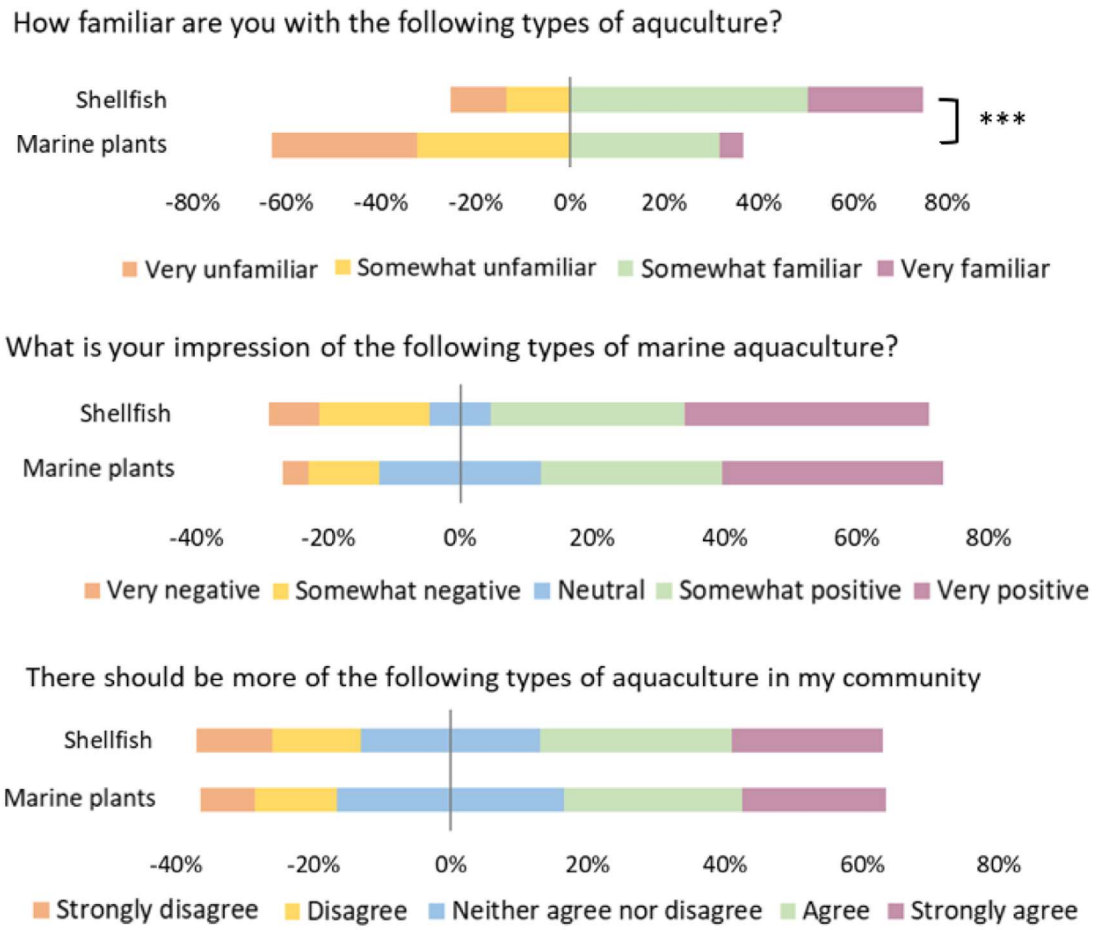

Fig. 2. Familiarity with (n=120, 118), impression of (n=119, 102), and desire for more (n=116, 111) shellfish and marine plant aquaculture. ***p<.001.

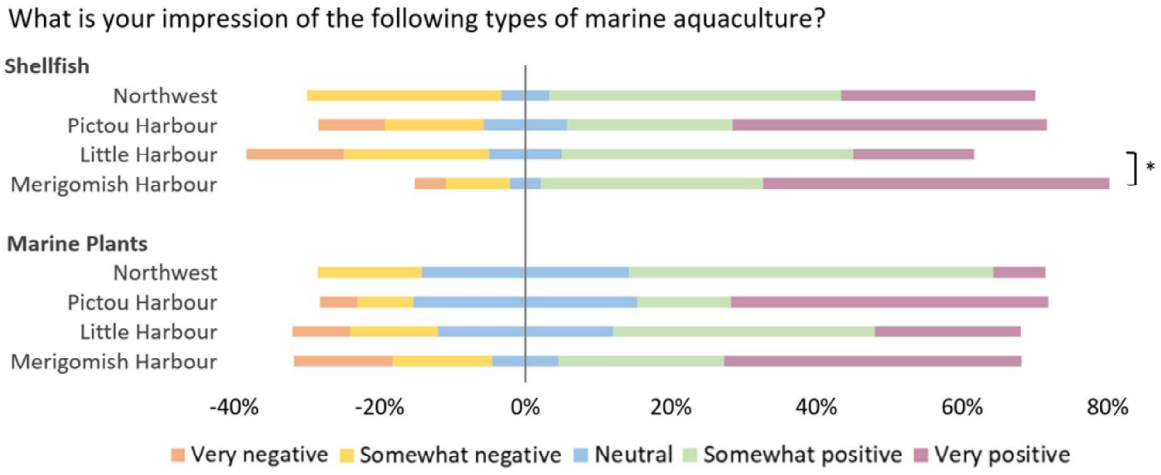

Fig. 3. Impression of shellfish (n=113) and marine plant (n=97) aquaculture within coastal areas of Pictou County. *p<.05.

waters they operate in, recognizing the potential positive environmental impact of marine farming on the environment (Fig. 6). Despite this positive view, approximately half of the participants disagreed or strongly disagreed that shellfish (50 %) and marine plant (53 %) aquaculture activities do not have impacts on coastal ecology, and some participants agreed or strongly agreed that they were concerned that shellfish (32 %) and marine plant (27 %) farming cause pollution and changes on the ocean bottom (Fig. 6).

The majority of participants agreed or strongly agreed that seeing debris from shellfish (65 %) and marine plant (67 %) farms on the shoreline would diminish their opinion of the industry. Some participants also indicated that farms may interfere with recreational use, enjoyment, and the aesthetic value of the coastline as indicated by a response of agree or strongly agree that shellfish (34 %) and marine plant (31 %) farms interfere or would interfere with their use and enjoyment of marine space, and that shellfish (40 %) and marine plant (36 %) farms would reduce the beauty of coastal views and spaces (Fig. 6). This concern was also evident in additional comments

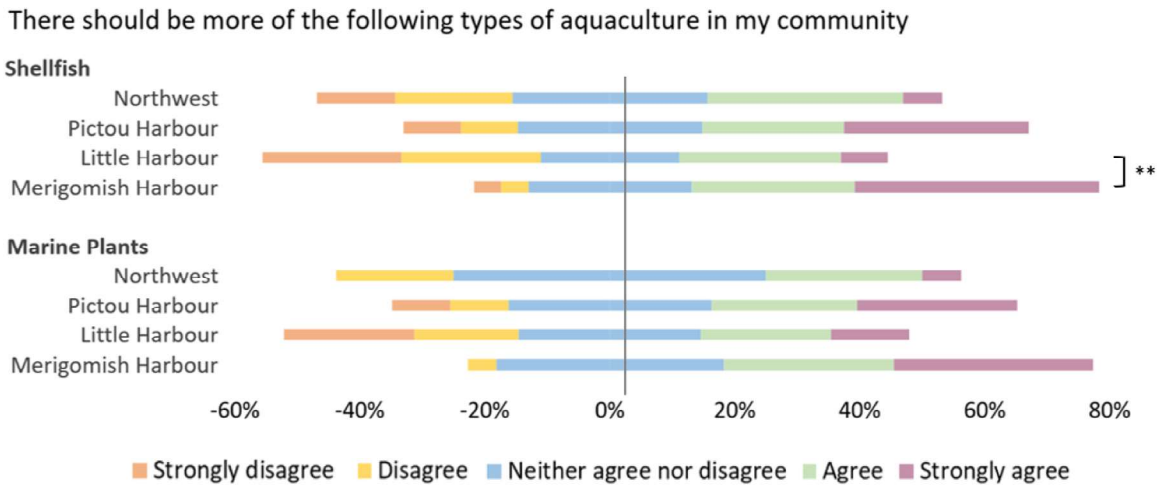

Fig. 4. Desire for more shellfish (n=110) and marine plant (n=105) aquaculture within coastal areas. **p<.01.

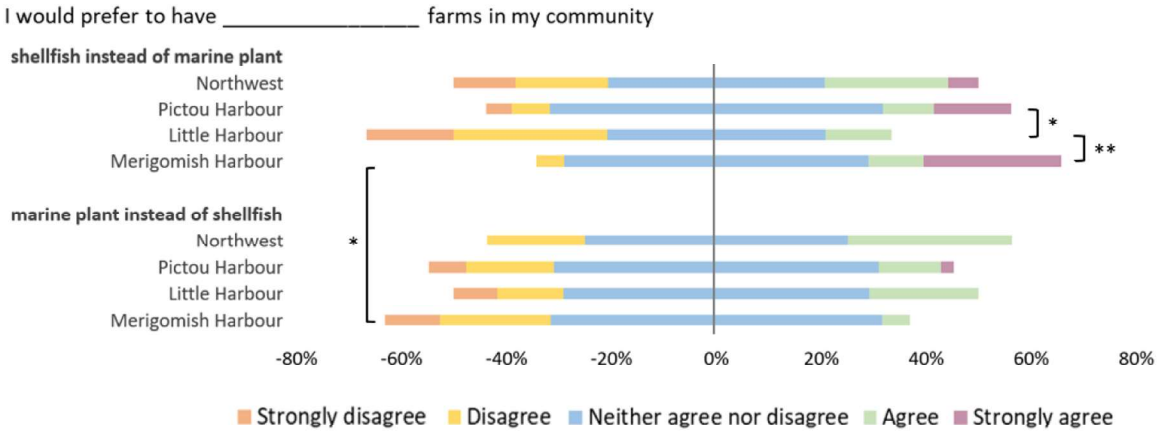

Fig. 5. Preference for shellfish instead of marine plant (n=101) and marine plant instead of shellfish (n=101) aquaculture within coastal areas of Pictou County. *p<.05 **p<.01.

submitted at the end of the survey, where some participants expressed concern about the current and potential impact of the accumulation of shells on their use of the shoreline; e.g. "*…our beaches are polluted with shellfish that limits our ability to even walk on the shores without heavy protective footwear*"; "*The shoreline is already not sandy and with all the additional oyster shells it is now dangerous for dogs to walk in parts of the water*".

The proportion of participants who agreed or strongly agreed that they trust farmers to manage shellfish (58 %) and marine plant (57 %) farms in a sustainable way was higher than the proportion of participants who agreed or strongly agreed that they trust the government to manage shellfish (39 %) and marine plant (39 %) farms in a sustainable way. This trust in local farmers but lack of trust in government is well-encapsulated in comments from two participants; "*We always preferred our pristine view, but we support our neighbour's efforts in sustainable harvesting, local employment, and good environmental effects*", "*I do not trust government to regulate in a way that protects those of us who live by and enjoy the Northumberland Strait.*" The majority of participants agreed or strongly agreed that their community should be involved in the management of shellfish (63 %) and marine plant (63 %) farms, and most participants agreed or strongly agreed that shellfish (75 %) and marine plant (77 %) farms should be owned by local individuals or groups (Fig. 6). Ownership also emerged as a concern in participant comments, though these concerns were related to coastal property rights and impacts on property value rather than farm ownership; e.g. "*No existing homeowner should have their ocean views marred by aquaculture equipment. They have paid high amounts for oceanfront property…*", "*I am also concerned that it will affect property value in a very negative way*".

Participants were also asked about community benefits and participation in aquaculture. Community benefits associated with aquaculture were important to participants; half of the participants (50 %) agreed or strongly agreed that they would be more likely to support aquaculture if their community received more benefits from farming. Many participants cited potential economic and community benefits in their comments in support of aquaculture development; e.g. "*Shellfish growing provides jobs that support a sustainable industry that can be community based and owned, allowing for more community based jobs and benefits that can support population growth in coastal communities*", and "*We already have a culture of seafaring and this would only add to it. It would be exciting to see more seafood involved in community food security projects and I would love to see a community oyster garden.*" Fewer participants agreed or strongly agreed that they would be more likely to support aquaculture if they were able to participate (28 %) (Fig. 7; Table A2.5). The desire for community involvement in management, together with local ownership of farms, indicates that participants want their community to be involved in and benefit from low-trophic aquaculture but are not interested in participating directly.

Fig. 6. Community perceptions of impacts of and priorities for low-trophic aquaculture.

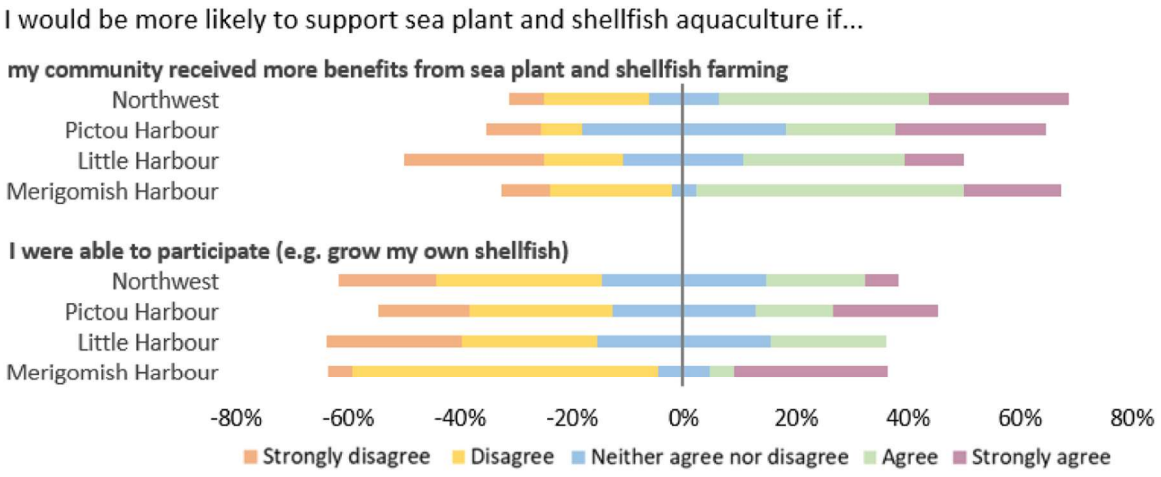

Fig. 7. Community benefits and participation in shellfish and marine plant aquaculture.

3.1.4. Community perceptions and priorities for low-trophic aquaculture across coastal areas

Some responses to statements about community perceptions and priorities differed across coastal areas. This was especially true for statements regarding negative impacts on the use, enjoyment, and aesthetic value of coastal spaces where a higher level of agreement was reported in *Little Harbour* (Table 2). A higher level of agreement was reported in *Little Harbour* than *Merigomish Harbour* and *Pictou Harbour* for the statements "The presence of shellfish aquaculture interferes/would interfere with my recreational use and enjoyment of marine space" ($p<.05$), and "The presence of marine plant aquaculture interferes/would interfere with my recreational use and enjoyment of marine space" ($p<.05$). A higher level of agreement in *Little Harbour* than *Pictou Harbour* was reported for the statements "Seeing debris from

Table 2
Median response to community perceptions and priorities questions by coastal areas where 1=strongly disagree, 2=disagree, 3=neither agree nor disagree, 4=agree, 5=strongly agree. [a]significant difference in distribution of responses in Little Harbour (LH) and Merigomish Harbour (MH) at $p<.05$ and [s]ignificant difference in distribution of responses in LH than Pictou Harbour (PH) at $p<.05$. NW = Northwest.

	Shellfish				Marine plants			
	NW	PH	LH	MH	NW	PH	LH	MH
Perceived environmental impacts								
The species growing on farms could clean the waters they operate in	3.5	4	4	4	4	4	3[a]	4[a]
Aquaculture activities do not have important impacts on coastal ecology	2	3	3	2	3	3	2	2
I am concerned that farms cause pollution and changes on the ocean bottom	3	2	3[a]	2[a]	3	2	3	2
Perceived social impacts								
Seeing debris from farms washed up on the shoreline would diminish/diminishes my opinion of the industry	4	4[b]	4[b]	4	4	4	4	4
The presence of aquaculture interferes/would interfere with my recreational use and enjoyment of marine space	2.5	2[b]	4[a,b]	2[a]	3	2[b]	4[a,b]	2[a]
The presence of aquaculture gear reduces/ would reduce the beauty of coastal views and spaces	3	3[b]	4[b]	2.5	3	3	4	2.5
Management & governance								
I trust farmers to manage farms in a sustainable way	3	4	3	4	3	4	3.5	4
I trust the government to regulate farms in a sustainable way	3	3	2	2.5	3	3	2	2.5
My community should be involved in the management of farms	4	4	4	3	4	4	4	3
Farms should be owned by local individuals or groups in my community	4	4	4	5	4	4	4	4

farms washed up on the shoreline would diminish/diminishes my opinion of the industry" ($p<.05$), and "The presence of shellfish farming gear reduces/would reduce the beauty of coastal views and spaces" ($p<.05$). A higher level of agreement was also reported in *Little Harbour* than *Merigomish Harbour* for the statement "I am concerned that shellfish farms cause pollution and changes on the ocean bottom" ($p<.05$). Responses to the question "Shellfish farms could clean the waters they operate in" and "I trust farmers to manage farms in a sustainable way" differed across areas ($p<.05$, $p<.05$, Table A2.2), but post hoc tests did not show any significant differences in responses to these questions between any specific pairings of coastal areas (Table 2). There was a higher level of agreement that "marine plants could clean the waters they operate in" in *Merigomish Harbour* compared to *Little Harbour*. Community benefits were least important in *Little Harbour*, while being able to participate directly in farming was of greatest importance in *Pictou Harbour*; however, responses to questions about these community benefits did not statistically differ across coastal areas (Fig. 7, Table A2.5).

4. Discussion

This survey compared support for, perceptions of, and priorities for two types of low-trophic aquaculture across neighbouring coastal areas in a region that is already home to shellfish farms. The survey approach was motivated by interest in developing an ADA in the area of study, and results provide insight into drivers of social acceptability of low-trophic aquaculture as well as specific insights for the potential development of an ADA in the area. Overall, results indicated a positive impression of low-trophic aquaculture in the region, while the spatial resolution of the survey revealed variation in perceptions and support for low-trophic aquaculture between neighbouring coastal areas.

4.1. Experience is more important than familiarity in social acceptability

The information deficit model suggests that opposition to science and technology is a result of a public deficit of knowledge [81]. If knowledge is interpreted as awareness or academic understanding (familiarity), then familiarity of aquaculture might be expected to be associated with greater acceptance. However, this hypothesis ignores contextual and individual factors that contribute to perceived

familiarity, factual knowledge, and the acceptance of science and technologies [61]. Amongst coastal residents who participated in this study, there was a higher level of self-reported familiarity with shellfish aquaculture than marine plant aquaculture, but this did not translate to a difference in social acceptance; impression and support for the development of both types of low-trophic aquaculture was high. This finding echoes the results of Flaherty et al.'s (2019) survey of Canadians in which respondents living in British Columbia reported a favorable impression of seaweed farming despite their low level of familiarity. In the same survey, familiarity of salmon farming was high in both British Columbia and Atlantic Canada, but impression of salmon farming was generally negative in British Columbia and positive in Atlantic Canada [22]. Communication strategies aiming to improve the acceptance of science and technology that are informed by the information deficit model rely on top-down information transfer and education [37,61], but these results show that a lack of familiarity does not prevent acceptance of an aquaculture species or system, nor does it guarantee acceptance.

If our conception of knowledge is restricted to a priori awareness and factual understanding, then the relationship between familiarity and acceptability of aquaculture does not support the information deficit model. However, in contrast to familiarity, experience is an important factor in social acceptability with exposure to aquaculture being associated with a more positive impression of aquaculture [41,54,55]. The role of experience and exposure in acceptability has previously been documented for wind energy projects and summarized by Wolsink et al. [78] as an inverted U; acceptance is initially high when public knowledge and exposure is low, then as information is shared attitudes become more complex and sometimes polarized, then finally acceptance increases when projects are complete and in operation. Here, the generally positive impression of shellfish aquaculture across coastal areas where shellfish farms are present and the especially positive impression of shellfish aquaculture, support for the development of more shellfish farming, and preference for more shellfish instead of marine plant aquaculture in *Merigomish Harbour*, a coastal area where a high proportion of survey participants have friends or family involved in shellfish farming, demonstrates the relationship between positive experience or exposure and social acceptability. Therefore, there is a relationship between knowledge of aquaculture and acceptability if the epistemic significance of experience is acknowledged. Overall, these findings highlight the difference between familiarity or awareness of aquaculture and practical experience or observation of aquaculture, where the former is not required for social acceptance of low-trophic aquaculture, but the latter may support it when that experience is positive. However, differences in impression of shellfish aquaculture between coastal areas suggest that this relationship is mediated by other place-based factors. Those working to improve acceptance will therefore benefit from focusing on providing opportunities for experiential knowledge and honest engagement with the public rather than top-down information transfer. This approach requires avoiding negative constructions of the public as uninformed, irrational, or self-interested opponents that are associated with information deficit models and not-in-my-backyard (NIMBY) discourse [26,7].

4.2. Spatial resolution matters for understanding social acceptability

Perceptions and acceptability of aquaculture can be understood at national and regional levels [22,24,41,54,57,60,75], which is important for evaluating industry social licence to operate (SLO) and national or regional differences in social acceptance of aquaculture. However, differences in support for aquaculture development between neighbouring coastal areas in this study demonstrate the important role of local context in social acceptability [47,79] and the need for smaller scale place-based understanding of social acceptability to support local aquaculture policy and development.

While impression of and support for low-trophic aquaculture was positive when the full coastal region of Pictou County was considered, when analysis was broken down into individual coastal areas, important differences between areas became evident. In particular, *Merigomish Harbour* stood out as being the most supportive of low-trophic aquaculture while *Little Harbour* stood out as being the least supportive. This difference appears to be driven by negative perceptions of current and potential impacts of low-trophic aquaculture on coastal viewsheds and beaches amongst participants in *Little Harbour*. Social impacts play an important role in social acceptability of aquaculture [36] and negative associations between support for shellfish aquaculture and its impact on aesthetic value and other coastal uses has been found elsewhere, including in Rhode Island and British Columbia [15,14]. Negative impacts of aquaculture on aesthetic value has also been valuated based on housing prices; for example, on the west coast of Scotland, where the visibility of farms is associated with lower property value [63]. However, impacts of shellfish farms on property values are not universal or predictable with distance to farm, visibility of gear, and lot size all playing a role [19,68,69]. Here, differences in the perceptions of the social impacts of low-trophic aquaculture between areas and the association of perceived social impacts with lower acceptance demonstrates differences in what communities value about coastal areas and the impact of those values on acceptance.

Where a shared value of natural coastal spaces appears to have influenced support for low-trophic aquaculture in *Little Harbour*, an area that is home to recreational beaches and cottages, the shared values and experience of participants living in *Merigomish Harbour* also influenced support for low-trophic aquaculture. Aquaculture is considered an important part of the blue economy, a narrative that emphasizes the economic benefits of coastal development including employment [38,62]. Indeed, many people in *Merigomish Harbour* work in aquaculture, and industry involvement is associated with a focus on the economic benefits of aquaculture [14]. Perceived economic benefits are also associated with social acceptance [79]. Although there are currently shellfish farms in both *Little Harbour* and *Merigomish Harbour*, conflict over the use of coastal space and the development of low-trophic aquaculture is likely to be higher in *Little Harbour* where the priorities of coastal residents are at odds with their perception of the impacts of low-trophic aquaculture.

4.3. Community involvement and shared benefits support trust and acceptability

Social licence originally emerged as the practice of addressing social risks in resource-based industries like aquaculture, but it is now used by multiple stakeholders to contest resource-based projects and development [40]. Increasing pressure on resource industries to meet the environmental and social expectations of society has led to regulatory and voluntary governance schemes that aim to support social licence [43]; but social licence is not only about reducing impacts – it also emphasizes relational aspects of governance and the importance of trust [44]. Empirical findings suggest that procedural fairness, distributional fairness, and confidence in governance are important determinants of trust, which ultimately leads to achieving social licence [82]. These factors were reflected in the results of this survey as outlined below and provide insight for the development of ADAs as a form of aquaculture governance that supports social licence for low-trophic aquaculture.

First, survey results reflect the importance of community involvement, a component of procedural fairness, in aquaculture governance. Participants expressed interest in community participation, and differences in perceived impacts and values across coastal areas suggests that siting of ADAs will benefit not only from the environmental assessments typically associated with siting, but from active collaboration with community members whose place-based values align with different visions for their coastline. For example, feedback from stakeholders regarding Nova Scotia's first ADA resulted in the removal or adjustment of ADA areas to reflect the concerns of fishers, farmers, groups with recreational interests, environmental groups, and the public [52].

However, consideration of community values and community involvement in ADA development will likely need to move beyond stakeholder engagement and towards a shared decision-making approach if it is to support procedural fairness. Such an approach would also reflect a shifting interest in the benefits of aquaculture from the blue economy narrative, which emphasizes economic benefits, to a blue communities narrative, which emphasizes community wellbeing [9].

Second, interest in local ownership and greater benefits from hosting low-trophic aquaculture in the region amongst participants emphasizes the need for distributional fairness, the perceived fairness of the sharing of costs and benefits of aquaculture. Focusing on monetary benefits, foreign ownership of farms and the distribution of benefits from farming have previously been noted as a concern for communities that host aquaculture sites [22,36]. Connections between ownership and local benefits have been shown in the salmon farming industry in Norway where producer surpluses are more likely to stay in the region when farms are owned locally [1]. Additionally, revenue from the sale of fish farm leases in Norway is distributed to communities that host fish farms as a means of addressing dissatisfaction with the level of financial benefit that communities receive from farming [28,59]. This type of policy is useful in a highly concentrated industry like salmon farming where large companies hold the majority of production [4], but may not translate to low-trophic aquaculture which remains largely unconsolidated and dominated by family firms and smallholders [17,45]. Although financial benefits are only one component of distributional fairness, the unconsolidated structure of shellfish farming may influence perceived fairness of cost and benefit sharing in Pictou County.

Third, the low level of trust in government to manage low-trophic aquaculture sustainability echoes findings that societal expectations of aquaculture are higher than expectations from regulators and authorities [27,60]. Previous experience with government regulation of industry may be a factor in Pictou County where residents have long been concerned about the social and environmental impacts of a pulp mill as well as government failure to monitor the impacts of the mill on human health [71,29,39]. Perceptions of aquaculture can be shaped by local environmental disasters related to other industries [24], and in this case, local experience of regulatory failure in another industry may be shaping trust in government to manage aquaculture rather than trust in the industry itself. In contrast to low trust in government, trust in farmers to manage low-trophic aquaculture and interest in community involvement in aquaculture management were high. In this case, the involvement of farmers in the development of an ADA could support confidence in the ADA as a governance process. The integration of an ADA process with principles from community-based marine aquaculture, a bottom-up approach to aquaculture development that has received positive feedback in Nova Scotia [5], may be beneficial. Regardless of the specific approach, transparency and community involvement including the participation of farmers will be important for trust and the legitimacy of an ADA.

Aquaculture zones such as ADAs could be a solution to some of the barriers to low-trophic aquaculture development, including social acceptance and the regulatory burden faced by local farmers – but the acceptance of low-trophic aquaculture development will depend on trust in the industry and the ADA. As a collaborative process, ADAs provide an opportunity to incorporate and emphasize distributional and procedural fairness which can in turn support confidence in ADAs as a governance process.

5. Conclusion

In this study, results show the important role of experience or exposure to low-trophic aquaculture in acceptability. They also reveal differences in perceptions of and support for aquaculture between coastal areas including the priorities of coastal property owners who value coastal views and recreation and members of farming communities who trust their neighbours to farm responsibly and value the benefits that low-trophic aquaculture brings to their community. Together, these results suggest that top-down communication is not enough to support the social acceptance of low-trophic aquaculture. Proponents of aquaculture will need to engage communities and consider place-based values and expectations for coastal development. In Pictou County, not all coastal residents will be or wish to be directly involved in low-trophic aquaculture, but community involvement and the distribution of benefits realized through aquaculture expansion can support trust in low-trophic aquaculture development. The promise of ADAs to support aquaculture acceptability and reduce regulatory burden will only be enhanced if they embrace these findings through the inclusion of procedural and distributive fairness that in turn build trust in aquaculture development and ADA governance.

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.marpol.2024.106445.

Data Availability

The data that has been used is confidential.

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