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Research

Drivers of social acceptability for bivalve aquaculture in Atlantic Canadian communities

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ABSTRACT. Aquaculture is a growing sector because of increased global demands for seafood; bivalve aquaculture production is also increasing in specific regions because of its perceived sustainability and similar environmental interactions across ecosystems. As socioeconomic impacts on prospective sites may differ, this research aimed to perform a high-level scoping of environmental, social, and economic drivers informing social acceptability of bivalve aquaculture in two communities in Nova Scotia and Prince Edward Island, Canada. Communities were surveyed through online questionnaires designed to examine bivalve farming perceptions, information sources, and potential deviations between communities. Results suggested that community perceptions of environmental effects were both positive and negative, social effects were mostly negative, and economic effects were somewhat positive. Results further suggested that insufficient transparency regarding industry practices and the local communication network may have a role in shaping bivalve farming perceptions. Variation between communities regarding perceived social and economic drivers of social acceptability emphasized the importance of community-based research to understand emerging and existing conflicts, including the role information sources may have in driving acceptability. Accordingly, aquaculture regulators and managers should consider community socioeconomic priorities and improved transparency about industry practices when evaluating prospective sites.

Key Words: *Atlantic Canada; bivalve farming; coastal communities; shellfish aquaculture; social acceptance; socioeconomic impacts*

INTRODUCTION

Seafood is becoming an increasingly important part of people's diets worldwide (Custódio et al. 2020). In 2017, seafood accounted for 17% of the global population's animal protein consumption, and this figure continues to grow with consistent rises in consumption over the last three decades (FAO 2020). As the global demand for seafood grows, so do aquaculture production rates. Aquaculture is responsible for producing almost half of seafood protein worldwide as of 2018 (FAO 2020), while some estimates suggest that aquaculture accounts for over half of seafood production globally (NOAA 2021). This production is estimated to outpace wild capture production by more than 10% by 2030 (FAO 2020).

Currently, 89% of marine bivalves consumed globally are produced through aquaculture (Wijsman et al. 2019). Bivalve aquaculture is often considered a greener industry than other kinds of aquaculture, especially finfish (NRC 2010, Rickard et al. 2018). This perception can be attributed to several factors including the lack of feed input required to grow bivalves (Wijsman et al. 2019), water clarity improvements (Newell and Koch 2004, Weitzman et al. 2019), removal of phytoplankton involved in eutrophication events (Guyondet et al. 2015), and promotion of habitat and vegetation restoration (Walker and Grant 2009, NRC 2010, van der Schatte Olivier et al. 2020). Despite potential benefits to aquatic ecosystems, marine bivalve farming can also negatively impact the production of ecosystem services. For example, metabolic waste products can cause eutrophication in poorly flushed areas (Turner et al. 2019), and can reduce primary production through phytoplankton overgrazing when bivalves are at high stocking densities (Wijsman et al. 2019). Ecosystem impacts stemming from bivalve aquaculture are thus context dependent and must be considered for each prospective site (Newell and Koch 2004, Guyondet et al. 2015). Similarly, public perceptions of ecosystem impacts stemming from bivalve aquaculture are context dependent and can be affected by a variety of drivers (Mather and Fanning 2019), potentially resulting in conflict with the aquaculture industry over the use of marine spaces (Dalton et al. 2017, Campbell et al. 2021).

Aquaculture has been a historically controversial issue. Concerns for aquaculture food safety and environmental sustainability are prevalent throughout North America, Europe, and Australia (Mazur and Curtis 2008, Chu et al. 2010, Ruiz-Chico et al. 2020). Although bivalve aquaculture tends to generate less controversy when compared to finfish farming (NRC 2010, Flaherty et al. 2019), perceived health risks and environmental concerns still exist for the bivalve farming industry (D'Anna and Murray 2015, Garza-Gil et al. 2016, Holden et al. 2019, Britsch et al. 2021). Public concerns regarding social and economic impacts from bivalve farming, including conflicts over marine space uses, limited or conflicting public-facing information, and impact on aesthetics, can also drive social acceptability of bivalve aquaculture (Mazur and Curtis 2008, D'Anna and Murray 2015, Dalton et al. 2017, Holden et al. 2019). These concerns extend to the local level, where some projects are under intense public scrutiny (Bavinck et al. 2017, Beswick 2019). Because of the complexity of these social and economic factors, a degree of synthesis is required to better approach social acceptability in local contexts. Accordingly, these perceived concerns on both a global and local scale could be part of the puzzle for determining the social acceptability of the bivalve aquaculture industry.

These conflicts can be further intensified by how the community acquires information about aquaculture (Young and Matthews 2010, Mather and Fanning 2019). For example, newspaper coverage of "marine aquaculture" is more negative in developed nations, with concerns about environmental impacts, health and food safety, and potential conflicts in ocean spaces (Froehlich et al. 2017, Kluger et al. 2019). Other sources of information,

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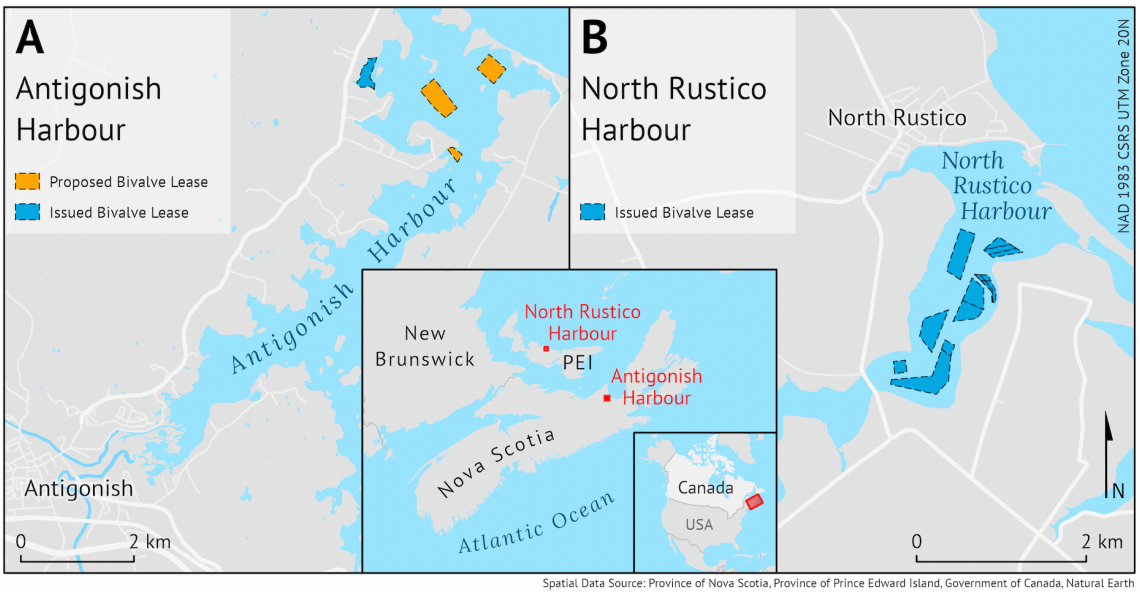
Fig. 1. Map of the Antigonish Harbour, NS area (A) and the North Rustico Harbour, PEI area (B). Existing bivalve leases are shown in blue and proposed bivalve leases are shown in orange.



including social media, word of mouth, and personal experiences with the industry, can also play a role in determining social acceptance (Flaherty et al. 2019, Mather and Fanning 2019). The extent that these sources of information impact perceptions can vary in differing contexts, especially on a local scale where vocal interest groups can receive significant attention within and outside of the community (Young and Matthews 2010, Froehlich et al. 2017, Mather and Fanning 2019). Therefore, understanding sources of information at a local level is an important part of exploring drivers of social acceptability for bivalve aquaculture.

Bivalve aquaculture is an industry with opportunities for sustainable growth. However, perceived environmental concerns, health concerns, and conflicting uses of marine space related to bivalve aquaculture development can lead to controversy, and ultimately, a lack of social acceptability. Based on Krause et al. (2020:2), social acceptability refers to "a collective community-based evaluation" of actualized or perceived trade-offs regarding bivalve aquaculture operations. This community-based evaluation of the industry may be informed by differing contextual factors. Identifying these factors is important to understand the extent that local conditions influence social acceptability, particularly for communities experiencing existing and emerging controversy with the industry (Krause et al. 2019). This research explores the drivers of social acceptability for bivalve aquaculture in two Atlantic Canadian communities. These communities, Antigonish Harbour and North Rustico Harbour, represent smaller, rural communities in Nova Scotia (NS) and Prince Edward Island (PEI) where controversy regarding bivalve aquaculture is emerging, including socioeconomic and species-specific concerns, respectively. The objectives of this research are to determine (1) drivers of social acceptability for bivalve aquaculture in these communities, (2) whether the drivers deviate between communities, and (3) whether the source of bivalve aquaculture information differs between communities. We argue that insights gained from identifying and comparing factors influencing social acceptability in two communities with differing bivalve aquaculture experiences could assist regulators and the industry with understanding and addressing concerns in a region where operations are expected to expand (DFA [date unknown], Flaherty et al. 2019).

BACKGROUND AND STUDY SITES

Antigonish Harbour

Antigonish Harbour is located in the northeastern region of Nova Scotia (NS), Canada (Fig. 1). The town of Antigonish borders the harbor with a population of 5000 (Statistics Canada 2017a), and is economically and culturally supported by two sectors: St Francis Xavier University and the local arts-based tourism industry (The Town of Antigonish [date unknown]). Education and tourism represent 18% and 15% of the workforce, respectively, while health care composes 18% of the workforce (Statistics Canada 2017a). A proposed oyster farm (Fig. 1), which would be one of two farms in the harbor and the larger of the two, has generated controversy in the community (Beswick 2019). The controversy of the proposed farm culminated in a meeting in Antigonish where some attendees raised concerns about impacts to the harbor ecosystem, recreational uses of the coastal space, and potential impacts to property values stemming from the implementation of a farm (MacKenzie 2019).

The aquaculture sector employed 881 Nova Scotians with a market value of more than $90 million in 2020 (DFA 2021). Farmed species include bivalves, finfish, and seaweeds; however, bivalve aquaculture is responsible for only 4% of the total provincial value derived from aquaculture production (DFA 2020). In NS, aquaculture has been promoted as a way to support

rural economic development (DFA 2021), and aquaculture operations in NS are expected to expand to meet existing seafood demands (DFA [date unknown], Flaherty et al. 2019). Despite federal and provincial support, aquaculture operations, particularly finfish farming, have been met with opposition in some communities across the province because of concerns about potential environmental impacts and conflicts with other marine industries, including tourism (Bavinck et al. 2017).

North Rustico Harbour

North Rustico Harbour is found in the north-central section of Prince Edward Island (PEI), Canada bordered by several small communities (Fig 1.). The town of North Rustico is the largest residential area with a population of 600 (Statistics Canada 2017b). The major economic drivers in North Rustico are the tourism and fishing industries (DFO and Parks Canada 2007). In particular, 13.5% of the workforce is employed in resource-based industries, including agriculture, forestry, fishing, and hunting (Statistics Canada 2017b). North Rustico Harbour is occupied by several mussel leases and oyster leases (Fig. 1); however, more farmers are transitioning from mussel to oyster leases in the harbor (M. Ouellette, *personal communication*, 14 February 2020). The transition has raised concerns for some residents in the North Rustico Harbour area, particularly regarding the aesthetics of the oyster cages (M. Ouellette, *personal communication*, 14 February 2020), despite similar ecosystem functions and services of mussel and oyster farming (NRC 2010).

PEI is the largest producer of mussels and second-largest producer of oysters in Canada (DFO 2016), and operations are expected to expand within the province (M. Ouellette, *personal communication*, 14 February 2020). The aquaculture industry is a major economic driver in PEI, with 8000 people employed in peak seasons and contributing almost 10% of total provincial GDP (DFC 2021). In particular, mussel farming plays a key role in PEI culture and identity (Krause et al. 2020). Bivalves and finfish are both farmed in PEI, with bivalves accounting for 91% of total aquaculture production in the province (DFC 2021). The PEI Aquaculture Alliance is a non-profit representing mussel, oyster, and finfish farmers in the province, and its primary function is to liaise with the federal and provincial governments regarding the promotion and growth of the industry.

METHODS

To fulfill the identified research objectives, a mixed methods approach was used in an online questionnaire. Following Krause et al. (2019), social acceptability for bivalve aquaculture can be assessed using two indicators: public attitude toward bivalve farming and emerging and existing conflicts. However, given the uncertainty about which drivers inform social acceptability in the study sites, we developed a scoping exercise using the three pillars of sustainability (environment, economy, society) to examine which drivers are relevant.

The questionnaire had both quantitative and qualitative components and was designed to target two main topics regarding bivalve aquaculture at the community level: values and information sources. Value statements about aquaculture perception organized using the three pillars of sustainability were assessed using a Likert-type scale. The value statements were based on D'Anna and Murray (2015). Statements were adjusted or removed to better reflect possible drivers of social acceptability for the region using newspaper coverage of the controversy in Antigonish Harbour (e.g., Beswick 2019, MacKenzie 2019), and to serve as a tool for comparison between the communities. Utilizing a Likert-type scale for value statements as described in D'Anna and Murray (2015) allowed for the application of commonly identified topics related to social acceptability of the bivalve aquaculture industry in rural Canadian communities. Survey questions about aquaculture information sources were based on Flaherty et al. (2019) where common information sources in Atlantic Canada were identified and used for comparison. Following Flaherty et al. (2019), survey questions were species-specific (i.e., oysters and mussels) because information sources can vary with the farmed species, which was particularly relevant to North Rustico Harbour. Last, an open-ended comment field was included to capture more detailed perspectives and emerging themes that may not have been addressed by the value statements.

The questionnaire began with demographic questions; the participant was asked to disclose their location (Antigonish Harbour or North Rustico Harbour), age, gender, and whether they were personally involved or had family/friends involved in the aquaculture industry. Next, participants were asked to rate their familiarity with mussel and oyster aquaculture separately on a 4-point Likert scale. The questionnaire continued with the participants being asked to identify from a list sources of information for mussel and oyster aquaculture separately, and could select as many sources as they determined necessary. Next, a series of value statements related to bivalve aquaculture were rated on a 6-point Likert scale, where the sixth option was "I don't know." The final section in the questionnaire was an open-ended comment field for respondents to leave thoughts and insights regarding bivalve aquaculture in their community. Participants were not required to answer any questions.

The online questionnaire was conducted from mid-June to early September in 2020 under Dalhousie University Marine Affairs Program Ethics Review Standing Committee file #2020-05. The questionnaire was administered online through Opinio, a survey tool hosted on Dalhousie servers. Respondents were required to be 18 years of age or older and a resident near either Antigonish Harbour or North Rustico Harbour. The online questionnaire was distributed using postcards with a link to the Opinio survey website. It has been demonstrated that a mailed survey invitation may increase recruitment for an online survey (Bandilla et al. 2014), which also removed the need to collect email addresses. The postcards were distributed to residential addresses using a Canadian mailing service (The Printing House). Smartmail Marketing™ routes available through Canada Post, the primary postal operator in Canada, determined the residential addresses that received postcards. The Smartmail Marketing™ routes were concentrated on residential areas within 2km of the harbors, which included the towns of Antigonish and North Rustico. Postcards were mailed to Antigonish Harbour (n = 3229) and North Rustico Harbour (n = 411) during the week of 15 June 2020; a second round of postcards were mailed to North Rustico Harbour (n = 411) in late August 2020 because of limited initial responses. The number of postcards mailed to households was used as the total population for each community.

The questionnaire had 118 total respondents: 75 from the Antigonish Harbour area (AH) and 43 from the North Rustico Harbour area (NRH). Demographic information for study respondents is described in Table 1. These samples represented a 95% confidence interval and a margin of error of 11% for AH, and a 95% confidence interval and a margin of error of 15% for NRH. Because of the low response rates, these samples cannot be generalized for the AH and NH populations. However, the samples provided relevant insight into individual perspectives for the two communities.

Table 1. Demographic information for Antigonish Harbour (n = 118) and North Rustico Harbour (n = 43) respondents.

		Antigonish Harbour (%)	North Rustico Harbour (%)
Age	18–24	9	2
	25–34	4	2
	35–44	7	14
	45–54	12	12
	55–64	23	14
	65+	45	56
Gender	Male	51	42
	Female	48	54
	Non-binary	1	2
	Other	0	2
Aquaculture Industry Involvement	Personal	3	5
	Family/Friends	18	33

Differences in value statements between communities were tested using U Mann-Whitney. The distributions of responses were dissimilar in the communities as identified by visual inspection of histograms; therefore, U Mann-Whitney tests were conducted to determine differences in the mean ranks of variables across study sites. All responses for the Likert-type scale were assigned a number from 1 to 5, corresponding with responses to the value statements ranging from strongly disagree (1) to strongly agree (5). The median response for each value statement was described using the language associated with the statements rather than the numeral. Responses to the open-ended comment field were grouped by primary theme (e.g., environment, social); for responses that addressed more than one theme, the theme most frequently discussed was used.

RESULTS

Identified drivers

Environmental drivers

Three statements were related to environmental drivers of social acceptability (Fig. 2). AH and NRH respondents both agreed that pollution and alterations to the ocean floor can stem from bivalve farming (median = agree). NRH respondents generally agreed that farmed bivalves could clean the waters the farms operate in (median = agree), while AH respondents felt neutral about this statement (median = neutral); however, the community responses regarding this statement were statistically similar ($p = 0.076$; Table A1.1). Both communities thought that bivalve aquaculture can have important impacts on coastal ecology (median = agree), although it is important to note that no differentiation was made between positive or negative impacts in the phrasing of this statement (Fig. 2). Accordingly, both communities shared positive and negative perceptions of all environmental drivers.

Environmental issues were addressed in several comments left by individual respondents from both communities. Some respondents had concerns about water quality, negative impacts to marine mammals and shorebirds, eelgrass, and overall harbor health. A respondent from NRH summarized most of the negative impacts participants identified:

> *Since our arrival on the Island 30+ years ago, my wife and I have seen more and more of these two industries (first mussel, now oyster) covering estuaries throughout the north shore of the province. Knowing the critical role of estuaries as nurseries of the marine life out of this ecosystem in waters in and around the Island... Having dove once under a mussel bed in one of our estuaries, I was astounded by the thick layer of suspended waste underneath it. However, I was also impressed by the amount of life, including starfish, clinging to the mussel socks.*

Some respondents indicated that bivalve farming could provide ecosystem services, such as "eel grass recovery" and reduction of "excessive nutrient inputs." One respondent indicated that negative environmental issues associated with bivalve farming can be mitigated when farmers use "the most up to date methods and follow the regulations."

Economic drivers

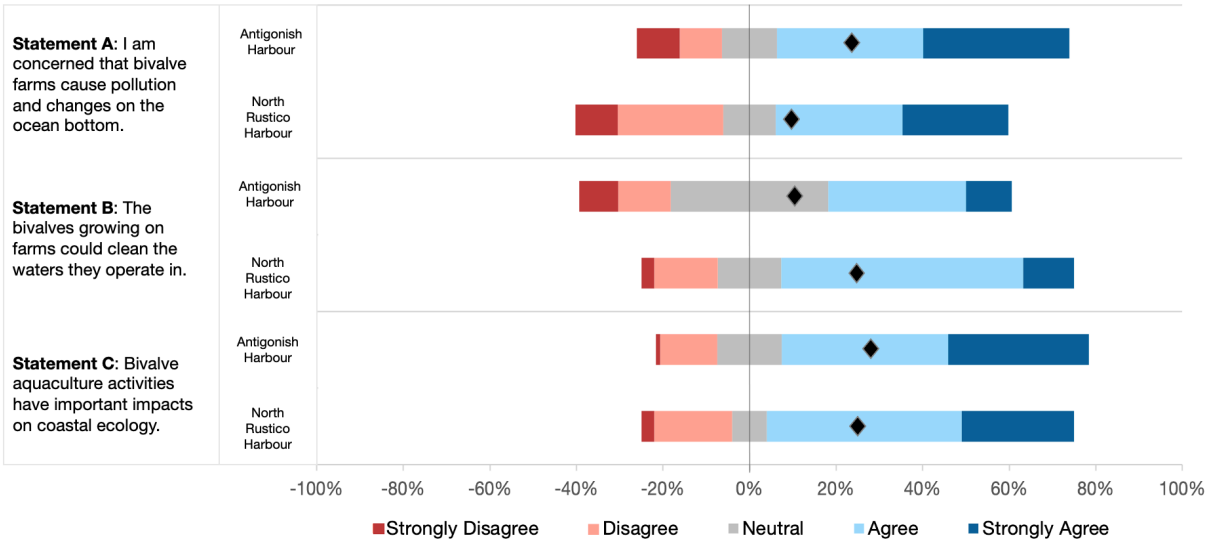
Four statements approached the economic drivers of social acceptability (Fig. 3). Respondents from NRH generally felt that bivalve aquaculture provides or could provide local, sustainable jobs with a benefit to their economy (median = agree), whereas AH respondents felt more neutrally about these possibilities (median = neutral); the variation in these responses were statistically significant between communities ($p < 0.05$; Table A1.1). AH respondents generally believed that bivalve farms could negatively impact marine or coastal businesses (median = agree), while NRH respondents felt neutral about this statement (median = neutral); however, the community perceptions for this statement were not statistically significant ($p = 0.218$; Table A1.1). The perceptions of economic drivers were the most variable between communities, with NRH being more positive overall.

Although the value statements indicated that economic drivers were perceived more positively than other drivers, particularly in NRH, comments regarding economic drivers were generally more negative. Some respondents indicated that bivalve farming "provides many jobs" and "can be an asset to the community" when "well operated... and maintained." However, several comments discussed potential negative impacts to property values resulting from bivalve aquaculture. Respondents felt that "aquaculture would... have a significant negative impact on the value of [their] properties" and "...how [bivalve aquaculture] affects beauty of the area [and] other [people's] property values... is important to consider." Impacts to property values was a recurrent theme for respondents in both communities.

Social drivers

Three statements were related to the social drivers of social acceptability (Fig. 4). AH and NRH respondents both felt that aquaculture gear would negatively impact their enjoyment of

Fig. 2. Environmental themed statements ranked on a 5-point Likert-type scale by respondents. The percentage of responses is plotted for each Likert category, with the bar centered at the neutral response. Accordingly, negative and positive percentages indicate overall disagreement or agreement with the statement, respectively. The diamond represents the median response on a scale from 1-5 for each statement, corresponding to responses to the value statements ranging from strongly disagree (1) to strongly agree (5). There are no statistically significant differences between communities.



coastal spaces (median = strongly agree and agree, respectively); however, these community variations in agreement were not statistically significant ($p = 0.184$; Table A1.1). Most AH respondents strongly believed that the presence of debris would diminish their enjoyment of the harbor and opinion of the industry (median = strongly agree), while NRH respondents did not believe as strongly (median = agree); these community variations were statistically different ($p < 0.05$; Table A1.1). AH and NRH respondents felt that there should not be more bivalve aquaculture in their communities (median = disagree), although it is important to note that the wording of this statement did not address whether respondents were satisfied with the current level of bivalve aquaculture in their communities. Overall, both communities had similar negative perceptions of social drivers, with NRH being slightly less negative about the presence of aquaculture debris.

Respondents in both communities indicated concerns about other social uses of the harbor becoming compromised. These concerns often stemmed from the physical attributes of the harbor; several respondents indicated that they believed the harbor was too "shallow" and "narrow" for bivalve aquaculture activities to occur without compromising current uses of the harbor. The following respondent from NRH identified potential positive benefits from oyster farming, such as cleaner waters, and proceeded to address the following social impacts that were frequently discussed in the comments:

> *Where I live we would... lose the recreational benefits and intangible benefits such as the beautiful view of the water in Rustico Bay. This is very important to tourism as well. People come to PEI to enjoy swimming, kayaking, gorgeous views and ugly black oyster cages would be a detriment to all of these. There are many areas more appropriate where [recreational] use isn't as important... there are kids playing and swimming in the water almost every day.*

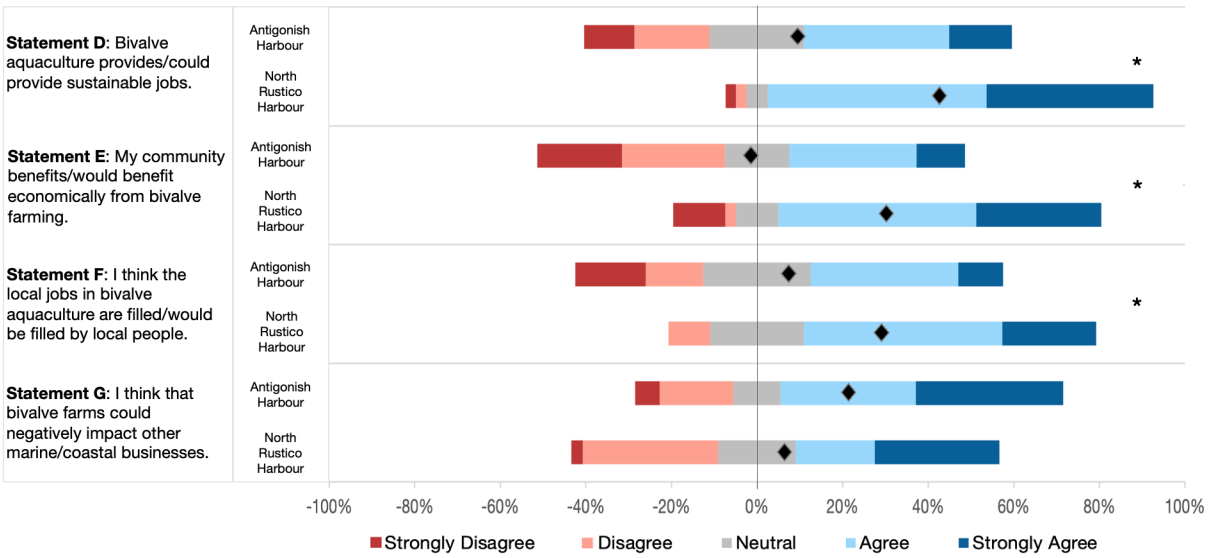
Governance drivers

Although none of the value statements discussed the role of government or aquaculture industry specifically, several comments mentioned that both stakeholders impact their perception of the bivalve aquaculture industry. The following NRH respondent indicated that their perceptions of bivalve aquaculture have changed over time, which addressed most of the negative responses left by other participants:

> *I used to feel that it was a moral responsibility to share [the harbor] with the aquaculture companies, but there is no 'sharing' on their side. They seem to have very little concern or consideration for us as they grow their leases and add more... gear. We are not consulted in any way. We are told that the water quality is improving, but I no longer trust either the government or the businessmen.*

Other respondents indicated that they would be more supportive of bivalve aquaculture on a smaller scale and if it were "owned by the local population." Only a couple of respondents contradicted these mostly negative perceptions of government and industry, expressing that "the public should have nothing to do with [bivalve aquaculture industry management] ... I hate not in my backyard type politics." Participants from both communities mentioned governance drivers.

Fig. 3. Economic themed statements ranked on a 5-point Likert-type scale by respondents. The percentage of responses is plotted for each Likert category, with the bar centered at the neutral response. Accordingly, negative and positive percentages indicate overall disagreement or agreement with the statement, respectively. The diamond represents the median response on a scale from 1-5 for each statement, corresponding to responses to the value statements ranging from strongly disagree (1) to strongly agree (5). The asterisk indicates statistically significant differences between communities.



Aquaculture information sources

In general, AH respondents selected more information sources for oyster aquaculture when compared to mussel aquaculture, and NRH respondents had a similar number of sources for both aquaculture types (Fig. 5). Word of mouth was the most frequently selected oyster and mussel aquaculture information source for both communities. AH respondents selected word of mouth more frequently for oyster aquaculture when compared to mussel aquaculture; a similar percentage of respondents from NRH selected word of mouth as an information source for both aquaculture types. Other sources of information that both AH and NRH respondents frequently selected were online websites and personal experiences. AH respondents selected online websites more frequently than NRH respondents for both types of bivalve aquaculture. NRH respondents selected personal experiences more frequently than AH respondents for both types of aquaculture as well. The percentage of AH respondents that selected scientific articles as a source of oyster aquaculture information was more than four times the percentage of NRH respondents; similarly, AH respondents selected scientific articles as a source for mussel aquaculture three times more than NRH respondents. Newspapers and industry contacts were also relevant sources, particularly in the NRH community.

DISCUSSION

This research identified the relevant environmental, economic, and social drivers affecting social acceptability of bivalve aquaculture in two communities where emerging conflict with the industry has occurred. The responses to the value statements were diverse, ranging from strongly disagree to strongly agree for several statements. Community perceptions of environmental effects of bivalve aquaculture were viewed both positively and negatively. In contrast, perceptions of social and economic effects were mostly negative and positive, respectively. Additionally, the emergence of governance drivers during the survey demonstrated that community perceptions of how aquaculture is regulated and managed can also impact social acceptability of the industry. Differences in community perception of the economic and social themes emphasized the importance of identifying drivers of social acceptability when emerging conflicts with bivalve aquaculture are found at the community level. Last, the use of different aquaculture information sources may reflect the nature of social acceptability issues in local contexts.

Drivers of social acceptability

Regarding environmental drivers, participants were concerned about pollution, and negative impacts to aquatic vegetation and coastal and marine wildlife. However, some participants identified potential positive impacts, including water cleanliness and artificial habitats that aquaculture gear can create. These mixed perceptions have been related to uncertainties about bivalve aquaculture interactions with coastal ecosystems (Mazur and Curtis 2008, D'Anna and Murray 2015, Flaherty et al. 2019). Aquaculture environment interactions are site-specific and depend on the farmed biomass (Turner et al. 2019, Filgueira et al. 2021). There are cases in which aquaculture exceeded the carrying capacity of the system leading to several ecosystem impacts (Raillard and Ménesguen 1994, Smaal et al. 2001), and in other cases, bivalve aquaculture has minimized potential eutrophication (Guyondet et al. 2015, Lavaud et al. 2020). Accordingly, the local context and documented positive and negative impacts in the scientific literature could explain mixed perceptions about potential environmental effects. Generally, community members are more likely to support aquaculture when

Fig. 4. Social themed statements ranked on a 5-point Likert-type scale by respondents. The percentage of responses is plotted for each Likert category, with the bar centered at the neutral response. Accordingly, negative and positive percentages indicate overall disagreement or agreement with the statement, respectively. The diamond represents the median response on a scale from 1-5 for each statement, corresponding to responses to the value statements ranging from strongly disagree (1) to strongly agree (5). The asterisk indicates statistically significant differences between communities.

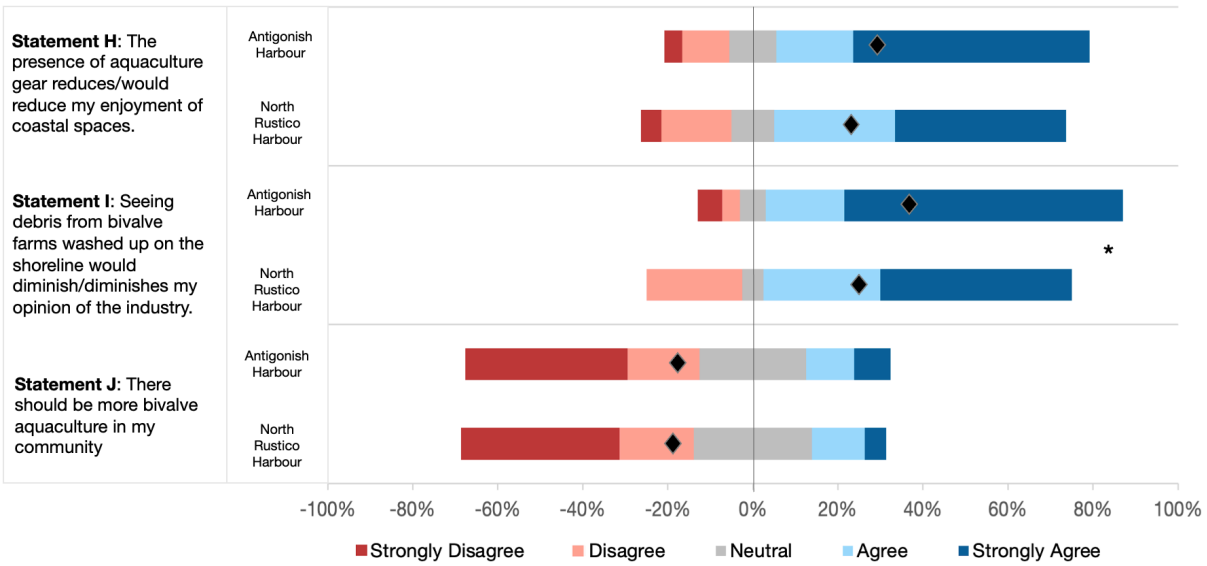


Fig. 5. Oyster and mussel aquaculture information sources selected by respondents. Antigonish Harbour (n = 311, n = 218) and North Rustico Harbour (n = 164, n = 147). Respondents could select more than one response.

	Oysters		Mussels	
	AH	NRH	AH	NRH
Word of Mouth	67%	79%	45%	77%
Online (websites)	61%	42%	41%	28%
Personal Experience	37%	51%	25%	53%
Newspapers	28%	35%	20%	35%
TV	15%	14%	16%	14%
Documentaries	21%	19%	19%	12%
Social Networking	23%	14%	13%	9%
Industry Brochures	23%	14%	12%	21%
Scientific Articles	57%	14%	33%	9%
Industry Contact	21%	37%	9%	33%
Educational Institutions	20%	12%	15%	9%
Magazines	13%	12%	11%	9%
Radio	20%	19%	20%	16%

Least selected
Most selected

they believe that activities do not degrade local ecosystems; this perception can be improved when communities are provided information about environmental impacts (Katranidis et al. 2003, Barrington et al. 2010, Flaherty et al. 2019). Therefore, localized studies about environmental effects of bivalve aquaculture could reduce mixed opinions about the potential impacts (Mazur and Curtis 2008).

Participants had negative perceptions of social drivers related to the enjoyment of coastal spaces, which echo findings from the literature (D'Anna and Murray 2015, Knapp and Rubino 2016). D'Anna and Murray (2015) found that perceptions were highly dependent on the involvement of participants in the industry, where industry involvement correlated with a focus on economic and environmental benefits rather than social impacts. The low involvement of participants in the aquaculture industry in our study could explain negative perceptions of social effects. Negative social impacts are often viewed as a trade-off for local economic benefits (Katranidis et al. 2003, Mazur and Curtis 2008, D'Anna and Murray 2015, Knapp and Rubino 2016); therefore, positive economic effects could play a role in mitigating the negative perceptions of the social drivers. Despite this potential mitigating role, findings from this study and the literature also suggest that economic and social trade-offs are not always straightforward. For example, the more positive view of economic aspects in NRH could be related to the longer history of the industry in this community compared to the emerging industry in AH. The positively perceived economic drivers in this study included the creation of local jobs; however, potential negative impacts on property values were a frequent concern. Evans et al. (2017) found that aquaculture could negatively impact property values, but this finding was not consistent across the three evaluated study sites. Furthermore, increases in local income triggered by aquaculture development may strengthen local economies (Katranidis et al. 2003, Evans et al. 2017). Accordingly, assessing aquaculture effects on social and economic drivers is highly dependent on coastal settings, further emphasizing the importance of localized studies that consider the social and economic dimensions of bivalve aquaculture (Whitmarsh and Palmieri 2009, Holden et al. 2019).

The questionnaire did not include questions designed to address governance drivers; however, participants addressed governance themes frequently in the comments. The influence of governance drivers on aquaculture perceptions has been recognized in the literature (Mather and Fanning 2019, Britsch et al. 2021). Participants of this study showed a desire for increased transparency and accountability from regulators and aquaculture managers in bivalve aquaculture site selection and regulation, particularly in the comments from AH, which emphasized distrust between community members and governance institutions. Trust is a key component of social acceptability for aquaculture operations (Barrington et al. 2010, Schlag and Ystgaard 2013, Holden et al. 2019), so existing controversy involving bivalve farming may stem from a lack of trust in government and industry, as well as limited transparency about project logistics and potential impacts to coastal spaces (Mazur and Curtis 2008, D'Anna and Murray 2015). Furthermore, because aquaculture developments depend on shared uses of coastal spaces between public and private interests, potential conflict for space may arise (Knapp and Rubino 2016, Holden et al. 2019). Given the role that coastal spaces and their cultural uses have in the well-being of communities (Outeiro and Villasante 2013, Campbell et al. 2021), the allocation of public space to a private entity must be a transparent process, and it can be an important determinant of social acceptability for bivalve aquaculture.

In general, Canadians have a favorable perception of the industry's potential for economic growth and perceived sustainability (Flaherty et al. 2019), which is echoed in international research (Chu et al. 2010, Bacher 2015, Ruiz-Chico et al. 2020). Although the surveyed communities felt that the industry has some environmental and economic benefits, concerns about negative environmental and social effects of bivalve aquaculture were strong. Given the relevance of the potential conflict for space, coastal zone management that considers all economic and social uses may address some of the concerns, minimizing impacts, and potentially improving the perception of the industry (D'Anna and Murray 2015, Evans et al. 2017, Holden et al. 2019). In general, improved transparency in the industry when dividing public and private spaces can address feelings of distrust and alienation (Mazur and Curtis 2008, D'Anna and Murray 2015). Because environmental, social, and economic effects of bivalve aquaculture are context-dependent, studies assessing social acceptability of the industry should be performed at a local scale (Mather and Fanning 2019, Krause et al. 2020). Finally, consideration of the socioeconomic context for prospective sites may improve the integration of bivalve farming with existing coastal spaces, ensuring long-term sustainability of the site and industry (Whitmarsh and Palmieri 2009, Thomas et al. 2018, Caporale et al. 2020).

Influence of local settings on social acceptability

Although both Antigonish Harbour (AH) and North Rustico Harbour (NRH) communities shared the same perception regarding the environmental implications of bivalve aquaculture, differing perceptions emerged in economic effects and to a certain degree in social drivers. AH respondents generally opposed the implementation of bivalve aquaculture in their community, as suggested by the more negative responses about potential aquaculture expansion. The variations in economic and social drivers between both communities can reflect how the same drivers may be perceived differently based on community context (Mazur and Curtis 2008, Ford and Williams 2016). For example, locals who value recreational uses as a crucial part of the coastal space are more likely to perceive changes to that space negatively (Shafer et al. 2010); similarly, homeowners with waterfront views may be more likely to perceive visual impacts from shellfish aquaculture on the surrounding landscape negatively (Dalton et al. 2017).

Similar to other communities throughout PEI, NRH has been a site for bivalve aquaculture developments for several decades (DFO 2006). In contrast, AH had only been recently considered as a prospective site at the time of this study (Beswick 2019). Shifts in community opinion can occur with exposure to industry; a community that initially disapproves of changes in land use for the proposed industry may perceive the industry more positively if the community observes economic benefits (Ford and Williams 2016). According to Katranidis et al. (2003), long-term exposure to the aquaculture industry can reveal economic benefits influencing social acceptability, which may relate to the experiences of both communities in this study. NRH may be more positive because of long-term exposure to the aquaculture industry while AH may be more negative because of the lack of exposure. Overall awareness of the aquaculture industry also seems to have a role in aquaculture perception, as those with higher awareness and exposure to the industry tend to be more supportive of aquaculture development (Mazur and Curtis 2008, Freeman et al. 2012, Thomas et al. 2018). However, it would be incorrect to assume that exposure to the industry is the only requirement to achieve social acceptance, as the interactions between aquaculture, coastal spaces, and communities are dynamic (Dalton et al. 2017, Thomas et al. 2018). Identifying and addressing the drivers of social acceptance for bivalve aquaculture requires contextualized consideration of environmental, economic, social, and governance dimensions.

Impacts of information sources on social acceptability

Most participants received their information about bivalve aquaculture through word of mouth along with personal experiences. The frequency of these sources, along with the selection of industry contacts by NRH, is supported by the existing literature, where word of mouth, personal experiences, and industry contacts were the most frequently cited information sources for bivalve aquaculture in Atlantic Canada (Flaherty et al. 2019). It has been suggested that personal experiences can play a large role in shaping public perceptions of aquaculture (Young and Matthews 2010, Bacher 2015). Furthermore, the level of knowledge about bivalve aquaculture that informs perceptions may vary with local contexts (Brunson and Shindler 2004), and having industry involved in the local communication network may improve acceptability (Brunson and Shindler 2004, Mazur and Curtis 2008, D'Anna and Murray 2015). Based on the long-term exposure to the industry in NRH, increased personal experiences and industry contacts operating within the local communication network could help explain the more positive perception of specific social and economic drivers. Accordingly, the different exposure to aquaculture in both communities can shape the communication network, level of knowledge, and, consequently, perception of the industry.

More than half of AH respondents indicated that they get some of their information about oyster aquaculture from scientific articles, whereas NRH respondents indicated they do not commonly use scientific articles as an information source. The contrasting interest in scientific articles for the communities could be explained by differing exposure to the industry. Because the prospective oyster farm in AH is a recent development, the local community's high interest in scientific publications could reflect how the community engages with the new development. Additionally, news articles were also commonly selected sources in both AH and NRH, echoing the results for Atlantic Canadians in Flaherty et al. (2019). News articles in Canada feature more negative coverage of marine aquaculture relative to other developed countries (Froehlich et al. 2017), and media interest in aquaculture tends to increase when controversy occurs (Young and Matthews 2010, Rickard et al. 2018). Given that the portrayal of aquaculture in the media has a role in aquaculture perception (Feucht and Zander 2017), and the media is viewed somewhat reliably in Atlantic Canada (Flaherty et al. 2019), the negative media portrayal of the industry may impact overall perceptions.

Even though participants selected seven sources of aquaculture information on average, some of the comments from participants suggested that there is a need for increased or improved sources of aquaculture information; for example, one respondent from AH stated that "... more information needs to be presented to the public." As previously established, effects and perceptions of bivalve aquaculture are context-dependent, which can result in the prioritization of certain effects depending on the community (Mazur and Curtis 2008, Ford and Williams 2016). Therefore, information needs in communities can differ as well (Mazur and Curtis 2008), as exemplified by the different frequency of use of scientific articles in this study. However, it is important to note that increasing information and knowledge does not necessarily improve public perceptions of bivalve aquaculture (Brunson and Shindler 2004, Ford and Williams 2016). In fact, increasing aquaculture knowledge can increase conflicting claims, resulting in more uncertainty (Young and Matthews 2010). Future research should explore how information sources and level of knowledge about the industry intersects with the formation of public perceptions.

Limitations

Recruitment was the primary limitation for this study. A lack of financial incentives, follow-ups with multiple contact strategies, and interest in the research topic were possible reasons for the lower response rates (Dillman 1991). Furthermore, participants were required to have devices with internet access to complete the survey, which was a limiting factor for recruitment. Our demographic information indicates most respondents in both communities were seniors (45% AH, 56% NRH; Table 1), which does not accurately reflect the demographics of the communities (26% AH, 35% NRH; Statistics Canada 2017a, 2017b). Further, the survey took place in the wake of ongoing controversy about a proposed oyster farm in the Antigonish Harbour, which may have caused bias in the survey results. Therefore, it is important to state that the perceptions in this study represent individual voices, but not the community as a whole. The outcomes of this study indicate what is important for the community, but not the level of acceptability within the community.

CONCLUSION

Aquaculture production is expected to increase worldwide as demands for seafood protein increases. Bivalve farming could be an important part of the solution; however, conflicts between the industry and coastal communities may impede further development. This research identified environmental, social, and economic drivers of social acceptability in two Atlantic Canadian communities and found that the drivers are similar to those in existing literature. Although the perception of environmental drivers was similar in both communities, there was variation in perceived social and economic drivers of social acceptability, which suggests that drivers of acceptability for the industry should be considered on a community basis to better address local contexts and conflicts. Communities have different needs and priorities for coastal spaces, and conflict for the use of those spaces can emerge as bivalve aquaculture continues to grow. Aquaculture regulators should consider community priorities, particularly socioeconomic priorities, for coastal spaces when evaluating prospective sites to improve the integration of bivalve farming with existing coastal uses. Given the role of local sources of information in aquaculture knowledge and perceptions, clearer communication and improved transparency from aquaculture regulators about industry practices may reduce uncertainty about potential effects. A better understanding of social acceptability drivers and improved community integration with the decision-making process can provide a stronger foundation for aquaculture regulators and communities to meet desired outcomes when developing coastal spaces. Future avenues could explore the role that local communication and trust networks have in generating bivalve aquaculture perceptions through follow-up interviews with key stakeholder representatives.

Responses to this article can be read online at:
https://www.ecologyandsociety.org/issues/responses.php/13358

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Data Availability:

The quantitative data that support the findings of this study are openly available in Open Science Framework at https://doi.org/10.17605/OSF.IO/AQWCX https://doi.org/10.17605/OSF.IO/AQWCX. All other data are not publicly available because they contain personal information that would make it difficult to

maintain anonymity and could compromise the privacy of research participants and citizens. Ethical approval for this research study was granted by the Dalhousie University Marine Affairs Program Ethics Review Standing Committee file #2020-05.

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Appendix 1. Statistical tests.

Table A1.1. Statistics for value statements. Medians were ranked using a 5-point Likert-type scale, where 1-2 indicated disagreement, 3 indicated neutrality, and 4-5 indicated agreement. U Mann-Whitney tests were conducted to determine the differences in the mean ranks of variables across study sites. The term 'bivalve' replaced 'shellfish' for the purposes of Figures 2, 3, and 4.

Statement	Location	n	Median	Mean Rank	U Mann-Whitney	P-value
Statement A: I am concerned that shellfish farms cause pollution and changes on the ocean bottom.	AH	71	4	59.80	1221.5	0.143
	NRH	41	4	50.79		
Statement B: The shellfish growing on farms could clean the waters they operate in.	AH	66	3	46.98	889.5	0.076
	NRH	34	4	57.34		
Statement C: Shellfish aquaculture activities do not have important impacts on coastal ecology.†	AH	68	2	52.37	1215.0	0.593
	NRH	38	2	55.53		
Statement D: Shellfish aquaculture provides/could provide sustainable jobs.	AH	68	3	45.24	730.5	p<0.001
	NRH	41	4	71.18		
Statement E: My community benefits/would benefit economically from shellfish farming.	AH	71	3	48.76	906.0	p<0.001
	NRH	41	4	69.90		
Statement F: I think the local jobs in shellfish aquaculture are filled/would be filled by local people.	AH	67	3	47.96	935.5	p<0.01
	NRH	41	4	65.18		
Statement G: I think that shellfish farms could negatively impact other marine/coastal businesses.	AH	70	4	57.14	1145.0	0.218
	NRH	38	3	49.63		
Statement H: The presence of aquaculture gear reduces/would reduce my enjoyment of coastal spaces.	AH	72	5	60.42	1302.0	0.184
	NRH	42	4	52.50		
Statement I: Seeing debris from shellfish farms washed up on the shoreline would diminish/diminishes my opinion of the industry.	AH	70	5	59.70	1106.0	p<0.05
	NRH	40	4	48.15		
Statement J: There should be more shellfish aquaculture in my community.	AH	71	2	56.25	1402.5	0.911
	NRH	40	2	55.56		

†Statement C was reworded in Figure 2 in the affirmative (i.e., Bivalve aquaculture activities *have* important impacts…) for clarity.