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Exploring community-based marine aquaculture as a coastal resource management opportunity in Nova Scotia, Canada

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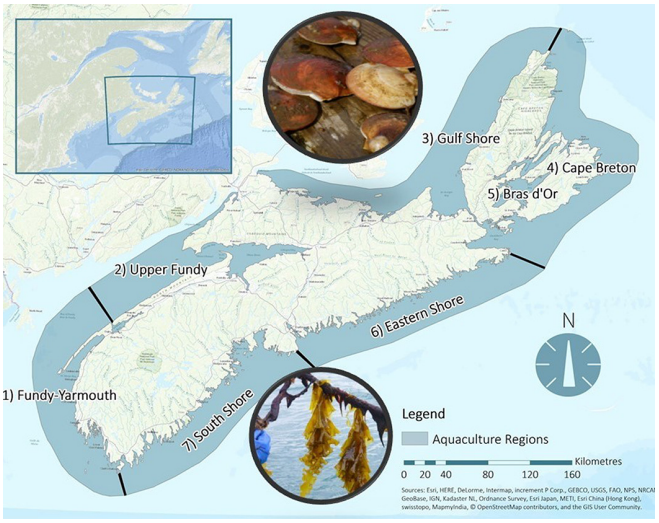
Abstract

Aquaculture is one of the world's fastest growing food production sectors and presents an opportunity for rural community development that can support coastal livelihoods. An ecosystem approach to aquaculture (EAA) has been recommended to facilitate socially and environmentally sustainable development, yet there remains a need to better involve people in planning and operational aspects. Community-based management may help to implement principles of the EAA; however, context-specific research is needed to understand its potential application and suitability. This research explores opportunities for community-based marine aquaculture (CBMA) for nonfinfish in the context of Nova Scotia, Canada, through a series of stakeholder interviews. Results suggest that all stakeholder groups interviewed were positive about the potential for CBMA to support sustainable aquaculture growth in the province; however, key questions around operationalizing CBMA remain. The aquaculture industry is on a continual path for growth worldwide and, therefore, it becomes increasingly important to proactively examine strategies such as CBMA that can help to facilitate EAA in a way that genuinely puts people at the centre of aquaculture development and governance.



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Introduction

Global trends show that aquaculture is increasing steadily as one of the fastest growing food production sectors (FAO 2016)—a phenomenon that has been commonly referred to as the "Blue Revolution" (Krause et al. 2015). Marine aquaculture contributes to approximately one-third of world fisheries and aquaculture production (FAO 2018) and takes place mainly in coastal areas (Le Gouvello et al. 2017), presenting socio-economic development opportunities for resource dependant rural coastal communities (Bailey 2008; Burns et al. 2014; Pelletier et al. 2016). However, because marine aquaculture sites are located in shared ocean spaces, there are many users and potentially conflicting opinions on how to manage the farming activity (Murray and D'Anna 2015; Armitage et al. 2017). Additionally, aquaculture has not always been developed sustainably and, in some cases, has resulted in environmental degradation and "ocean grabbing" (Bennett et al. 2015; Belton 2016). Coastal communities are thereby challenged to plan and manage aquaculture development in a way that supports societal needs and well-being, without threatening the ability for current and future generations to benefit from the marine environment. Yet communities are also beholden to operate under the regulatory authority of multiple jurisdictions, including both the provincial and federal governments. Furthermore, as Canada continues to move towards reconciliation and recognition of the rights of Indigenous Peoples (via mechanisms like the United Nations Declaration on the Rights of Indigenous Peoples and the resulting private members bill currently with the Canadian Senate), communities will need to work with Indigenous peoples on natural resource projects that take place in Indigenous territories.

How can, or should, communities approach aquaculture development? The ecosystem approach to aquaculture (EAA), which has been recommended by the United Nations Food and Agricultural Organization (FAO) to help facilitate sustainable aquaculture development worldwide, may offer one potential approach. It is guided by three key principles, suggesting that aquaculture development should: (*i*) not threaten ecosystem function and service, (*ii*) support human well-being and equity, and (*iii*) be developed through a multi-sectoral or integrated approach (FAO 2010). Furthermore, with stakeholder participation being a critical component of the strategy, it has been suggested that the EAA may improve social acceptability of aquaculture and reduce user conflict (FAO 2010). Yet the operationalization of the EAA has proven to be a challenge, as much of the focus has been on addressing the technical and biological aspects of aquaculture development instead of social concerns (Costa-Pierce 2010). This has led to a "people–policy gap" in aquaculture development, meaning there is a need to better involve people in the design and management of operations (Krause et al. 2015). Community-based management, which engages communities in planning and decision-making for shared, or common pool, resources (Fernandez-Gimenez 2008) may be one option that could help fill this gap.

Community-based management initiatives have been applied worldwide in many sectors (e.g., forestry, fisheries, agriculture, protected areas), including several studies on freshwater and marine aquaculture activities (see for example, Saphakdy et al. 2009; Rougier et al. 2013; Ateweberhan et al. 2014; Galappaththi and Berkes 2014; Todinanahary et al. 2017). Most aquaculture-related community-based initiatives have been carried out in developing countries as a way to support rural economic development and enhance livelihoods (Armitage 2005; Blythe et al. 2017). However, some successful community-based initiatives have been launched in developed countries. The most iconic example in Atlantic Canada is the We'koqma'q First Nation trout farm. Although the co-management model of this farm has changed over time, it is grounded on a community-based

initiative, and the revenue of the operation is re-invested in the community (Atlantic Canada Opportunities Agency 2018). Given the potential to bring equity, inclusivity, and sustainability to resource management, community-based marine aquaculture (CBMA) could have potential to support the social dimensions of the EAA, and consequently could be an approach for future aquaculture developments.

Inherent challenges involved with CBMA must also be acknowledged, since coastal resource management is already complex and "local communities" are not the homogenous entities they can oftentimes be depicted as (Weinstein et al. 2007; Billé 2008; Madden and McQuinn 2015). In addition, community-based projects could adopt very different operational and regulatory models (Lane and McDonald 2005), which could affect the effectiveness of a CBMA initiative. Moreover, the general understanding of community-based management depends on local context and perceptions (Armitage 2005; Gruber 2010; Beyerl et al. 2016). Consequently, it cannot be assumed that a community-based management model is applicable for all communities. Context-specific research is required to determine suitability and achieve long-term effectiveness (Diana et al. 2013; Krause et al. 2015; Bennett 2016; Beyerl et al. 2016). Should there be interest in CBMA to facilitate aquaculture development, there is a need for improved understanding of its applicability for different locations and contexts.

The scope of this research is to explore the opportunity for nonfinfish CBMA in Nova Scotia (NS), Canada, by examining various stakeholder perspectives (provincial government, municipal government, industry, and academia). The selection of these stakeholder groups aimed to cover a variety of perspectives on CBMA, and a formal comparison among them was not intended. Interviews with these stakeholder groups involved with aquaculture research and development help to conceptualize CBMA as a possible coastal resource management strategy that could facilitate increased future aquaculture development and support an EAA. It is important to reiterate that this study does not aim to explore the viability of CBMA in a specific location, which would require engagement with community members and other relevant stakeholders such as fishers as well as with rightsholders such as the relevant Mi'kmaw bands or larger regional groups (such as the Atlantic Policy Congress of First Nations Chiefs). Nova Scotia was selected as an approriate study area because it has potential for increased marine aquaculture that is supported by provincial government, a populated coastline with many small coastal communities, and a need for rural economic development (Province of Nova Scotia 2009a; Ivany et al. 2014; NS Department of Fisheries and Aquaculture 2016). Opportunities for cultivation of commercial shellfish and (or) seaweed species were of specific focus for this research. Although shellfish and seaweed farming can be technologically demanding, it is generally accepted that these forms of aquaculture involve lower input systems and use more simplistic gear in comparison to finfish aquaculture (Petersen et al. 2010; Kim et al. 2017). Given that CBMA could follow different operational and regulatory models, with different degrees of community involvement, it was assumed that the focus on shellfish and seaweeds could minimize risk and decrease complexity for communities to start-up. With the aquaculture industry on a path for growth in NS and worldwide, this research examines CBMA as a possible opportunity to support sustainable development by integrating local communities into the aquaculture development and management process.

Methods

Study area: NS, Canada

Located in the Northwest Atlantic Ocean, NS has 7579 km of coastline with a variety of oceanographic and climatic conditions deemed suitable for a diverse aquaculture sector in seven different regions (**Fig. 1**; Sebert and Munro 1972; Stantec 2009; Manning and Hubley 2015). The aquaculture regions are broadly based on the biophysical suitability for commercial cultivation of a number of

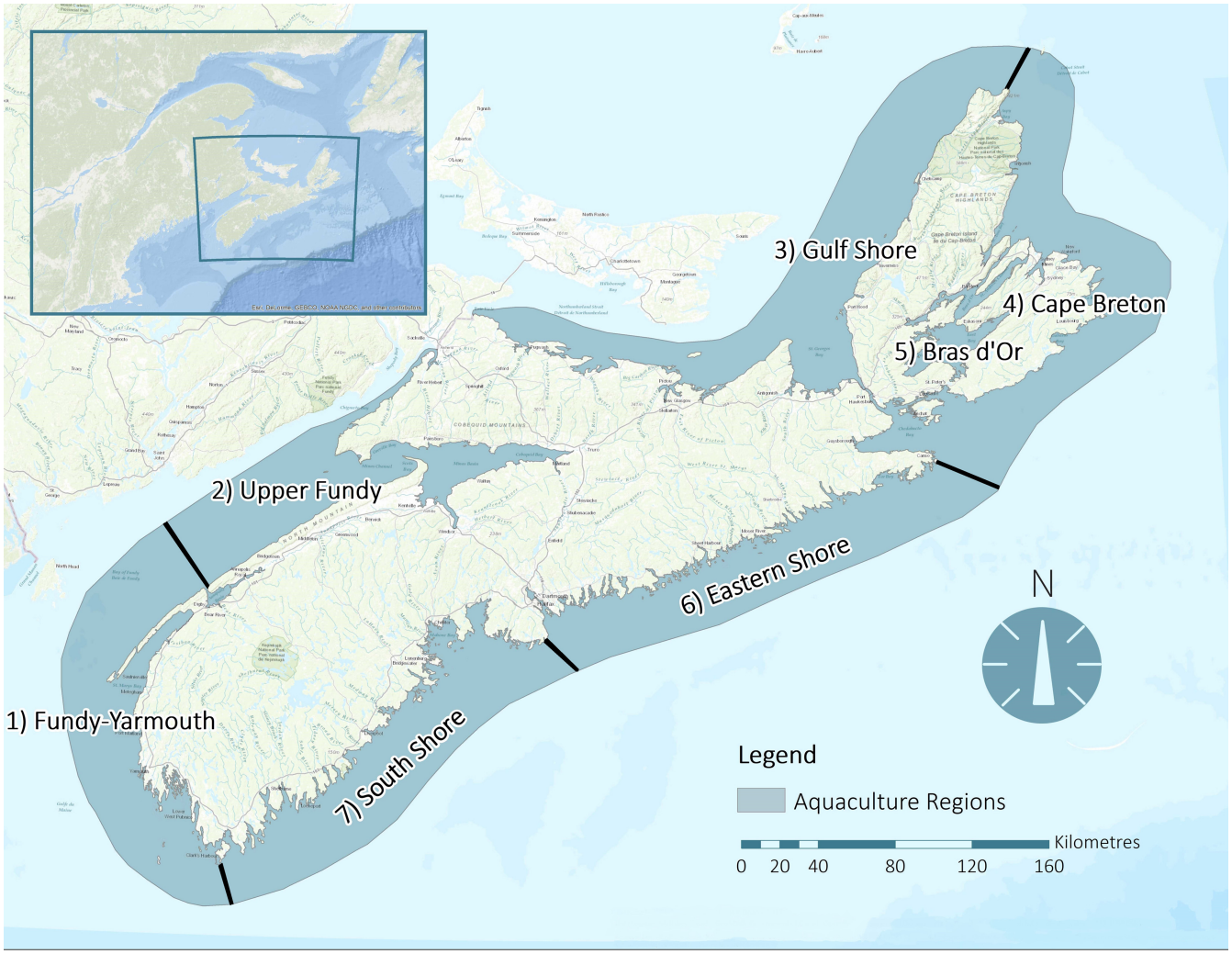

Fig. 1. Map of study area, Nova Scotia, Canada, including seven aquaculture regions: (1) Fundy–Yarmouth, (2) Upper Fundy, (3) Gulf Shore, (4) Cape Breton, (5) Bras d'Or, (6) Eastern Shore, and (7) South Shore. Map layer source: Sources: Esri, HERE, DeLorme, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, MapmyIndia, © OpenStreetMap contributors, and the GIS User Community.

different species, including blue mussel (*Mytilus edulis*), bay scallop (*Argopecten irradians*), sea scallop (*Placopecten magellanicus*), American oyster (*Crassostrea virginica*), and European Oyster (*Ostrea edulis*) (Stantec 2009). Although seaweed aquaculture is not well-established in the province, some of the species to consider for development include sugar kelp (*Saccharina latissima*) and winged kelp (*Alaria esculenta*) (Chopin 2017; Ross 2017). Both of these seaweeds are native to the area, have been cultured in integrated multitrophic aquaculture trials in the Bay of Fundy, New Brunswick, and were determined to be ready for more widespread commercial cultivation (Chopin 2015, 2017; Ross 2017).

From the socio-economic perspective, NS has the third highest child and family poverty rates in Canada and the highest in Atlantic Canada (Frank 2016). There is a growing reliance on food banks in the province, as seen with a rise of 40% usage rates between 2008 and 2016 (Food Banks Canada 2016).

Approximately half of the population resides in rural areas, which have been affected by economic and demographic declines since the 1990s, as populations shift to urban areas (Statistics Canada 2011; Canadian Rural Revitalization Foundation 2015). Additionally, marine aquaculture activities take place mainly in the coastal zone where 70% of Nova Scotians live (Province of Nova Scotia 2009a). The need to find innovative ways to sustain and (or) grow rural economies, while also protecting the natural resource base, has been identified previously as a priority for the province (Ivany et al. 2014; Canadian Rural Revitalization Foundation 2015). Aquaculture is being promoted as one way to support rural economic development (Province of Nova Scotia 2012; NS Department of Fisheries and Aquaculture 2016) and recommendations have been made to see fisheries and aquaculture exports double (Ivany et al. 2014). Recognizing the rural development opportunities that aquaculture can bring, several Community Aquaculture Development Groups have already been established in the province with the Aquaculture Association of Nova Scotia (AANS; AANS 2017). These groups are described by the AANS as being interested and supportive of sustainable aquaculture development in their communities, yet they are challenged by how to best proceed with development (T. Smith, personal communication, 2017).

Stakeholder interviews

From June to September 2017, a series of targeted semi-structured interviews ($n = 16$) were conducted (under Dalhousie ethics #2017-4160), with participants from four stakeholder categories, selected according to the following rationale:

1. Provincial government representatives ($n = 2$): Provincial government representatives were targeted due to their expertise on aquaculture development, leasing and licensing processes, and other regulations. The provincial government staff directory was used to initially identify potential participants, with division managers being targeted specifically for interviews.

2. Local government representatives ($n = 6$): Councillors and community and economic development officials for varying levels of local government (municipalities, towns, and municipal districts) in rural coastal areas were selected because of their knowledge on the unique challenges and opportunities for these communities. Priority was given to targeting local representatives within areas where Community Aquaculture Development Groups have been established with AANS.

3. Industry ($n = 4$): Aquaculturists (e.g., existing or past aquaculture license or lease holders), industry employees, representatives of industry associations, and (or) nongovernmental organization (NGO) representatives were selected to share operational and regulatory knowledge related to aquaculture development.

4. Academia ($n = 4$): Researchers from social or natural science backgrounds were selected to provide expertise on topics such as planning, rural and community development, sustainability, fisheries and aquaculture, marine ecology, and oceanography.

Although no one declined interviews, there were several people contacted who did not respond. Interviews were conducted in person and information was recorded via handwritten notes and an audio recording device. Given the specific background that participants should have to be part of the study, a purposive sampling was adopted. Interviews were carried out until data saturation was reached, that is, until the point at which new ideas did not emerge during the interviews. The final sample size ($n = 16$) is within the range of other studies that follow the same sampling design (e.g., Guest et al. 2006; Palinkas et al. 2015). Note that the aim was to solicit a variety of opinions to begin to understand the range of perspectives around CBMA and to minimize the risk reaching saturation at early stages of the study due to similarities among participants. The aim was not to compare between stakeholder groups.

The results of the interviews (see interview script in **Supplementary Material 1**) were organized around five topics: (*i*) potential for aquaculture expansion in NS, (*ii*) understanding of community-based management, (*iii*) benefits and challenges, (*iv*) suitable areas and communities, and (*v*) operationalization strategies.

Results and discussion

In this section we summarize the major findings of this study around key topics and discuss these results in light of the literature, providing examples to position the potential of CBMA in NS in the larger context of the EAA.

Aquaculture expansion

Before delving into the topic of CBMA, it is important to understand interview participant perceptions on the general suitability of NS for increased aquaculture development. Nearly all interview participants ($n = 14/16$) agreed that it was a suitable place for development for both environmental and socio-economic reasons. Two indicators related to environmental conditions were consistently cited throughout all stakeholder groups: (*i*) the size of the coastline and (*ii*) their perception of good water quality. The coastline size (7579 km) likely makes NS a suitable place because of the perceived amount of space for development, as well it provides a variety of environmental conditions that create opportunities for a diverse industry (Sebert and Munro 1972; Stantec 2009; Manning and Hubley 2015). This is supported by one interview participant who said, "We have such a large coastline and our industry is quite small in comparison to other provinces and areas, we definitely have great potential for more production and development across the species and areas, provided that it can be done responsibly" (provincial stakeholder/participant #Dq-40). The perception of good coastal water quality is likely attributed to the rural, underdeveloped character of the coastline (Province of Nova Scotia 2009b). Broadly speaking, water quality may be perceived as good when compared with densely populated industrialized countries or regions, but there is no clear depiction of the state of water quality for the whole coast of NS and there are indications of pollution and contamination in certain urban and rural areas alike (Province of Nova Scotia 2009b). Despite the large-scale suitability assessment (e.g., Stantec 2009) and existing monitoring data of coastal waters, site-specific testing would still have to occur to properly qualify water quality parameters.

Socio-economic suitability indicators that were commonly cited by interview participants included a historical connection to the marine environment, access to infrastructure (e.g., ports, wharves, roads, processing facilities), access to markets, the need for rural development, and availability of local expertise. One participant referenced the current underdeveloped nature of the aquaculture industry in NS in comparison with the smaller neighbouring maritime province of Prince Edward Island (PEI), stating "in the Northumberland Strait, our [NS] shellfish sector is only a small fraction of what PEI's shellfish production is, despite being in basically the same body of water, so I don't think we're taking full advantage of the opportunities we have here in Nova Scotia" (provincial stakeholder/participant #Dq-40). To provide more perspective on this, PEI has 1260 km of coastline (i.e., less than one-fifth of that in NS), yet it is the largest producer of blue mussels in Canada and second largest producer of oysters behind the west coast province of British Columbia (25 725 km of coastline) (Sebert and Munro 1972; Manning and Hubley 2015).

There were no participants who outright disagreed that NS was a suitable place for increased marine aquaculture development. The high acceptance of aquaculture may be attributed to the stakeholder groups interviewed who could gain from increased development activities. Had other stakeholder groups such as tourism operators or commercial fishermen been interviewed, there may have been more variance in perspectives on this topic.

There were participants in the academia stakeholder group ($n = 2$) who were unsure about increased aquaculture development. In expressing this uncertainty, one of the participants stated, "I don't know if I can answer that question generally. I know it can be hugely controversial" (academia stakeholder/participant #wv-31). This response is likely related to previous controversies around aquaculture in the province, namely with finfish aquaculture (see Doelle and Lahey 2014; Grant et al. 2016; Loucks et al. 2014, 2016). In the advent of increased development, participants identified the potential for conflict and, therefore, the need for adequate conflict management between user groups. This is reflected in the response of one participant who, when describing some of the challenges, said "... there's all these other resource users, but that is a problem that is managed by scale. You don't get so big that you're taking up more room than you should and interfering with people's lives and lifestyles" (industry stakeholder/participant # ag-75). Both the EAA and community-based management arrangements are intended to address social and ecological issues related to natural resource usage. Therefore, these two approaches may help to alleviate some of the concerns around future aquaculture development and complement current efforts from the NS Department of Fisheries and Aquaculture to increase the social acceptability of aquaculture (Terpenning et al. submitted).

Multiple notions of "community based"

Interview participants expressed differing perceptions of what it means for something to be community based. This likely could have been anticipated, as community-based management is a broad concept that is dependent on local context and perceptions and, therefore, its definitions can vary (Armitage 2005; Gruber 2010; Beyerl et al. 2016). As one participant stated, "... there is no one formula to design it, but absolute criteria would be required to make it happen and sustain it over the long-term" (academia stakeholder/participant #fJ-10). Despite inconsistencies between responses, one participant offered a holistic understanding, stating that community-based management involves:

> "... accessibility to a resource that is not restricted to a single business or only to business ownership, but it can be accessed by community members without business affiliations. Therefore, then, the community has input into how that resource is managed and exploited ... And, there would be outcomes of that resource that would feed back into the community" (industry stakeholder/participant #zd-85).

These three aspects related to accessibility, input, and integration are well-aligned with literature on community-based management as an approach that (*i*) addresses critical issues related to resource access, (*ii*) enhances participation and local decision-making processes, and (*iii*) offers the ability for community members to obtain benefits (financial or otherwise) from resource management (Armitage 2005; Fernandez-Gimenez 2008). Should the community choose to prioritize local businesses in goods and service provision, community benefits may be amplified. Furthermore, these aspects connect with principles of the EAA focused on human well-being, equity, and the need for an integrated, multi-sectoral approach to aquaculture development (FAO 2010). This idea around integration is a critical component of the EAA and was expressed about a third of the time in the interviews ($n = 5$) to ensure that aquaculture expansion does not occur in isolation, but instead works with other sectors to provide wider benefits to society. In fact, integration is becoming a key piece of current aquaculture regulations, such as in NS, that aim for full community and stakeholder engagement (Terpenning et al. submitted).

Benefits and challenges

Interview participants were also asked about their perspective on the potential benefits and challenges of CBMA, the responses to which have been organized under four categories: (*i*) governance, (*ii*) economic, (*iii*) social, and (*iv*) environmental (**Table 1**). The identified benefits further reiterate the

Table 1. Summary of potential benefits and challenges of community-based marine aquaculture based on interviews with multiple stakeholders in Nova Scotia, Canada.

	Benefits	Challenges
Governance	- Local empowerment and decision-making - Increased transparency - Resource access	- Navigation of regulatory process - Bureaucracy ("red tape") - Adaptive capacity (quick decision-making)
Economic	- Rural economic development (jobs, income, tax base) - Spin-off economic benefits - Diversify local economy - Keep more money in the community - Opportunities for innovation - Attract young people/families to rural areas - Access to more assets and expertise - More support for aquaculture industry	- Start-up costs and funding - Processing - Market access for product - Risk for investors - Labour market - Seed supply/hatchery - Potential displacement of commercial wild harvesters
Social	- Education - Local food security/sovereignty - Eco/experiential tourism opportunities - Social interactions - Meaningful activity	- Teamwork/consensus building - Conflict - Capacity/knowledge
Environmental	- Stewardship - Sustainable development	- Climate change - Invasive species/species migration - Disease

potential for CBMA to facilitate an EAA by providing for rural coastal community livelihoods beyond solely economic development. Related to this, one participant stated, "I think [CBMA] would give [aquaculture] the social acceptability that it needs and keep it in a scale that is suitable to the community because they are making the decisions" (industry stakeholder/participant #ag-75). Opportunities for increased social learning and innovation have also been identified as a potential beneficial outcome of collaborative resource management due to the diversity of perspectives, approaches, and sources of information and knowledge involved (Armitage et al. 2007). There is a need for novel ideas to help sustain and (or) grow rural economies in NS (Ivany et al. 2014) and, therefore, CBMA may offer an opportunity to increase local socio-economic innovations. It may also highlight an area for potential future research to understand the extent to which CBMA in NS could contribute to learning and innovation within the industry.

As for challenges, in addition to what were described as the "normal challenges for any business and starting up an aquaculture farm" (industry stakeholder/participant #RU-72), challenges around teamwork and conflict were also identified. These types of challenges, e.g., lack of consensus or conflict among team members, are commonly referenced for community-based resource management initiatives, which again highlights the importance of having conflict resolution mechanisms in place (Castro and Nielsen 2001; Lane and McDonald 2005). Although having more people and opinions involved in the resource management process may present issues, it was also indicated to be a potential benefit, as there would be "more people involved who want to see it succeed" (industry stakeholder/participant #RU-72). This is reinforced by the example of the involvement of a local school in CBMA of sea cucumbers in Madagascar, as it has been said that the "many hands" involved has led to the school farm being one of the best maintained and having the highest rates of juvenile sea cucumber survivorship (Rougier et al. 2013).

Although one of the major barriers to feasibility identified by participants ($n = 11$) was funding for initial start-up costs, it was also thought that a community-based model may present increased funding opportunities. This was emphasized by one participant who stated:

> "One of the limiting factors to aquaculture has always been access to capital, so, presumably, if you have greater access to capital because you are sourcing from a lot more people that would enable projects to happen and overcome a lot of the barriers" (industry stakeholder/participant #ag-75).

In other regions of the world, similar initiatives have been said to attract a substantial amount of attention from public- and private-sector investment such as government, development agencies, social entrepreneurs, and conservation groups (Ateweberhan et al. 2014), which could also represent potential funding sources in NS. Attention from the public sector is crucial given that in addition to funding opportunities, political and regulatory constraints may play a role in the development of these types of community-based initiatives (**Table 1**). This becomes even more relevant for activities that involve shared resources, such as mariculture, which can lead to conflict among different users. In the specific Canadian context, it is also important to consider that the regulatory framework involves provincial and federal institutions, and communities do not have the authority to execute their preferences and visions regarding the use of the marine space.

Although none of the participants identified the potential environmental effects of aquaculture (**Table 1**), these aspects cannot be neglected, and they could be a challenge for CBMA. Both shellfish and seaweed farming could result in benthic organic loading and alteration of water quality properties in the vicinity of the farm (Weitzman et al. 2019). In addition, the deployment of infrastructure and additional biomass in the ocean could result in ecosystem effects such as the alteration of the food web, pollution, or the introduction of exotic or invasive species (Weitzman et al. 2019). These potential effects depend on the location and size of the farm as well as management practices. As for all aquaculture operations, a CBMA operation should consider these aspects and it should be subjected to the corresponding aquaculture regulations. Despite potential challenges, all interview participants ($n = 16$) revealed the unanimous belief that CBMA could be a feasible strategy that could be implemented to benefit rural communities in NS.

Suitable areas and communities

Interview participants were asked to think about the hypothetical implementation of CBMA in NS in terms of potentially suitable areas and interested groups or community members. It was generally thought that any rural coastal community in NS interested in starting up such an initiative likely could; however, three commonly cited suitability factors for areas included: (*i*) access to relevant infrastructure (e.g., wharves, road access, processing facilities, etc.), (*ii*) proximity to sheltered waterbodies, and (*iii*) sense of community and (or) tradition of resource sharing.

First Nations (one of Canada's three Indigenous peoples) were commonly mentioned ($n = 8$) as a group that could be interested in CBMA development, potentially influenced by the successful local example of the We'koqma'q First Nation trout farm (see Community partnership). Examples of community-oriented values abound in Indigenous cultures and, furthermore, the importance of seafood consumption to Coastal Indigenous peoples across the world and in Canada has been well-documented (Lee 1992; Cisneros-Montemayor et al. 2016; Bennett et al. 2018). The Mi'kmaq First Nation, one of the predominant Indigenous peoples in Atlantic Canada, are no exception, as it has been estimated that, before European settlement, 90% of their dietary needs were obtained from aquatic resources (Miller 2004; McMillan and Prosper 2016). Ancient examples of what could be considered CBMA, such as the clam gardens of Indigenous peoples in the Pacific Northwest (estimated to

be well over 1000 years old), reveal that the concept is not new, and the revival of such a coastal resource management strategy could benefit modern society (Augustine and Dearden 2014; Deur et al. 2015; Neudorf et al. 2017). Although this model is far from industrial aquaculture, it fits within the broad definition of co-management. CBMA, therefore, could potentially present a culturally aligned development opportunity (Fleming et al. 2015) for interested First Nations communities in the province.

Support for young people and families was also referenced many times ($n = 8$) by interview participants. NS has an aging population and continues to experience an out-migration of youth and young workers from rural areas, which can have impacts on local economies, families, and community support structures (Harling Stalker and Phyne 2014; Canadian Rural Revitalization Foundation 2015; NS Department of Seniors 2017). This is encompassed in a statement by one of the interview participants who said, "If you are from anywhere outside of a big urban centre, it's really hard to envision being able to stay in your community. Not to say that aquaculture is the be all and end all on that front, but a thriving industry right in the community, with spin-off activities associated with it, allows for youth to start to envision a future for themselves within their community" (provincial stakeholder/participant #gR-39). This statement suggests that aquaculture is perceived as a potential thriving industry that could be attractive to youth rather than seasonal and social employment.

Half of the participants ($n = 8$) mentioned that areas with a strong tradition of fisheries would be more suitable because of the access to infrastructure and people with experience on the water. As one participant stated, "NS has lots of port and harbour facilities, lots of boats, and people who are comfortable on boats and know the ocean" (academia stakeholder/participant #md-96). This is further reiterated by another participant who said, "We have the expertise of fishermen who have been in this province for generations. A lot of aquaculturists are or were fishermen who have become farmers" (local government stakeholder/participant #nc-99). There was a discrepancy between interview participants on this, however, as others ($n = 4$) thought that areas of less traditional fisheries activity would be more suitable, with one participant noting that "the mentality of farming versus wild harvesting is very different" (provincial stakeholder/participant #gR-39). NS does have a long-standing tradition of fishing and people who are accustomed to working on the water (Barnard 1986), which may make fishermen a group more apt to participate in CBMA and share their knowledge on the local marine environment. In some regions of the world, aquaculture has been introduced as an alternative or supplemental livelihood strategy in response to wild fisheries declines (Crawford 2002; Sheriff et al. 2008); however, it cannot be assumed that all fishermen would be interested in participating in CBMA initiatives. Also, there may be less of a need for economic development activities in regions where fisheries remain profitable, which is reinforced by the view of one participant who did not think it would work in their region because "the lobster fishery is so lucrative that people may not have the incentive to look for sources of additional income" (industry stakeholder/participant #zd-85). Regardless, this difference in opinion highlights the importance of consulting local fishermen as stakeholders in potential CBMA initiatives, particularly in communities with a strong tradition of fishing.

Although more densely populated and, historically polluted, areas may typically not be considered suitable for aquaculture development, there were some interview participants ($n = 3$) who suggested using CBMA to support ecological restoration in areas such as the Halifax Harbour. This would be similar to the "oyster gardening" practices in various regions of the United States, which have grown substantially in popularity (Hamilton et al. 2005; Rossi-Snook et al. 2010; Fay et al. 2012; Krasny et al. 2014). For example, in Delaware, one oyster gardening program reported growth from 65 volunteer gardeners at 45 locations in 2006 to 150 volunteers at more than 100 locations in 2010 (Rossi-Snook et al. 2010). While the primary purpose for many oyster gardening programs has been for ecological

restoration, it has also been said to foster a greater stewardship ethic amongst participants (Rossi-Snook et al. 2010; Krasny et al. 2014).

Stewardship was identified in the interviews as both a potential goal and benefit for CBMA. One industry participant stated, "We're concerned about water quality and, often, the first to notice changes to it. There's a stewardship aspect to aquaculture . . . It is in our interest to do so because clean water is what we have to have" (industry stakeholder/participant #ag-75). Active engagement in environmental stewardship programs can lead to behavioural changes that are favourable toward environmental activism and conservation (Ryan et al. 2001; Jefferson et al. 2015). This notion also aligns with current trends in terrestrial community gardening, which have been said to provide numerous health and well-being benefits (Kingsley et al. 2009; Jermé and Wakefield 2013) as well as connect people to their food and the environment (Litt et al. 2011; Datta and English 2016). Furthermore, it is increasingly acknowledged that many forms of aquaculture do not have to conflict with conservation (Dempster et al. 2006; Augustine and Dearden 2014; Walton et al. 2015), as there have recent been efforts to highlight the potential opportunities and synergies between aquaculture and both terrestrial and marine protected areas (Le Gouvello et al. 2017). By engaging more people in aquaculture through CBMA, there may be improved overall stewardship for marine ecosystems in coastal communities, which also supports the environmental principles of the EAA.

Operationalization strategies

Given that CBMA would be a new concept implemented in NS, there is not a clear procedure on how to operationalize it, yet participants focused on the necessity for the process to be guided by a bottom-up governance approach (**Fig. 2**). Some interview participants ($n = 4$) indicated that this kind of initiative could not be implemented in a top-down manner by the provincial or federal government and, instead, must come from the bottom-up. Previous research related to fisheries management in NS has indicated concern and frustration with top-down management approaches that were misaligned with community priorities (Wiber et al. 2010), demonstrating the importance taking this consideration seriously for successful operationalization of CBMA. The bottom-up participatory or decentralized approach versus the top-down centralized approach is commonly discussed in environmental resource management. Oftentimes, bottom-up is advocated for in situations where top-down has been perceived to have shortcomings or failures (Rhoads et al. 1999; Lane and McDonald 2005; Fraser et al. 2006). Studies have cautioned against understanding these two approaches as

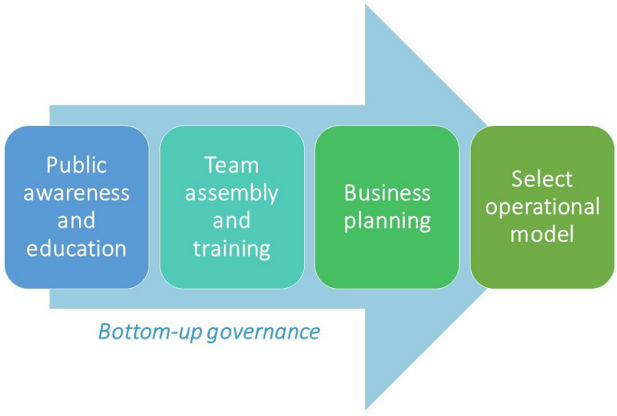

Fig. 2. Possible steps toward operationalization of community-based marine aquaculture, as identified by interviews.

dichotomous and, rather, they should be considered multi-scalar, ranging from decentralized (local) to centralized (federal) (Lane and McDonald 2005). Ultimately, CBMA would function along this scale, with local-level decision-making for the aquaculture operation, operating within the parameters of provincial and federal regulation.

For a process to truly take a bottom-up approach, interview participants identified that support for bottom-up processes needs to be built through advocacy and awareness of its potential benefits. It was suggested that this could be done through public meetings, workshops or "café approaches" (i.e., small working groups). Also, several participants ($n = 4$) acknowledged that a strong local leader and champion of CBMA would be a critical component in public education, building credibility, and rallying community support. Previous research on the role of local leaders (or "opinion leaders") in advancing the adoption of aquaculture innovation supports this notion, as it was found they were able to effectively spread knowledge awareness, basic how-to information, and influence opinions on the benefits of aquaculture (Blythe et al. 2017).

With community support established, interview participants described the importance of assembling the right team members with a broad array of different expertise and skillsets, ranging from aquaculture knowledge (e.g., technical, biological) to various business aspects (e.g., administration, planning, marketing, product development). The need for training of core members on aquaculture practices, if they did not have that expertise already, was also acknowledged by some interview participants. An example of such is a handbook that was developed for community-based freshwater aquaculture initiatives in rural areas of southeast Asia, which provides a series of training modules on a range of topics, including aquaculture techniques, participatory approaches, and business planning (SEAFDEC 2007).

It was mentioned that both short- and long-term planning would be needed to guide development and operation. These needs are encompassed in the response of one participant who said:

> "To make it happen, you need a team with people with different skills, including people who can see in the short-term and accomplish tasks on a daily basis, but also those with a broader view of the operation. This would include having a business plan to make sure people are moving forward in the same direction" (industry stakeholder/participant #Pi-38).

Interview participants identified some potential operational models that could be applied to implement and manage CBMA in NS (**Fig. 3**). To categorize the potential CBMA models, they are identified and discussed next as "ideal types" for clarity and consistency (Weber 1978; Zhang 2016). However, the operational models may not fit into clear categories in practice and, instead, could be hybrids of some of the ideal types identified, depending on community-context and stakeholder needs and values.

Community ownership

Community ownership was identified by several interview participants ($n = 8$) as a way that CBMA could be operationalized, which may involve local-level, publicly elected government such as a municipality or First Nations Band Council owning and operating the aquaculture lease and license. One participant theorized the potential of this operational model, stating:

> "The municipality leases a body of water from the province . . . and makes it accessible for community members for shellfish or seaweed farming . . . the benefits are then individual, so it's the municipality making something available for individual gain. It becomes a source of food, a source of supplemental income, and a source of meaningful activity" (industry stakeholder/participant #zd-85).

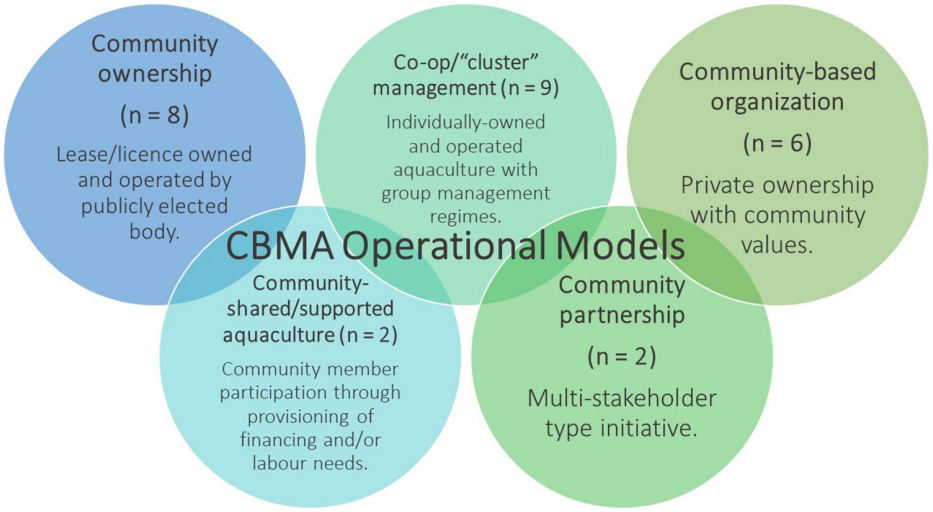

Fig. 3. Ideal type operational models for community-based marine aquaculture in Nova Scotia, based on interviews with multiple stakeholders.

Participants ($n = 6$) referenced the opportunity for private ownership and operation of an aquaculture lease/license by a community-based organization such as a registered nonprofit, charity, NGO, business, or social enterprise with community values, purpose and benefits. This model may involve the establishment of a community board of directors to oversee operations, with board meetings open to the public.

Community partnership

Community partnership, a multi-stakeholder type initiative, was another way in which some participants ($n = 2$) thought CBMA could be operationalized. This would involve a partnership arrangement between varying stakeholders, which may include the private sector (business, social enterprise, NGOs, etc.), community groups, and public entities such as municipal and provincial government. The We'koqma'q First Nation trout farm (NS, Canada) may provide an example of community partnership. Although the Band Council owns the leases and license for aquaculture, they partnered with private business on certain aspects of the operation (Thompson n.d.). The model for the We'koqma'q First Nation trout farm has since evolved, but this was the initial model that triggered development. Additionally, the example of CBMA in Madagascar described previously is a community partnership arrangement, as it is a joint project between an international NGO called Blue Ventures Conservation and local community members referred to as the Vezo people. It also involves researchers and academia from a local university, private business (i.e., a seafood exporter and an aquaculture company that provides the juvenile sea cucumbers for grow-out) (Astuti 1995; Blue Ventures Conservation 2015; Todinanahary et al. 2017).

Community-shared or -supported aquaculture

Community-shared or -supported aquaculture was another potential operational model referenced by some participants ($n = 2$). This typically involves a group of members who purchase shares from a participating farm and, in return, receive supply of freshly produced goods on a regular basis (Fieldhouse 1996). Farmers and members share the benefits and risks. Farmers benefit from this arrangement from financial and, in some cases, labour support associated with the member involvement. Members, on the other hand, receive fresh foods, knowledge on where their food is coming

from, and the satisfaction of supporting local food systems (MacMillan Uribe et al. 2012; Campbell et al. 2014). Community-supported agriculture (CSA) and fisheries have been applied widely and continue to grow in popularity (Fieldhouse 1996; MacMillan Uribe et al. 2012; Campbell et al. 2014; Kis 2014). Although this is a tangible way to involve community members, there are some limitations. This is reflected by one participant who said:

> "Knowing where your food comes from has become a more important issue for people who can afford to think that way. A CSA, although a guarantee of getting good food, is not a cheap way to buy food, and may be limited to people at a certain income level" (industry stakeholder/participant #ag-75).

Therefore, if participation can only occur by buying shares, then it may not be socio-economically accessible for all community members.

Cooperative (co-op) or "cluster" management

Another way participants ($n = 9$) thought CBMA could be operationalized was through cooperative (co-op) or "cluster" management. This would involve linking individual aquaculture operations into voluntary agreements with groups of farms to establish shared management practices and support systems (Knowler 2008; Mills et al. 2011; Diana et al. 2013; Galappaththi and Berkes 2014). An example to draw upon is the emergence of community-based aquaculture in Sri Lanka in which individual small-scale shrimp farming operations have formed community associations and established community-level rules to coordinate production efforts, reduce pollution in the shared water resource, and work as a liaison between the shrimp farmers and government (Galappaththi and Berkes 2014). Benefits for these kinds of arrangements include: (*i*) easier access to certification schemes (Diana et al. 2013), (*ii*) collective power in marketing to local or export markers (Knowler 2008), and (*iii*) pooling of resources (e.g., shared access to equipment for invasive species mitigation such as high-pressure water treatment machinery for invasive tunicates) (Fisheries and Oceans Canada 2010). This model may be considered community-based from the perspective that it demonstrates collective action, but it is not explicit in how broader community members would be able to participate.

Adaptive management

While the previous models may provide different frameworks toward operationalization, as one participant highlighted, CBMA development would be "an evolving process, with no one set answer for how it applies" (local government stakeholder/participant #Nn-99). This statement touches on the need for adaptive management to be incorporated into any of the potential operational models. Adaptive management has also been identified as an important component of the EAA, as it has been said that it "cannot follow a precise blueprint" (Bailey 2008). More specifically, adaptive co-management has been defined as a long-term arrangement that allows for stakeholders to share management responsibilities and learn from actions based on the feedback learning process, which allows for trust-building between parties and improved transparency (Ruitenbeek and Cartier 2001; Folke et al. 2002; Berkes 2004). Therefore, adaptive management mechanisms should be built in to any CBMA operations, which should include agreed upon goals and evaluation methods for determining operational success. Whereas aquaculture involves both social and natural systems, any evaluation methods should include both environmental and socio-economic indicators (Blythe 2013). In other areas of the world where CBMA has been applied, issues have been encountered in trying to determine indicators of success after the initiative has already been established (Ateweberhan et al. 2014). Therefore, this would provide an inclusive, proactive, and flexible approach to operationalized CBMA.

Conclusion

This exploratory research has compiled the opinions and perspectives from select participants with in-depth knowledge about nonfinfish aquaculture and community-based management regarding the potential of CBMA in NS. Accordingly, this study lays the foundation for better understanding CBMA as a coastal resource management opportunity in the context of future aquaculture development in NS. The findings presented in this article demonstrate interest and potential for CBMA to help grow the nonfinfish aquaculture industry in an innovative way in NS, while also supporting social and ecological sustainability goals inherent in the EAA. The involvement of community members in planning and operation of aquaculture could help to remove barriers to access, allowing for people to gain more of a connection with their seafood and become educated on sustainable aquaculture practices much like trends in oyster gardening or terrestrial community gardens. Because of continued interest in moving aquaculture offshore, to minimize environmental effects while increasing production (Buck and Langan 2017), it may be even more important than ever to explicitly consider and prioritize aquaculture closer to home, where a connection between food production and consumption can remain strong.

Several steps toward implementation of CBMA and possible operational models were identified to help guide future efforts; however, further research may also be needed to include other stakeholder and rightsholder perspectives, examine potential examples of CBMA already operating in the province, determine other suitable areas and interested communities, and provide resources that can help to facilitate CBMA development by minimizing risks and maximizing beneficial outcomes. If governments and communities gain interest in pursuing nonfinfish CBMA development and take steps toward piloting projects, efforts must proceed with caution due to the challenges involved with collaborative coastal resource management (e.g., the need for a strong commitment, and a sound operational plan). In other words, the adoption of a community-based initiative does not necessarily guarantee the success of the operation. Furthermore, simply because an aquaculture development may be community-based does not necessarily mean it is more sustainable; therefore, continued evaluation and monitoring of socio-economic and environmental impacts of initiatives should be required. Although the focus for this article was on nonfinfish aquaculture in NS, research of this kind becomes increasingly important nationally and internationally due to the projected continued growth of the aquaculture industry. This phenomenon necessitates proactive strategies such as CBMA that can achieve a dual mandate to support the EAA in sustainable aquaculture development, while also enhancing livelihoods for people in coastal communities.

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Author contributions

JB, RF, and MB conceived and designed the study. JB performed the experiments/collected the data. JB analyzed and interpreted the data. JB, RF, and MB contributed resources. JB, RF, and MB drafted or revised the manuscript.

Competing interests

The authors have declared that no competing interests exist.

Data availability statement

All relevant data are within the paper and in the Supplementary Material.

Supplementary material

The following Supplementary Material is available with the article through the journal website at doi:10.1139/facets-2019-0010.

Supplementary Material 1

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